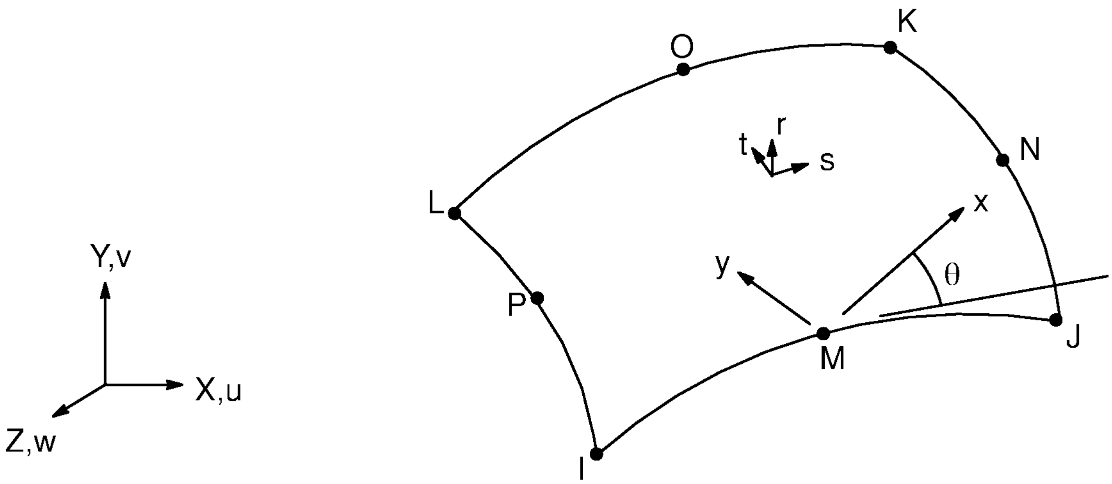
14.93 SHELL93 — 8–Node Structural Shell



Matrix or Vector	Geometry	Shape Functions	Integration Points
Stiffness Matrix	Quad	Equations (12.5.14–1), (12.5.14–2), and (12.5.14–3)	Thru–the–thickness: 2 (linear material) 5 (nonlinear material) In–plane: 2 x 2
	Triangle	Equations (12.5.5–1), (12.5.5–2), and (12.5.5–3)	Thru–the–thickness: 2 (linear material) 5 (nonlinear material) In–plane: 3
Mass Matrix	Quad	Equations (12.5.10–1), (12.5.10–2), and (12.5.10–3)	Same as stiffness matrix
	Triangle	Equations (12.5.2–1), (12.5.2–2), and (12.5.2–3)	Same as stiffness matrix
Stress Stiffness Matrix	Same as mass matrix		Same as stiffness matrix

Matrix or Vector	Geometry	Shape Functions	Integration Points
Thermal Load Vector	Same as stiffness matrix		Same as stiffness matrix
Transverse Pressure Load Vector	Quad	Equation (12.5.10–3)	2 x 2
	Triangle	Equation (12.5.2–3)	3
Edge Pressure Load Vector	Same as in–plane mass matrix, specialized to the edge		2

Load Type	Distribution
Element Temperature	Linear thru thickness, bilinear in plane of element
Nodal Temperature	Constant thru thickness, bilinear in plane of element
Pressure	Bilinear in plane of element, linear along each edge

Reference: Ahmad (1) Cook(5)

14.93.1 Other Applicable Sections

Chapter 2 describes the derivation of structural element matrices and load vectors as well as stress evaluations. Section 13.1 describes integration point locations. The mass matrix is diagonalized as described in Section 13.2.

14.93.2 Assumptions and Restrictions

Normals to the centerplane are assumed to remain straight after deformation, but not necessarily normal to the centerplane.

Each pair of integration points (in the r direction) is assumed to have the same element (material) orientation.

There is no significant stiffness associated with rotation about the element r axis. A nominal value of stiffness is present (as described with SHELL63), however, to prevent free rotation at the node.

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

14.93.3 Stress–Strain Relationships

The material property matrix [D] for the element is:

$$[D] = \begin{bmatrix} BE_x & B\nu_{xy}E_x & 0 & 0 & 0 & 0 \\ B\nu_{xy}E_x & BE_y & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & G_{xy} & 0 & 0 \\ 0 & 0 & 0 & 0 & \frac{G_{yz}}{f} & 0 \\ 0 & 0 & 0 & 0 & 0 & \frac{G_{xz}}{f} \end{bmatrix} \qquad (14.93\text{–}1)$$

where:

$B = \dfrac{E_y}{E_y - (\nu_{xy})^2 E_x}$

E_x = Young's modulus in element x direction (input as EX on **MP** command)

ν_{xy} = Poisson's ratio in element x–y plane (input as NUXY on **MP** command)

G_{xy} = shear modulus in element x–y plane (input as GXY on **MP** command)

$f = \begin{Bmatrix} 1.2 \\ 1.0 + .2 \dfrac{A}{25t^2} \end{Bmatrix}$, whichever is greater

A = element area (in s–t plane)

t = average thickness

The above definition of f is designed to avoid shear locking.

14.93.4 Stress Output

The stresses at the center of the element are computed by taking the average of the four integration points on that plane. See Section 13.6 for more details.

The output forces and moments are computed as described in Section 2.3.