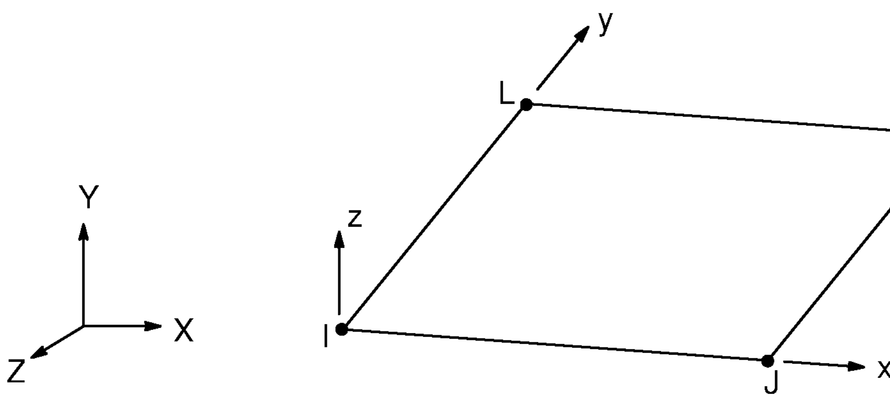
14.28 SHELL28 — Shear/Twist Panel



Matrix or Vector	Shape Functions	Integration Points
Stiffness Matrix	None (see reference)	None
Mass Matrix	None (one–sixth of the mass of each of the IJK, JKL, KLI, and LIJ subtriangles is put at the nodes)	None
Stress Stiffness Matrix	No shape functions are used. Rather, the stress stiffness matrix is developed from the two diagonal forces used as spars	None

Reference: Garvey(116)

14.28.1 Assumptions and Restrictions

This element is based directly on the reference by Garvey(116). It uses the idea that shear effects can be represented by a uniform shear flow and nodal forces in the direction of the diagonals. The element only resists shear stress; direct stresses will not be resisted.

The shear panel assumes that only shearing stresses are present along the element edges. Similarly, the twist panel assumes only twisting moment, and no direct moment.

This element does not generate a consistent mass matrix; only the lumped mass matrix is available.

14.28.2 Commentary

The element loses validity when used in shapes other than rectangular. For non–rectangular cases, the resulting shear stress is non–uniform, so that the patch test cannot be satisfied. Consider a rectangular element under uniform shear:

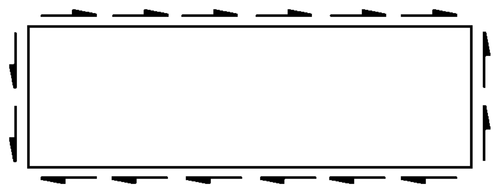


Figure 14.28–1 Uniform Shear on Rectangular Element

Then, add a fictional cut at 45° to break the rectangular element into two trapezoidal regions (elements):

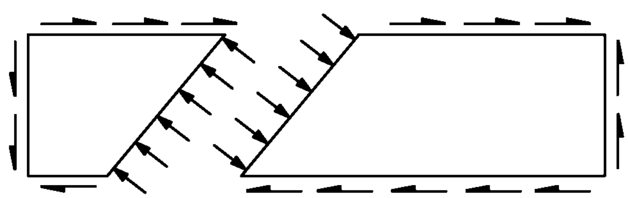


Figure 14.28–2 Uniform Shear on Separated Rectangular Element

As can be seen, shear forces as well as normal forces are required to hold each part of the rectangle in equilibrium for the case of "uniform shear." The above discussion for trapezoids can be extended to parallelograms. If the presumption of uniform shear stress is dropped, it is possible to hold the parts in equilibrium using only shear stresses along all edges of the quadrilateral (the presumption used by Garvey) but a truly uniform shear state will not exist.

14.28.3 Output Terms

The stresses are also computed using the approach of Garvey(116).

When all four nodes lie in a flat plane, the shear flows are related to the nodal forces by:

$$S_{IJ}^{fl} = \frac{F_{JI} - F_{IJ}}{\ell_{IJ}} \tag{14.28–1}$$

where:

S_{IJ}^{fl} = shear flow along edge IJ (output quantity SFLIJ)

F_{JI} = force at node I from node J (output quantity FJI)

F_{IJ} = force at node J from node I (output quantity FIJ)

ℓ_{IJ} = length of edge I–J

The forces in the element z direction (output quantities FZI, FZJ, FZK, FZL) are zero for the flat case. When the flat element is also rectangular, all shear flows are the same. The stresses are:

$$\sigma_{xy} = \frac{S^{fl}_{IJ}}{t} \tag{14.28–2}$$

where:
σ_{xy} = shear stress (output quantity SXY)
t = thickness (input as THCK on **R** command)

The logic to compute the results for the cases where all four nodes do not lie in a flat plane or the element is non–rectangular is more complicated and is not developed here.

The margin of safety calculation is:

$$M_s = \begin{cases} \dfrac{\sigma^u_{xy}}{\sigma^m_{xy}} - 1.0 \text{ if both } \sigma^m_{xy} \text{ and } \sigma^u_{xy} \neq 0 \\ 0.0 \text{ if either } \sigma^m_{xy} \text{ or } \sigma^u_{xy} = 0 \end{cases} \tag{14.28–3}$$

where:
M_S = margin of safety (output quantity SMARGN)
σ^m_{xy} = maximum nodal shear stress (output quantity SXY(MAX))
σ^u_{xy} = maximum allowable shear stress (input as SULT on **R** command)