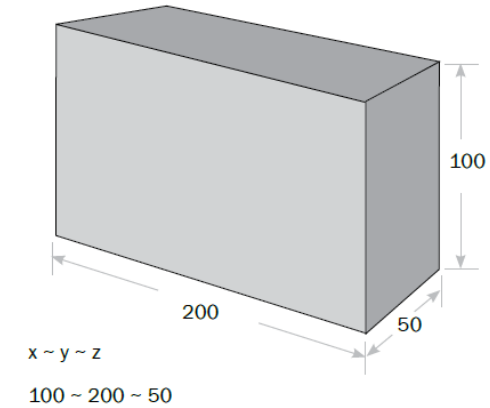
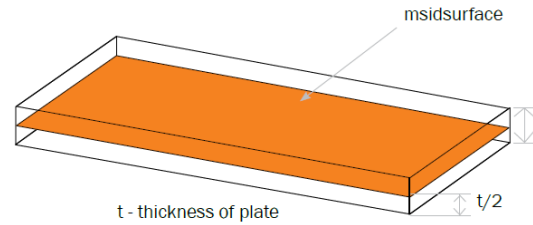
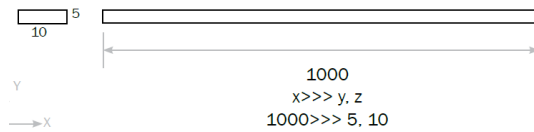


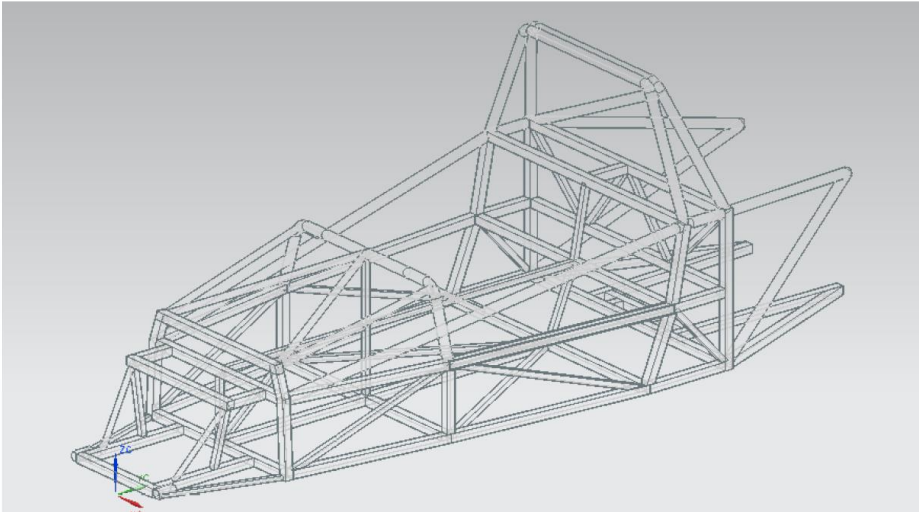
1D v 2D v 3D elements



INCREASED COMPLEXITY

Use the simplest elements possible

1D Elements



Use of 1D elements



Types Of 1D Elements:

Rod	Bar	Beam	Pipe
Tension/ compression (and Torque for some software) U_x, R_x (1,4)	All 6 dofs $U_x, U_y, U_z, R_x, R_y, R_z$ (123456) Applicable for symmetric c/s	Same as bar but also support unsymmetric sections i.e. shear center and warpage	Same as beam. Except it has internal non zero diameter
Tension compression members (truss), Shafts subjected to Torque, Connection elements	Shaft subjected to multiaxial loading, bolted, welded joints, connection elements	Same as bar + for unsymmetric c/s	Piping systems, Structural analysis

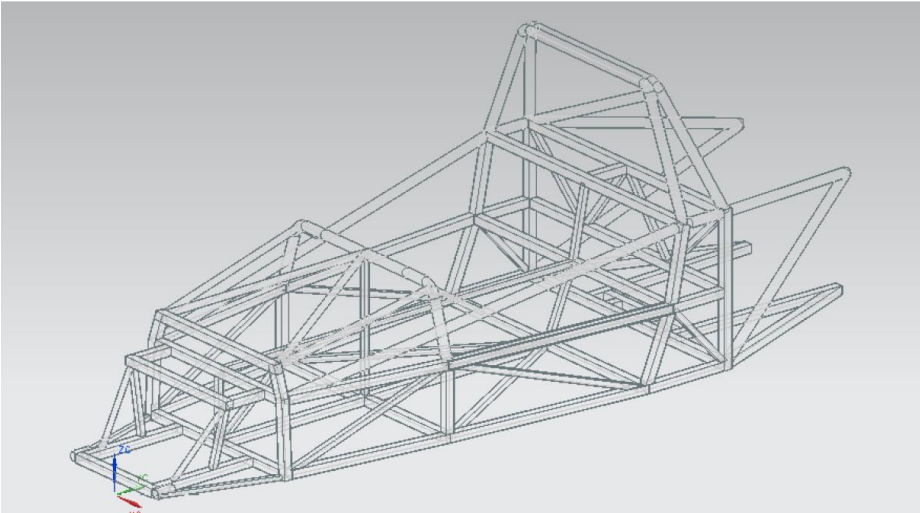
Use the simplest elements possible

Orientation of the section is needed

1D MCR example



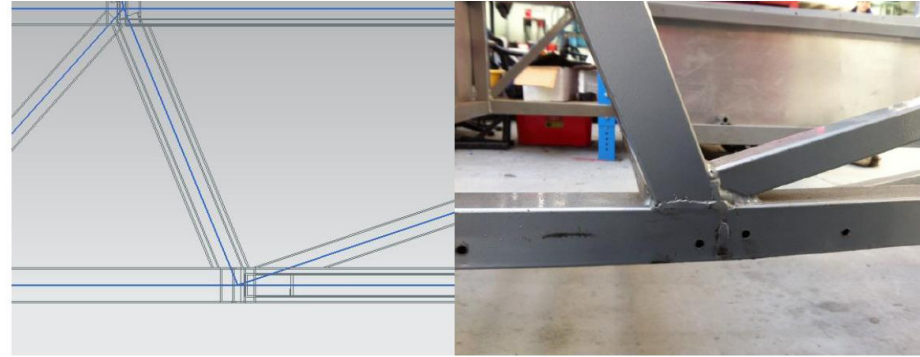
A simple optimisation study



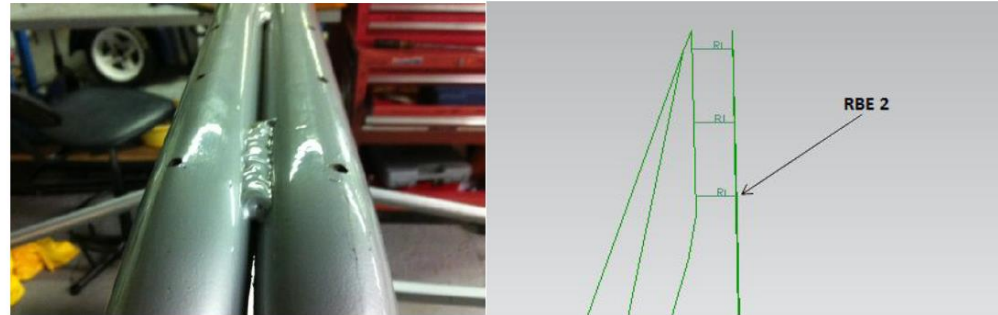
1D MCR example: issues



Curved tubes

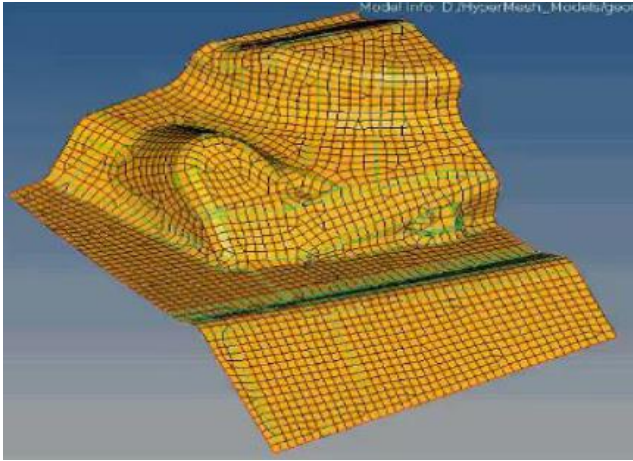


Structural/shear panels

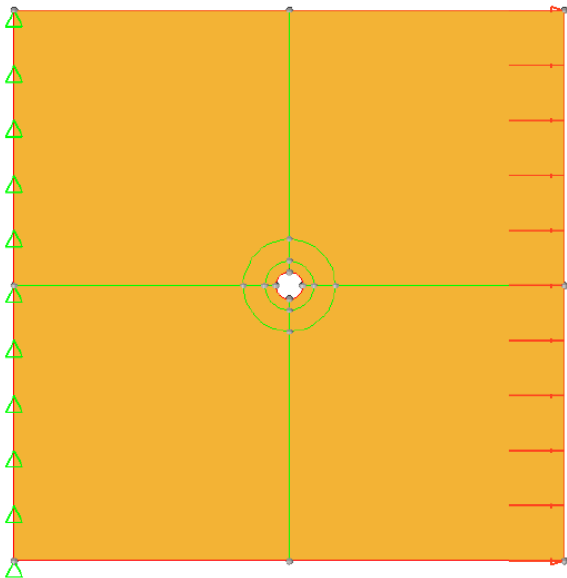


1D connections

2D examples



Use 2D elements to model 'sheet' parts



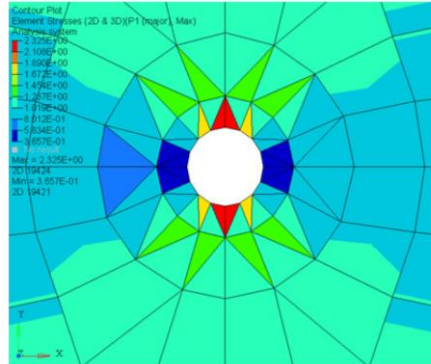
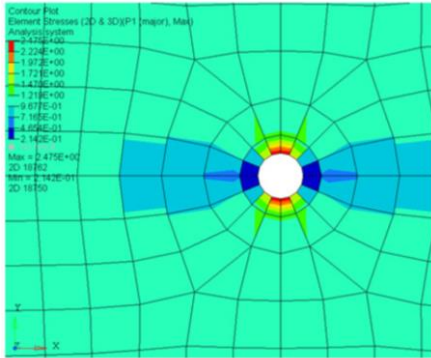
Problem

Nominal Stress = force/area = $10,000 / (1000 \times 10) = 1\text{MPa}$

Stress concentration factor for circular hole in large plate = 3

Theoretical stress = $3 \times 1 = 3\text{MPa}$ around the hole

2D example: Quads/Tris & refinement

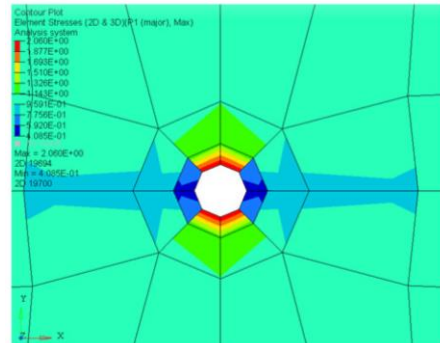
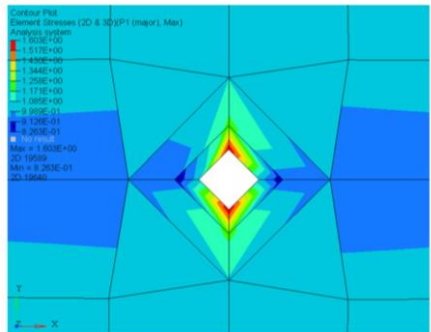


Quads v tris

Quads = 2.48MPa

Tris = 2.33MPa

Use quads wherever possible!



Mesh refinement

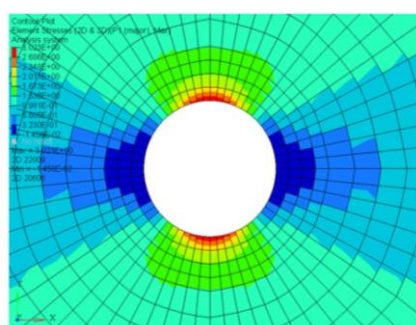
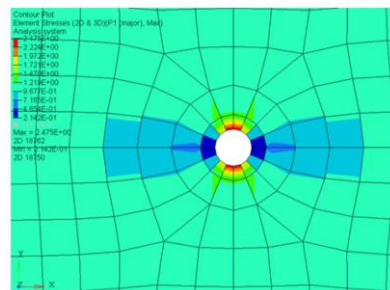
4 elements = 1.6MPa

8 elements = 2.06MPa

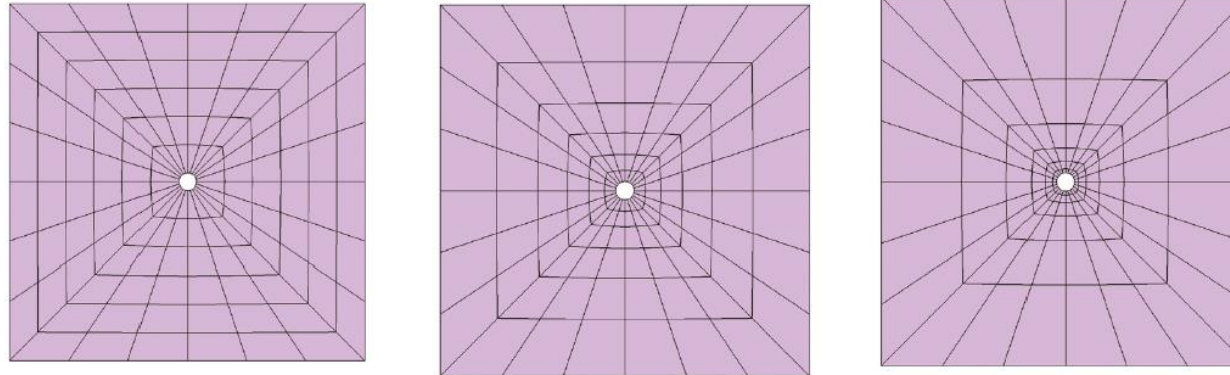
16 elements = 2.48MPa

64 elements = 3.02MPa

Refine your mesh to get accurate results!



2D example: Biasing



INCREASED BIASING →

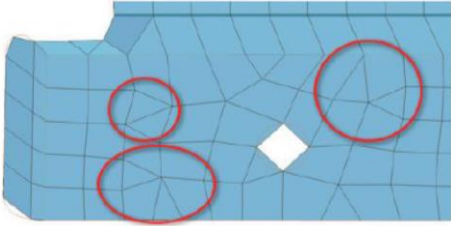
↑ INCREASED BIASING

Stress N/mm ² (exact answer 3 N/mm ²)	Nodes	Elements
1.59	168	144
2.13	168	144
2.41	168	144
2.56	168	144
2.65	168	144

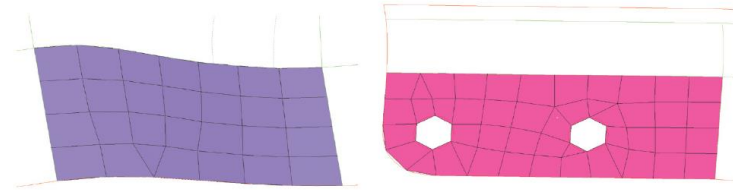
Note that the no. of nodes and thus the CPU time is the same

2D Meshing: What not to do

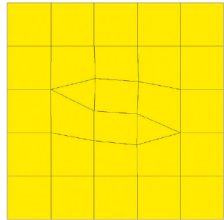
1) Back to back triangles should be avoided. Two tria elements should not be connected to each other directly.



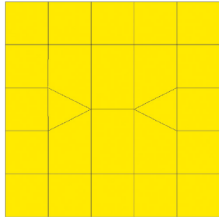
4) Avoid tria elements on outer edges or holes



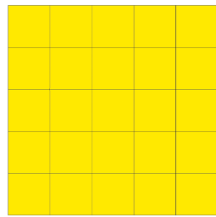
2) On plane surfaces triangular element should be avoided.



not recommended

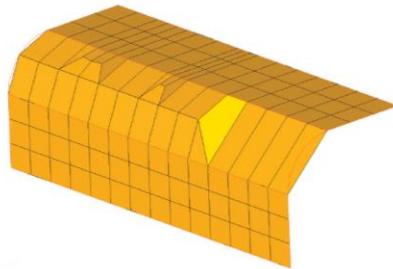


not recommended

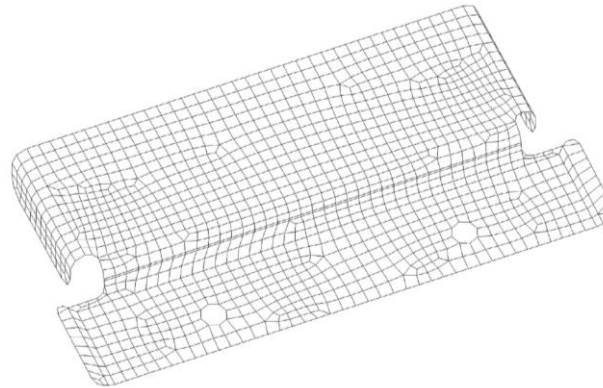


recommended

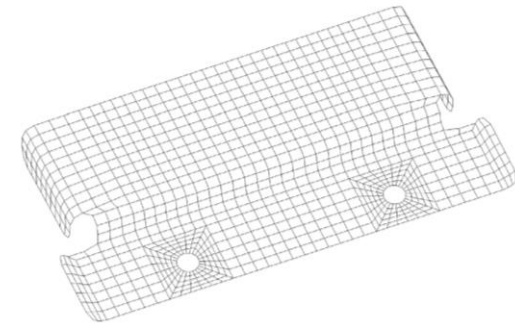
3) No mesh transition on constant radius fillets / curvatures



The mesh transition should be carried out on the planer surfaces (and not in the area of the fillet)

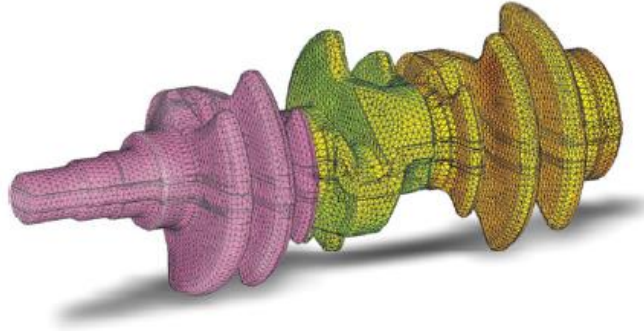


Example of a bad mesh



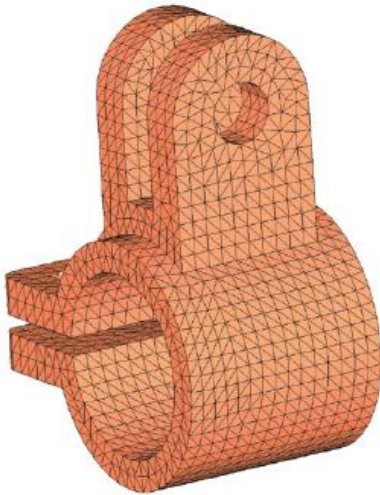
Example of a good mesh

3D Elements: Tetras



Use 3D elements to model 'solid' parts

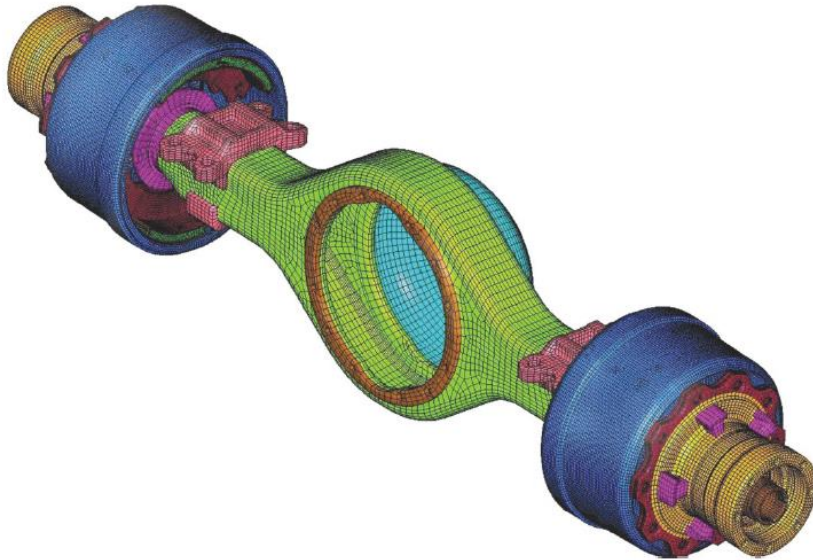
Many software packages now offer Automatic meshing using **tetras** if the CAD is simple and error free. Alternatively use 2D (tria) to 3D (tetra)



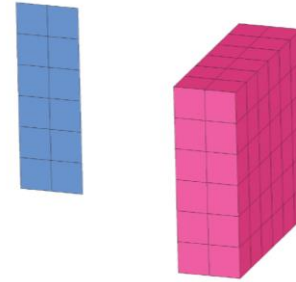
Advantage: Very quick, no meshing efforts

Disadvantage: Results in a very high number of nodes and elements. There is no control over the mesh flow and the specific mesh pattern requirement (like bolted, welded joints or contact surface simulation).

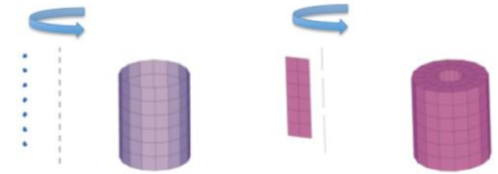
3D Elements: Brick Meshing



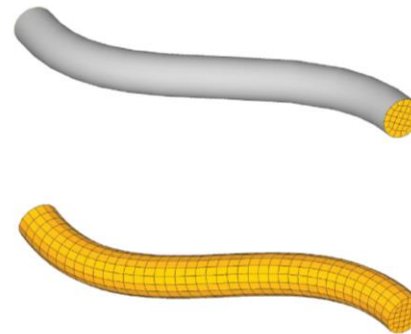
Extrude / Drag



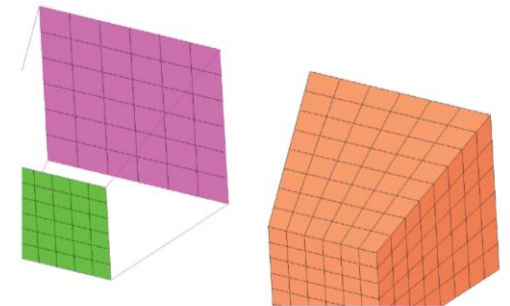
Rotate / Spin



Sweep / Line Drag



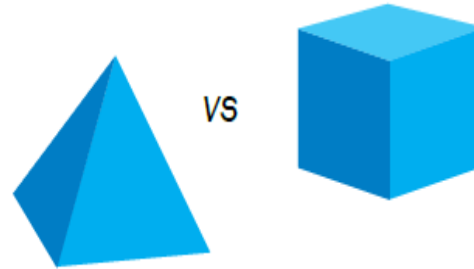
Linear Solid



“planning, hard work and patience”

3D elements

Brick And Tetra Meshing Comparison



- The number of elements and nodes generated by a brick mesh are of the order of 1/2 to 1/50 in comparison to a tetra mesh. A brick mesh reduces the solution time and results in the ease of handling the model on a workstation (pre and post display).
- Analysis types like crash or nonlinear give preference to brick mesh due to the number of nodes and mesh flow lines.
- The time consumed in brick meshing is more and requires experience, hard work, and a lot of patience too.
- Over the years, the algorithm for tetra meshing has improved and accuracy wise there is not much difference in tetra 10 and brick 8 elements.