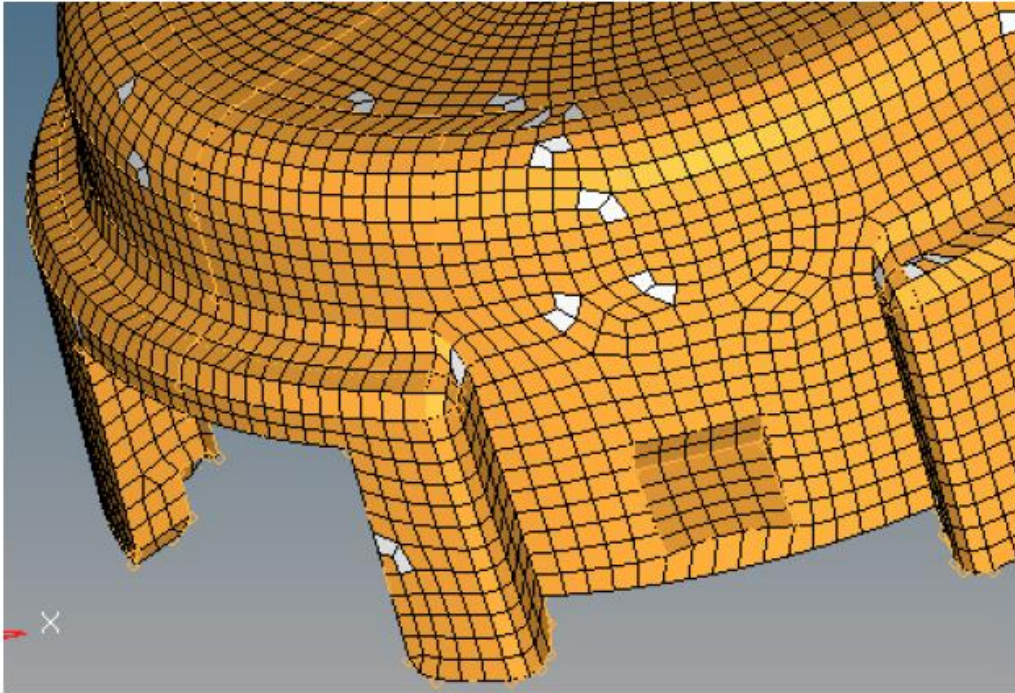
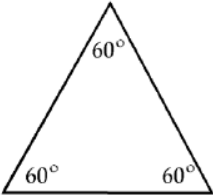
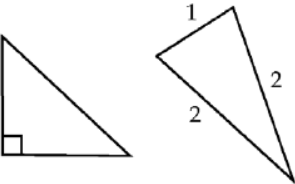
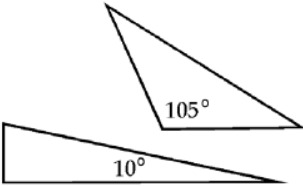
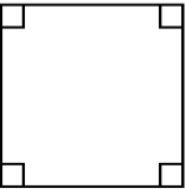
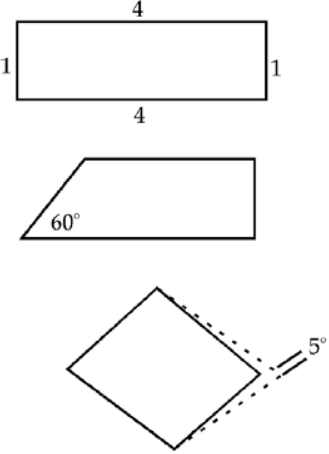
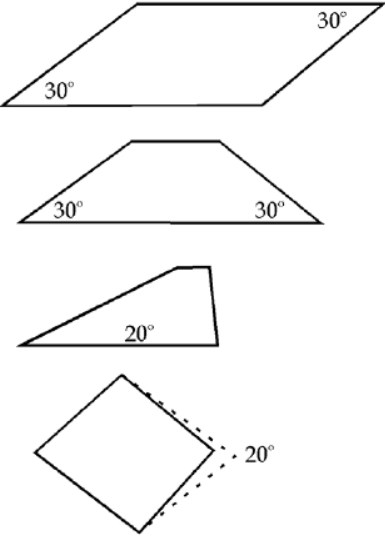


Element Quality



- **DEPENDANT ON INDUSTRY**
- Poor element quality leads to poor results
- Different software packages measure different things.
- Things measured include....

2D Element Quality

BEST	OK	VERY POOR
		
		

Ideal shape for quad elements – Square

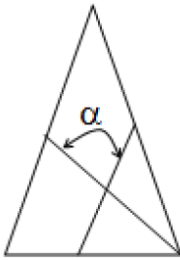

Ideal shape for triangular elements – Equilateral triangle


ble

Skewness

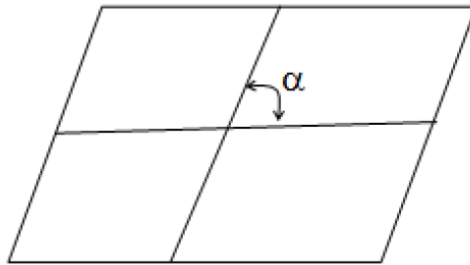
Skewness

Skew in trias is calculated by finding the minimum angle between the vector from each node to the opposing mid-side and the vector between the two adjacent mid-sides at each node of the element. Ninety degrees minus the minimum angle found is reported.



Triangle skew = $90 - \alpha$

Skew in quads is calculated by finding the minimum angle between two lines joining opposite mid-sides of the element. Ninety degrees minus the minimum angle found is reported.



Square skew = $90 - \alpha$

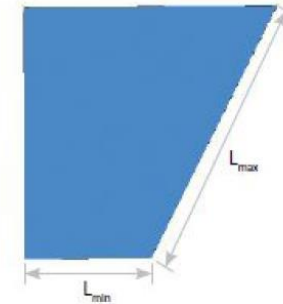
Ideally skew = 0 deg (<45 deg is generally ok)

The skew check is performed in the same fashion on all faces of three-dimensional elements.

Aspect ratio and warpage

Aspect Ratio

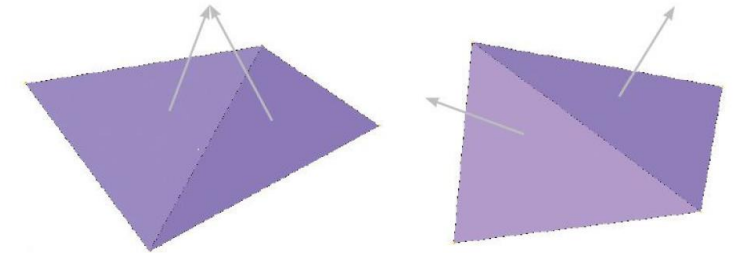
- Aspect ratio in two-dimensional elements is calculated by dividing the maximum length side of an element by the minimum length side of the element.
- The aspect ratio check is performed in the same fashion on all faces of three-dimensional elements.



Ideally aspect ratio = 1 (5 is generally ok)

Warpage

- Warpage in two-dimensional elements is calculated by splitting a quad into two trias and finding the angle between the two planes which the trias form. The quad is then split again, this time using the opposite corners and forming the second set of trias. The angle between the two planes which the trias form is then found. The maximum angle found between the planes is the warpage of the element.
- Warpage is 0 degs on a tria!
- Warpage in three-dimensional elements is performed in the same fashion on all faces of the element.



Ideally warpage = 0 deg (10 deg is generally ok)

Jacobian & Element length

- The Jacobian ratio is a measure of the deviation of a given element from an ideally shaped element. The Jacobian value ranges from -1.0 to 1.0, where 1.0 represents a perfectly shaped element.
- If all other criteria are 'perfect' then the Jacobian value would be one

Ideally Jacobian = 1 (0.6 is generally ok)

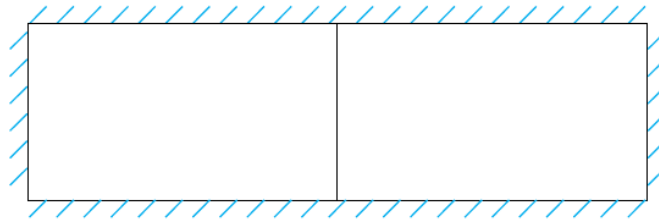
- Non linear analysis is driven by the smallest element length

Free Edges

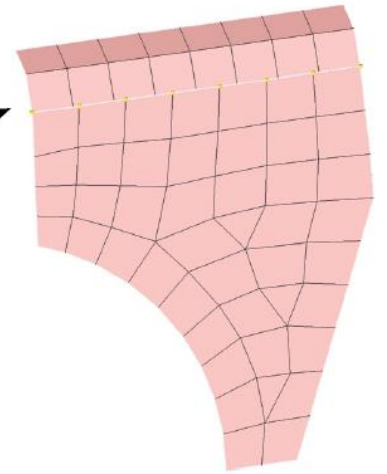
Any single quad element has 4 free edges.



Two elements



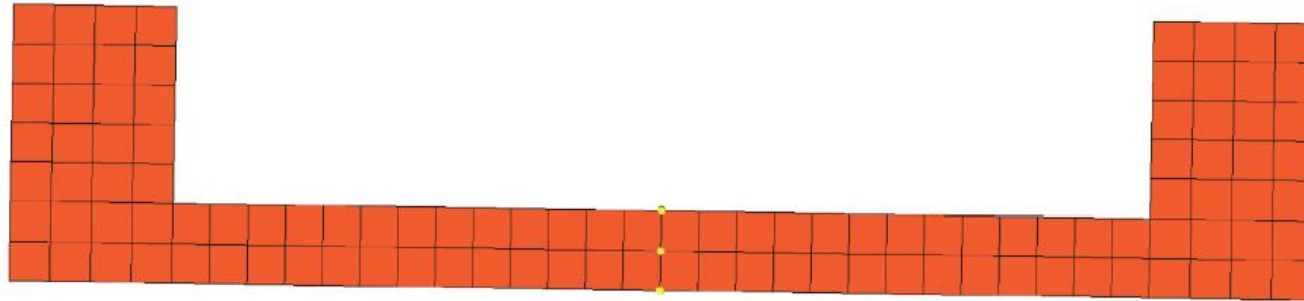
White line indicates free edge and unconnected nodes.



Duplicate elements/Nodes & Normals

Duplicate elements/nodes:

- Potentially cause by modelling errors such as reflect/rotate



Element Normals:

- Contacts?
- Top/middle/bottom stresses?

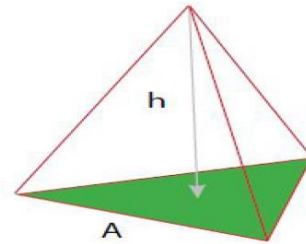
3D Element Quality additional checks

Tetra Collapse

Ideal Value = 1.0 (Acceptable > 0.1)

Tetra collapse = $h * 1.24 / A$

(Defined as the distance of a node from the opposite face divided by the area of the face multiplied by 1.24)

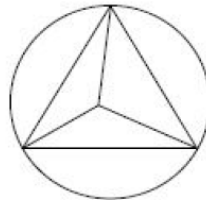


Volumetric Skew

Create a sphere passing through the corner nodes of the tetra, fit an ideal (equilateral) tetra in it. Find the volume of the ideal and actual tetra elements.

Ideal value = 0 (Acceptable < 0.7)

Volumetric Skew = $(V_{\text{ideal}} - V_{\text{actual}}) / V_{\text{ideal}}$



Example of mesh quality check

