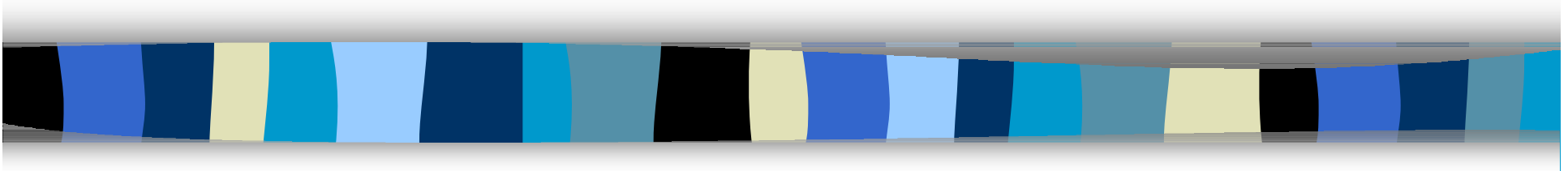


# Bolted Joints Analysis with ANSYS Application



BOSC

# Outline of Presentation

- n Bolted lap joints FEM considerations
- n Contact analysis introduction
- n FEM analysis
- n Conclusions
- n Problems to be solved





# Bolted Lap Joints FEM Considerations

- n Bolt idealization
- n Stress area of bolts
- n Contact pressure/stress of joints
- n Strength of bolts
- n External forces
- n Creep
- n Vibration loosening
- n Fatigue corrosion



# Contact Analysis Introduction



# Contact Algorithm

## n Pure lagrange multipliers method

- Near zero penetration and slip, no contact stiffness
- More DOF, over constraint, chattering
- Solver issue: PCG, impact, eigenvalue buckling

## n Augmented lagrange method

- Less expensive, more robust
- Contact element superposition
- Less accurate, ill condition if too big contact stiffness

## n Lagrange multiplier on normal & penalty on tangent

- Behaviors between above two

# Contact Capabilities

	Node-to-Node			Node-to-Surface	Surface-to-Surface	
	CONTAC 12	CONTAC 52	CONTA 178	CONTA 175, TARGET 169, 170	CONTA 171,172 TARGET 169	CONTA 173,174 TARGET 170
Point-to-Point	Y	Y	Y			
Point-to-Surface				Y		
Surface-to-Surface				Y	Y	Y
2-D	Y		Y	Y	Y	
3-D		Y	Y	Y		Y
Sliding	small	small	small	large	large	large
Cylindrical Gap	Y		Y			
Pure Lagrange Multiplier			Y	Y	Y	Y
Augmented Lagrange Multiplier			Y	Y	Y	Y
Lagrange Multiplier on Normal and Penalty on Tangent			Y	Y	Y	Y
Internal Multipoint Constraint (MPC)				Y	Y	Y
Contact Stiffness	user- defined	user- defined	semi-automatic	semi-automatic	semi-automatic	semi-automatic
Auto-meshing Tools	<u>EINTF</u>	<u>EINTF</u>	<u>EINTF</u>	<u>ESURE</u>	<u>ESURE</u>	<u>ESURE</u>
Lower-Order	Y	Y	Y	Y	Y	Y
Higher- Order				Y (2-D only)	Y	Y
Rigid-Flexible	Y	Y	Y	Y	Y	Y
Flexible- Flexible	Y	Y	Y	Y	Y	Y
Thermal Contact				Y	Y	Y
Electric Contact				Y	Y	Y
Magnetic Contact				Y	Y	Y

# Contact Pair Basic Concept

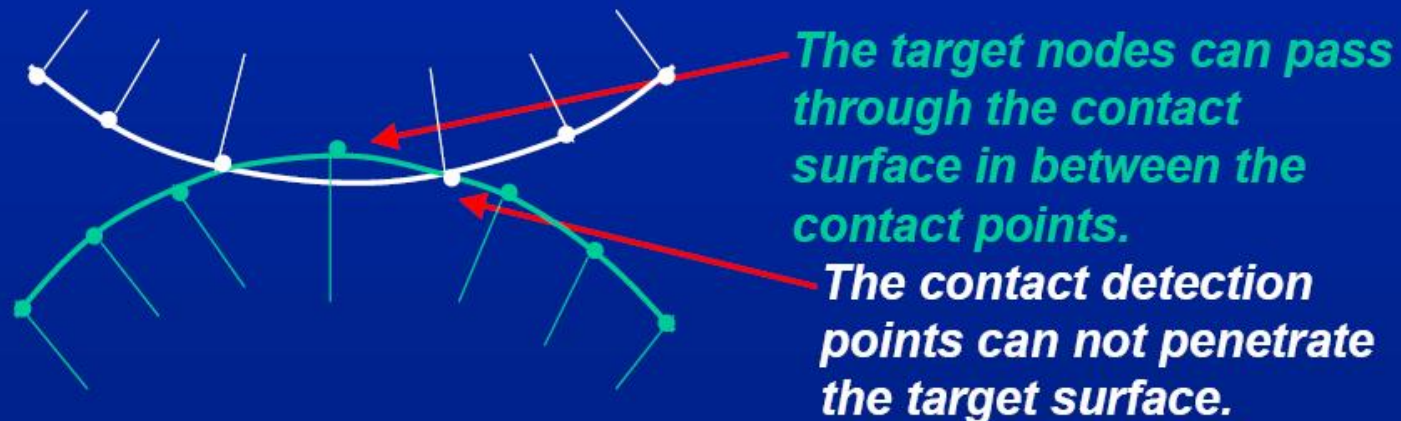
**Target (master) surface - a continuous surface**

**Contact (slave) surface**

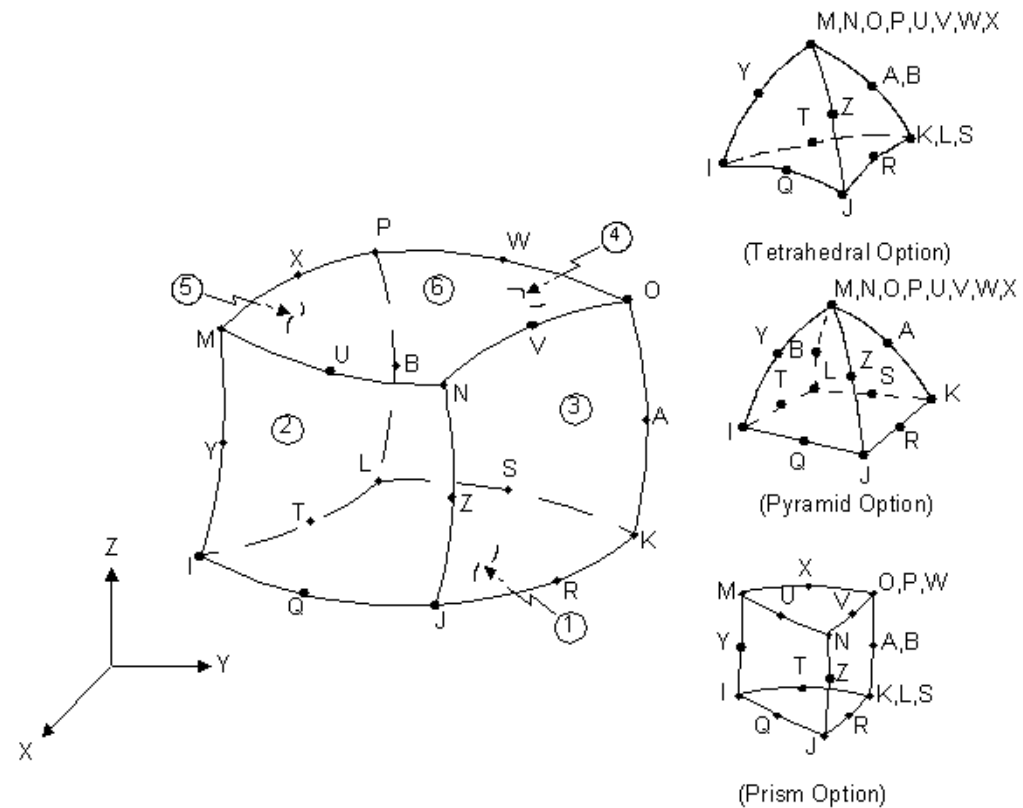
- A set of discrete contact nodes
- Contact constraint equation

**Symmetric (two pass) contact**

- Difficulty of contact pressure interpretation
- Overconstraint of the model



# 3D Elements—Solid95 (1)



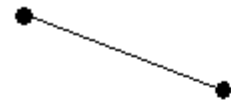




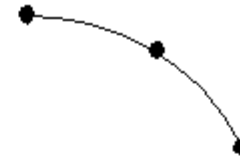
## 3D Elements—Solid95 (2)

- n 3D-20 nodes
- n Higher order element (contrast Solid45)
- n Can tolerate irregular shapes
- n Have compatible displacement shapes
- n Well suited to model curved boundaries
- n Suitable for plasticity, creep, stress stiffening, large deflection, and large strain analysis

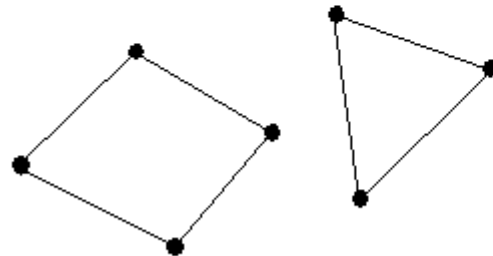
# Surface to Surface Elements



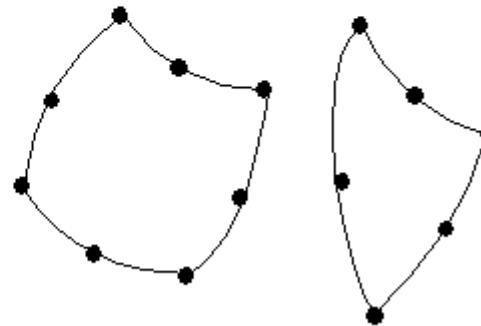
CONTA171



CONTA172



CONTA173



CONTA174