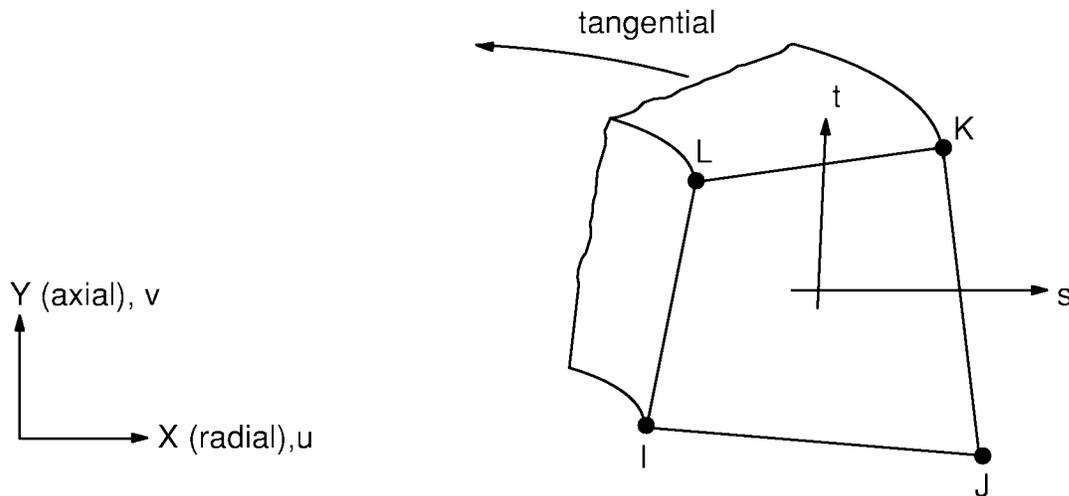# 14.25   PLANE25 — 4–Node Axisymmetric–Harmonic Structural Solid

Matrix or Vector	Geometry	Shape Functions	Integration Points
Stiffness Matrix	Quad	Equations (12.7.5–1), (12.7.5–2), and (12.7.5–3) or if modified extra shape functions are included (KEYOPT(2) = 0) and element has 4 unique nodes. Equations (12.7.6–1), (12.7.6–2), and (12.7.6–3)	2 x 2
Stiffness Matrix	Triangle	Equations (12.7.1–1), (12.7.1–2), and (12.7.1–3)	3

Matrix or Vector	Geometry	Shape Functions	Integration Points
Mass Matrix	Quad	Equation (12.6.5–1), (12.6.5–2), and (12.6.5–3)	2 x 2
	Triangle	Equation (12.6.1–1), (12.6.1–2), and (12.6.1–3)	3
Stress Stiffness Matrix	Quad	Equation (12.7.5–1), (12.7.5–2), and (12.7.5–3)	2 x 2
	Triangle	Equation (12.7.1–1), (12.7.1–2), and (12.7.1–3)	3
Thermal Load Vector	Same as stiffness matrix		Same as stiffness matrix
Pressure Load Vector	Same as stress stiffness matrix, specialized to the surface		2

Load Type	Distribution
Element Temperature	Bilinear across element, harmonic around circumference
Nodal Temperature	Bilinear across element, harmonic around circumference
Pressure	Linear along each face, harmonic around circumference

Reference: Wilson(38), Zienkiewicz(39), Taylor(49)

14.25.1   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.

14.25.2   Assumptions and Restrictions

The material properties are assumed to be constant around the entire circumference, regardless of temperature dependent material properties or loading. For MODE > 0,

the extreme values for combined stresses are obtained by computing these stresses at every 10/MODE degrees and selecting the extreme values.

14.25.3   Use of Temperature

In general, temperatures have two effects on a stress analysis:

1. Temperature dependent material properties.

2. Thermal expansion

In the case of MODE = 0, there is no conflict between these two effects. However, if MODE > 0, questions arise. As stated in the assumptions, the material properties may not vary around the circumference, regardless of the temperature. That is, one side cannot be soft and the other side hard. The input temperature for MODE > 0 varies sinusoidally around the circumference. As no other temperatures are available to the element, the material properties are evaluated at T_{ref} (input on **TREF** command). The input temperature can therefore be used to model thermal bending. An approximate application of this would be a chimney subjected to solar heating on one side only. A variant on this basic procedure is provided by the temperature KEYOPT (KEYOPT(3) for PLANE25). This variant provides that the input temperatures be used only for material property evaluation rather than for thermal bending. This second case requires that α_x, α_y, and α_z (input on **MP** commands) all be input as zero. An application of the latter case is a chimney, which is very hot at the bottom and relatively cool at the top, subjected to a wind load.