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MEMORANDUM FOR PRS (In-House Publication)

FROM: PROI (STINFO) 27 June 2002

SUBJECT: Authorization for Release of Technical Information, Control Number: **AFRL-PR-ED-VG-2002-166**
C.T. Liu (PRSM), "Investigating the Constraint Effect in a Particulate Composite Material" (viewgraphs)

ASME Pressure Vessel Technology Meeting **(Statement A)**
(Vancouver, Canada, 7-9 August 2002) (Deadline: 30 July 2002)

1. This request has been reviewed by the Foreign Disclosure Office for: a.) appropriateness of distribution statement, b.) military/national critical technology, c.) export controls or distribution restrictions, d.) appropriateness for release to a foreign nation, and e.) technical sensitivity and/or economic sensitivity.
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PHILIP A. KESSEL Date
Technical Advisor
Space and Missile Propulsion Division

Investigating the Constraint Effect in a Particulate Composite Material

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Objectives

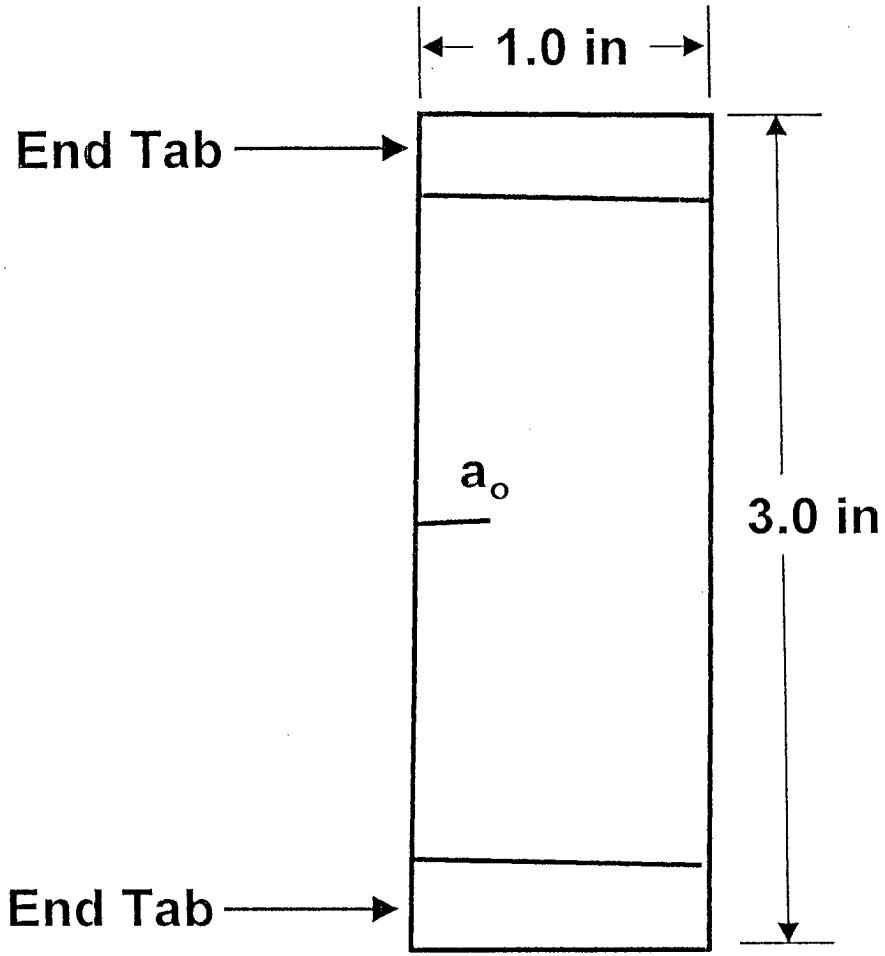
- Investigate the Constraint Effect on the Critical Stress Intensity Factor, K_{Ii}, for the Onset of Crack Growth in a Particulate Composite Material
  - Specimen Thickness: 0.2 in., 0.5 in., 1.0 in., 1.5 in.

- Initial Crack Length: 0.2 in., 0.3 in., 0.4 in.

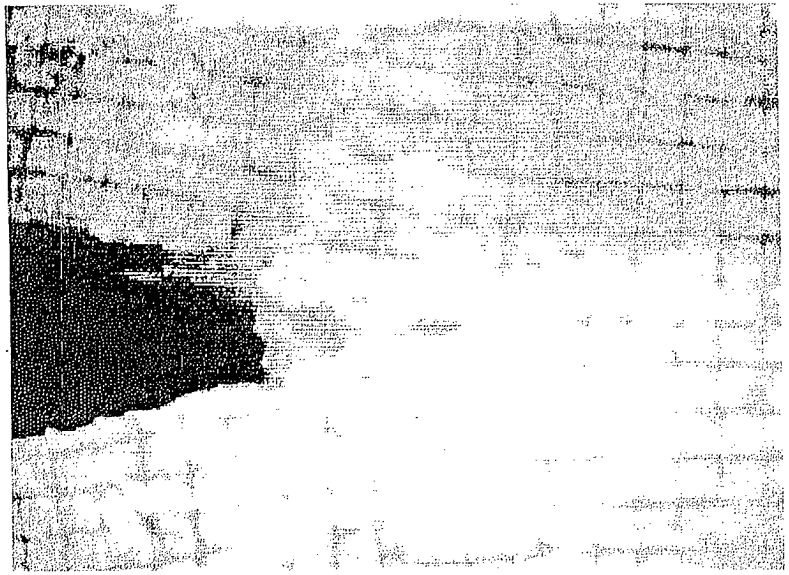
Conclusions

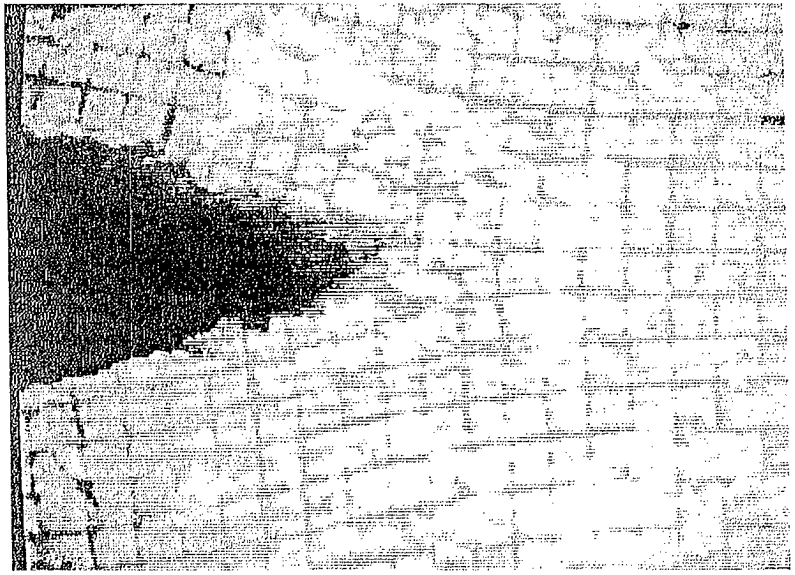
- Experimental findings indicate that, on the first approximation, K_{Ii} is independent of specimen thickness and initial crack length for the cases considered in this study.
- Due to the development of damage at the crack tip, the constraint is minimized at the crack tip and the Poisson's effect is negligible.
- For the particulate composite material under investigation, the plane-strain fracture toughness does not exist

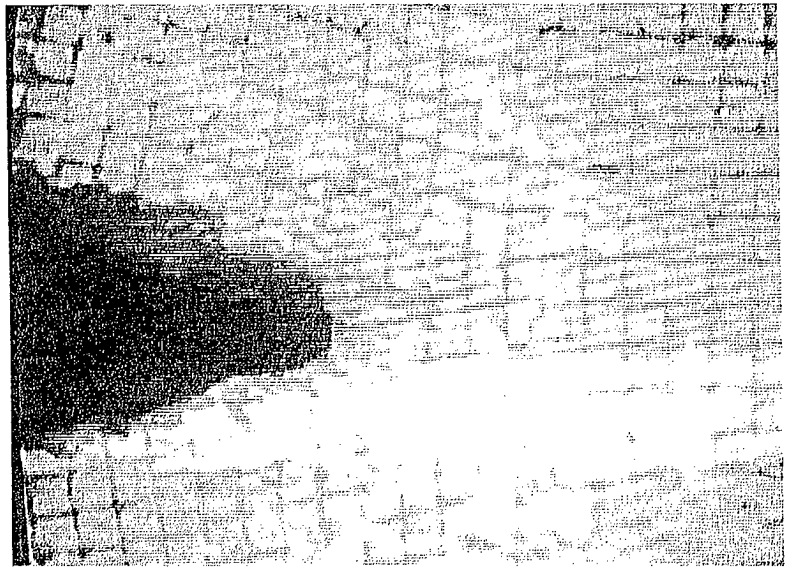
Specimen Geometry



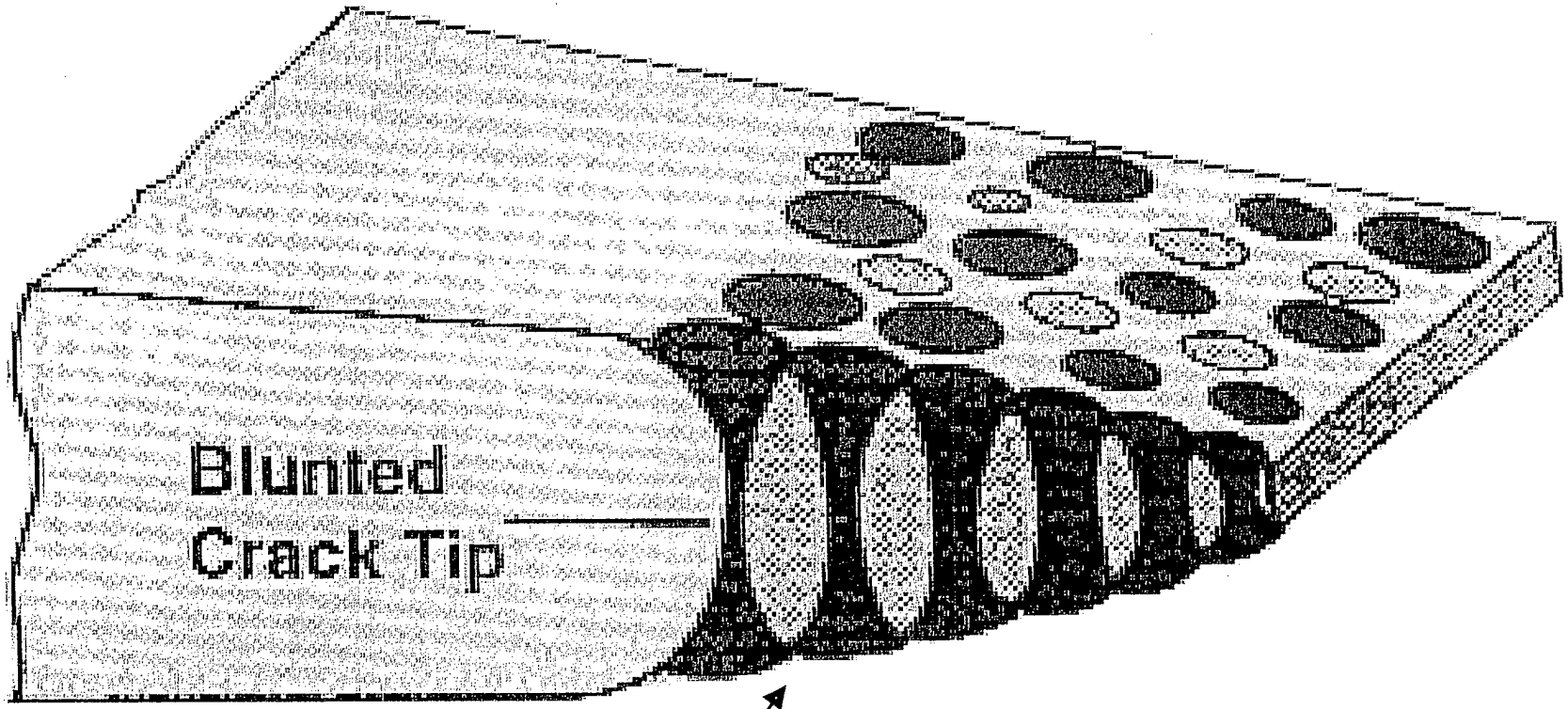
Crack Tip Profiles
(crosshead speed = 0.508 mm/min)





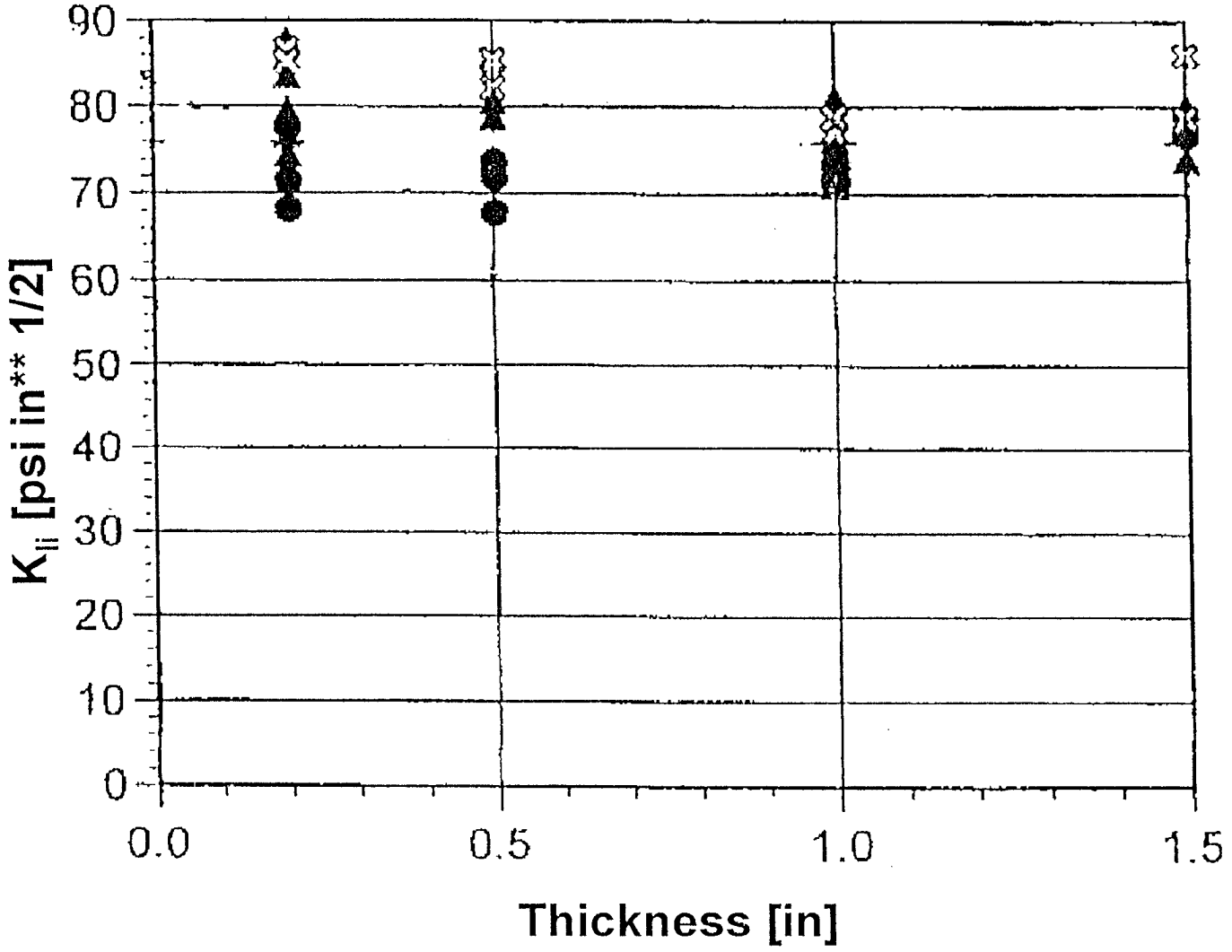


Crack Tip Damage Model

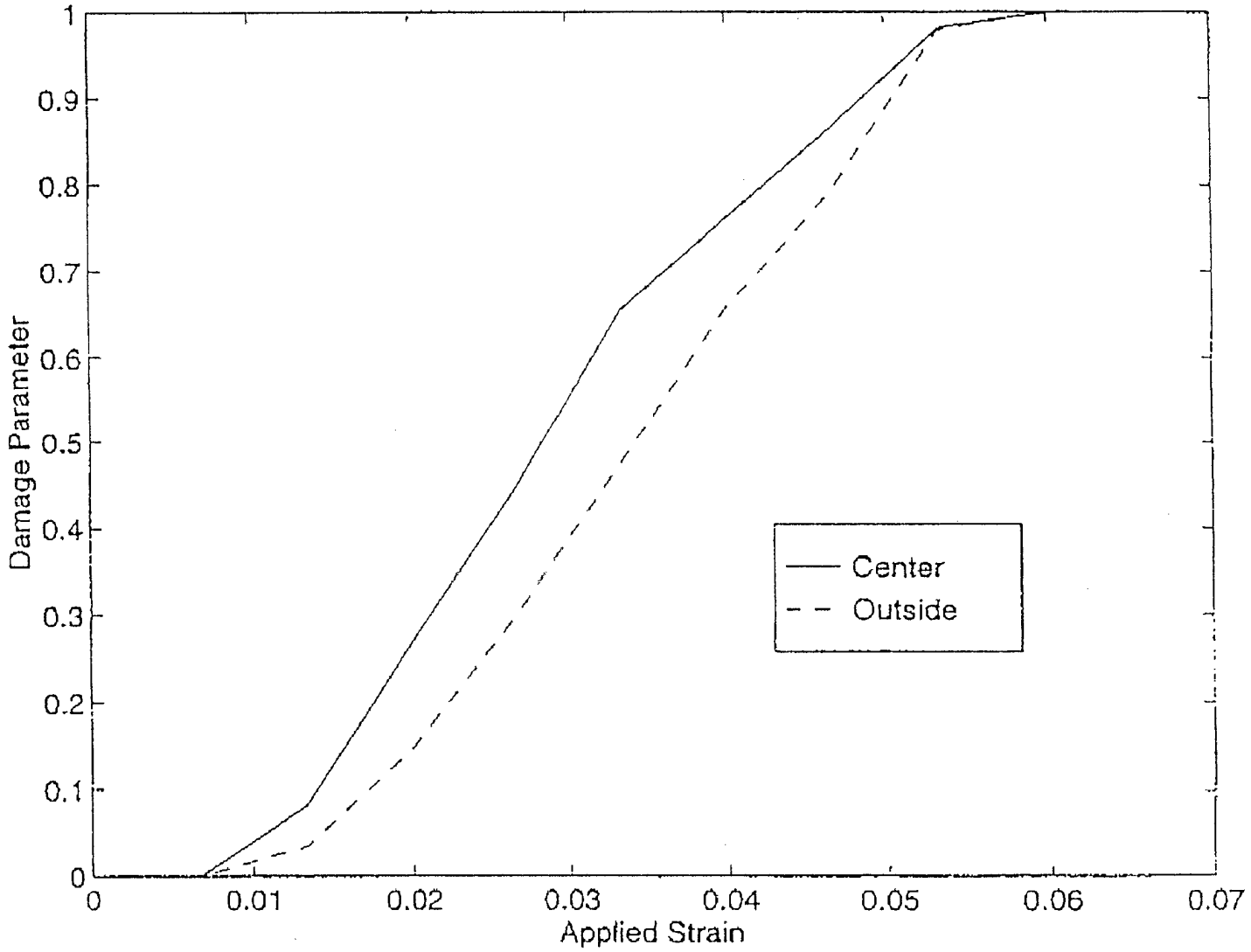


Highly Damaged Zone

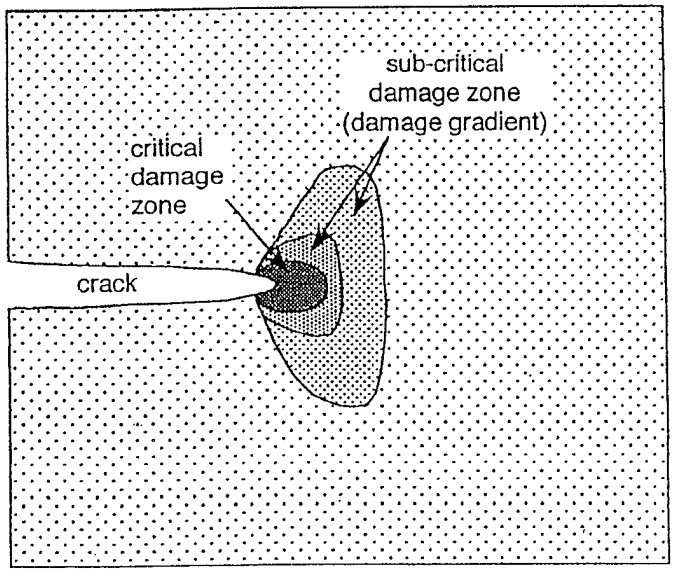
Mode I Stress Intensity Factor vs. Specimen Thickness. (Ambient Pressure)

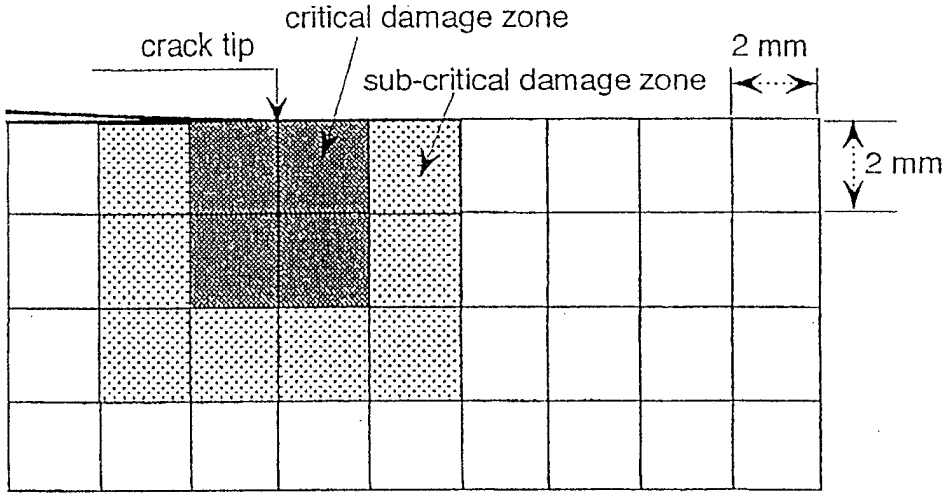


Damage Distribution near the Center and the Surface of the Specimen



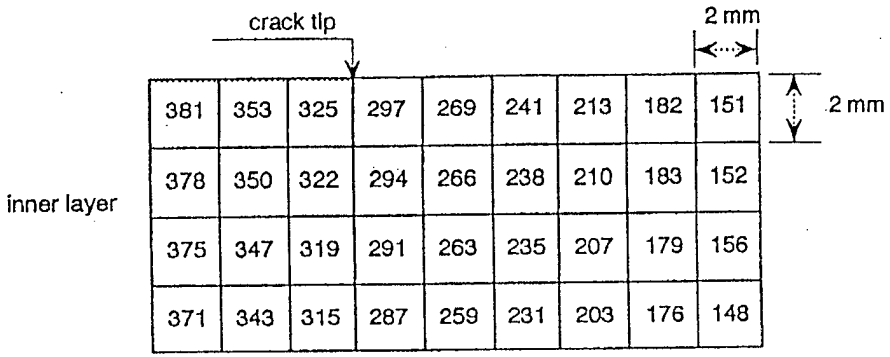
Finite Element Model

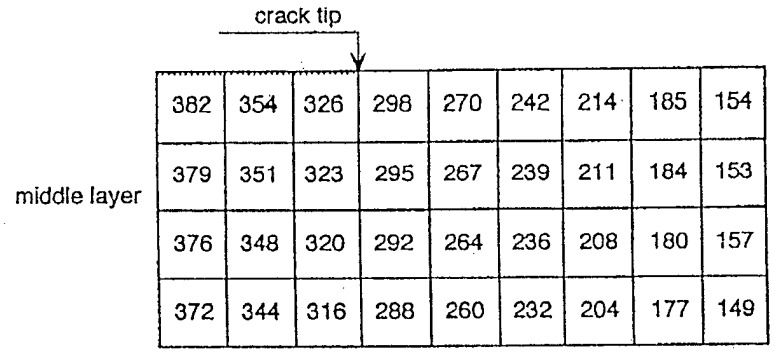


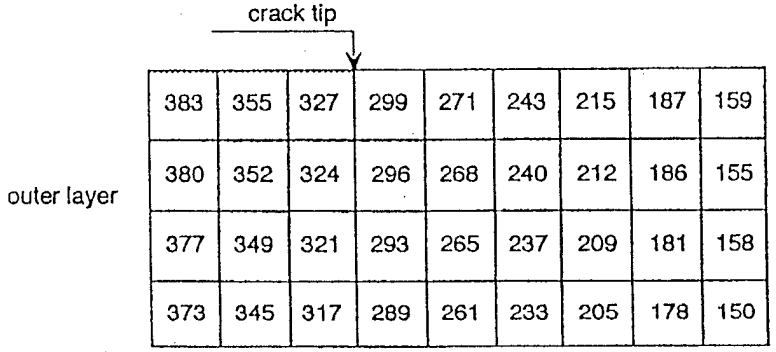


FEM mesh at crack tip

Finite Element Models of the Three Layers of the Analyzed Specimen





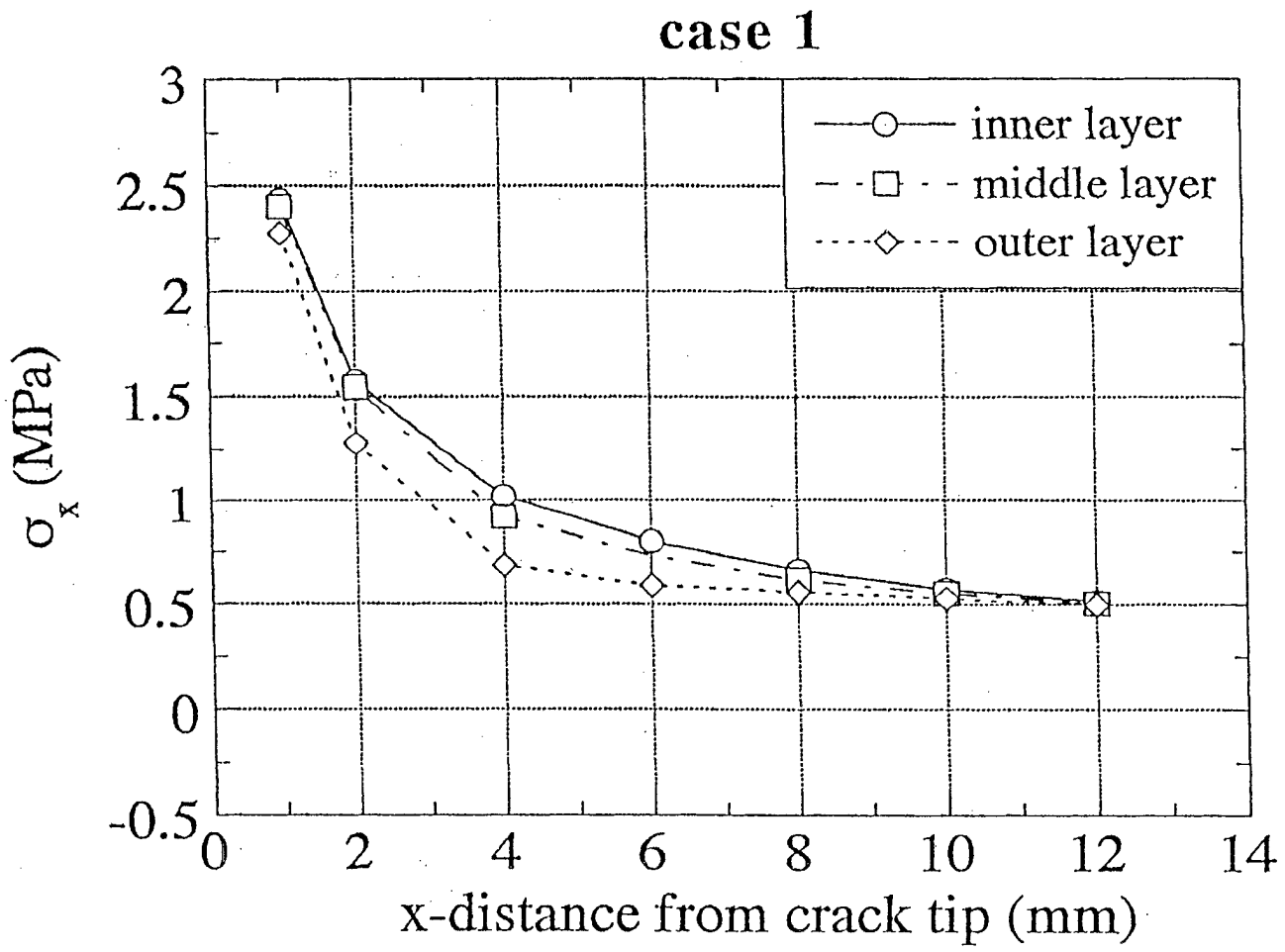


Summary of Crack-damage Interaction Analysis

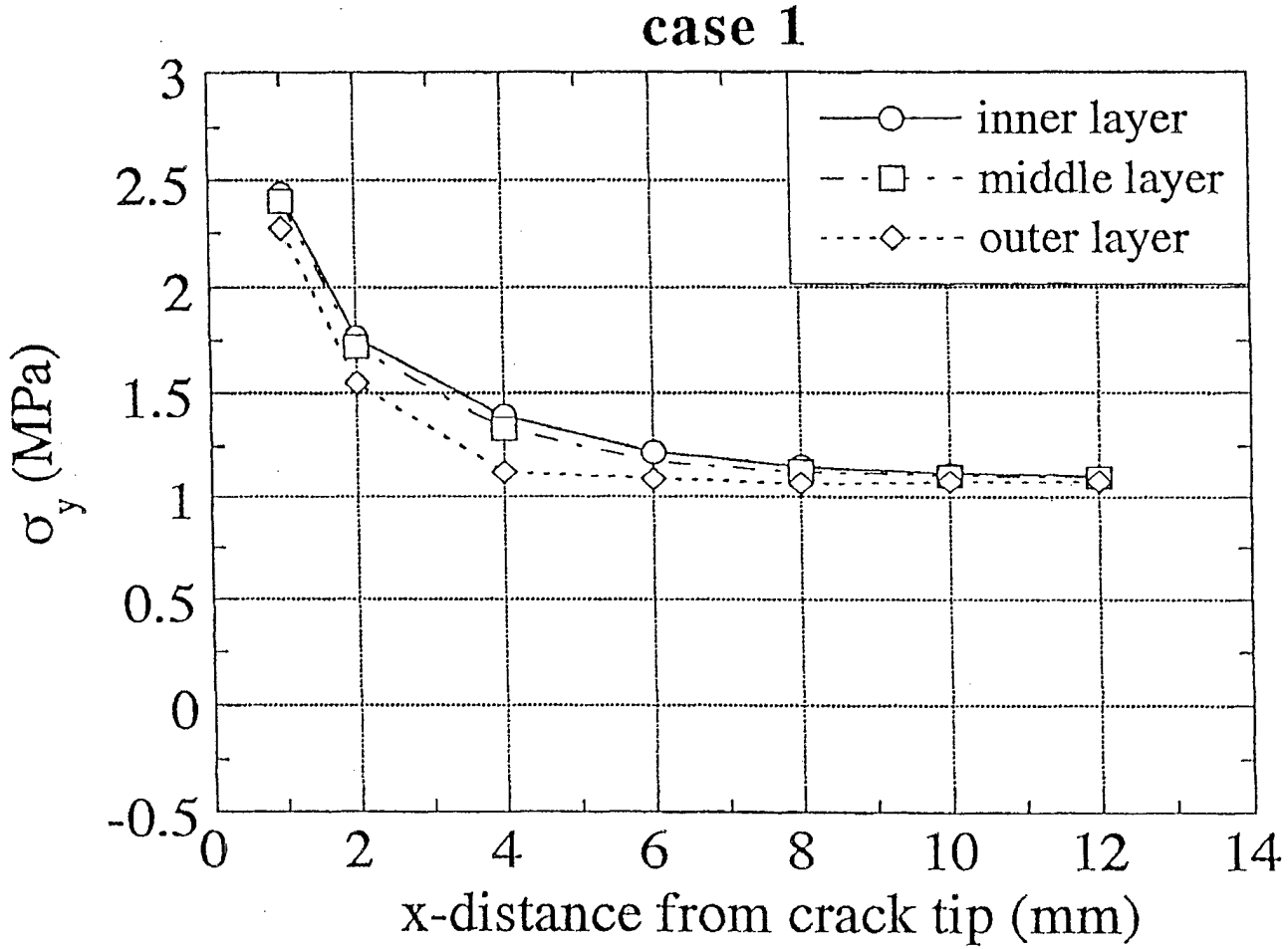
case	damage element	damage element modulus MPa (psi)	Poisson's ratio	inside layer K_I MPa-cm$^{0.5}$	middle layer K_I MPa-cm$^{0.5}$	outside layer K_I MPa-cm$^{0.5}$
thin*	none	0.414 (60)	0.4999	1.871	-	-
1	none	-	0.4999	1.931	1.903	1.802
2	325, 297	0.414 (60)	0.4999	0.422	2.246	1.871
3	325, 297 326, 298	0.414 (60)	0.4999	0.535	0.440	2.208
4	325, 297 326, 298 327, 299	0.414 (60)	0.4999	0.573	0.524	0.455
5	325, 297, 322, 294	0.414 (60)	0.4999	0.392	2.285	1.906
6	325, 297, 322, 294 326, 298, 323, 295 327, 299, 324, 296	0.414 (60)	0.4999	0.522	0.497	0.432
7	325, 297, 322, 294 326, 298, 323, 295 327, 299, 324, 296 353, 350 ,347, 319 291, 263, 266, 269 354, 351, 349, 320 292, 264, 267, 270 355, 352, 349, 321 293, 265, 268, 271	0.414 (60) 0.828 (120)	0.4999 0.4999	0.546	0.514	0.442
8	325, 297, 322, 294 326, 298, 323, 295 327, 299, 324, 296	0.414 (60)	0.1	0.336	0.339	0.342

* thin specimen, specimen thickness = 0.508 cm.

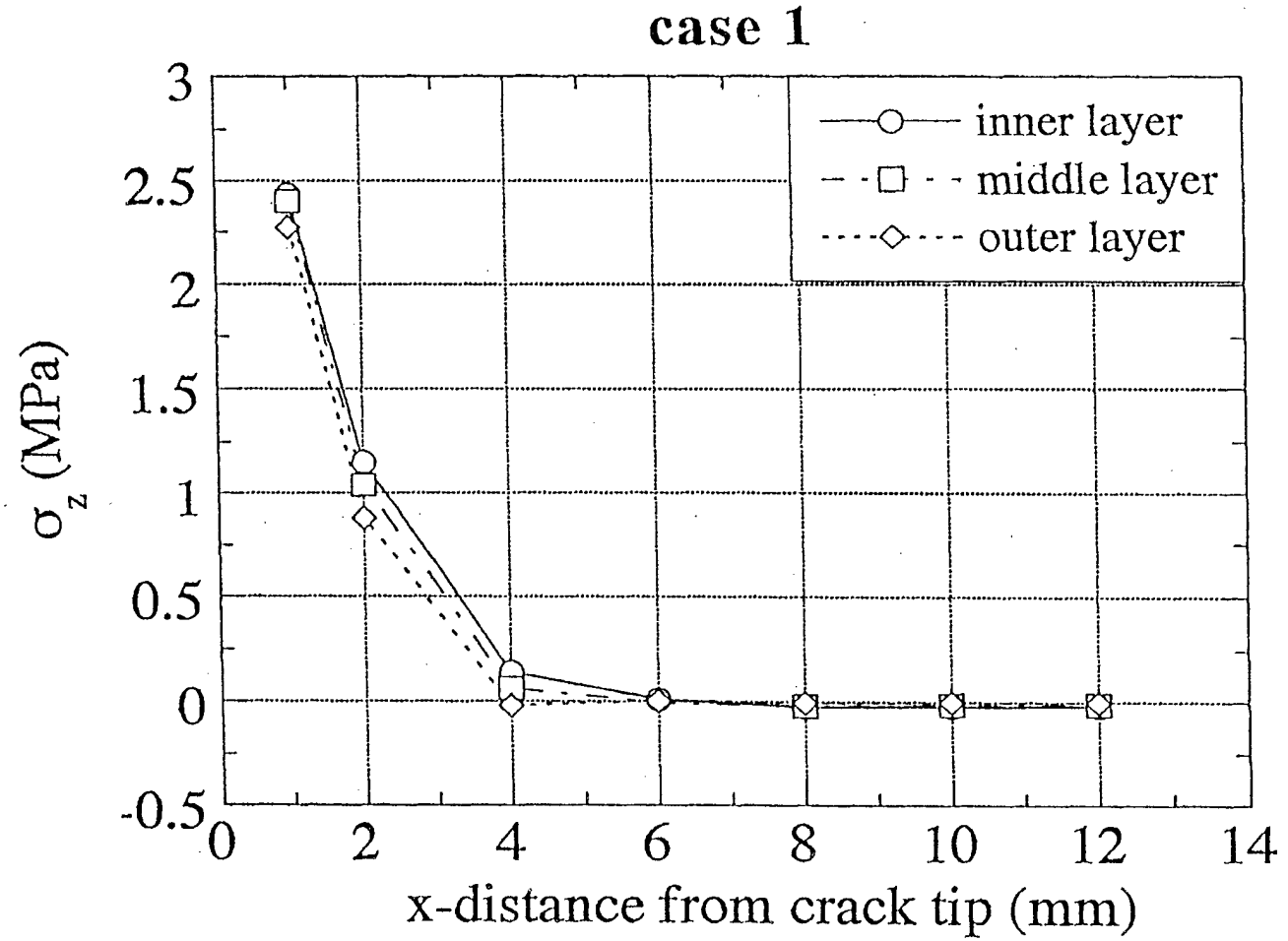
Stress Distributions in the Horizontal Direction



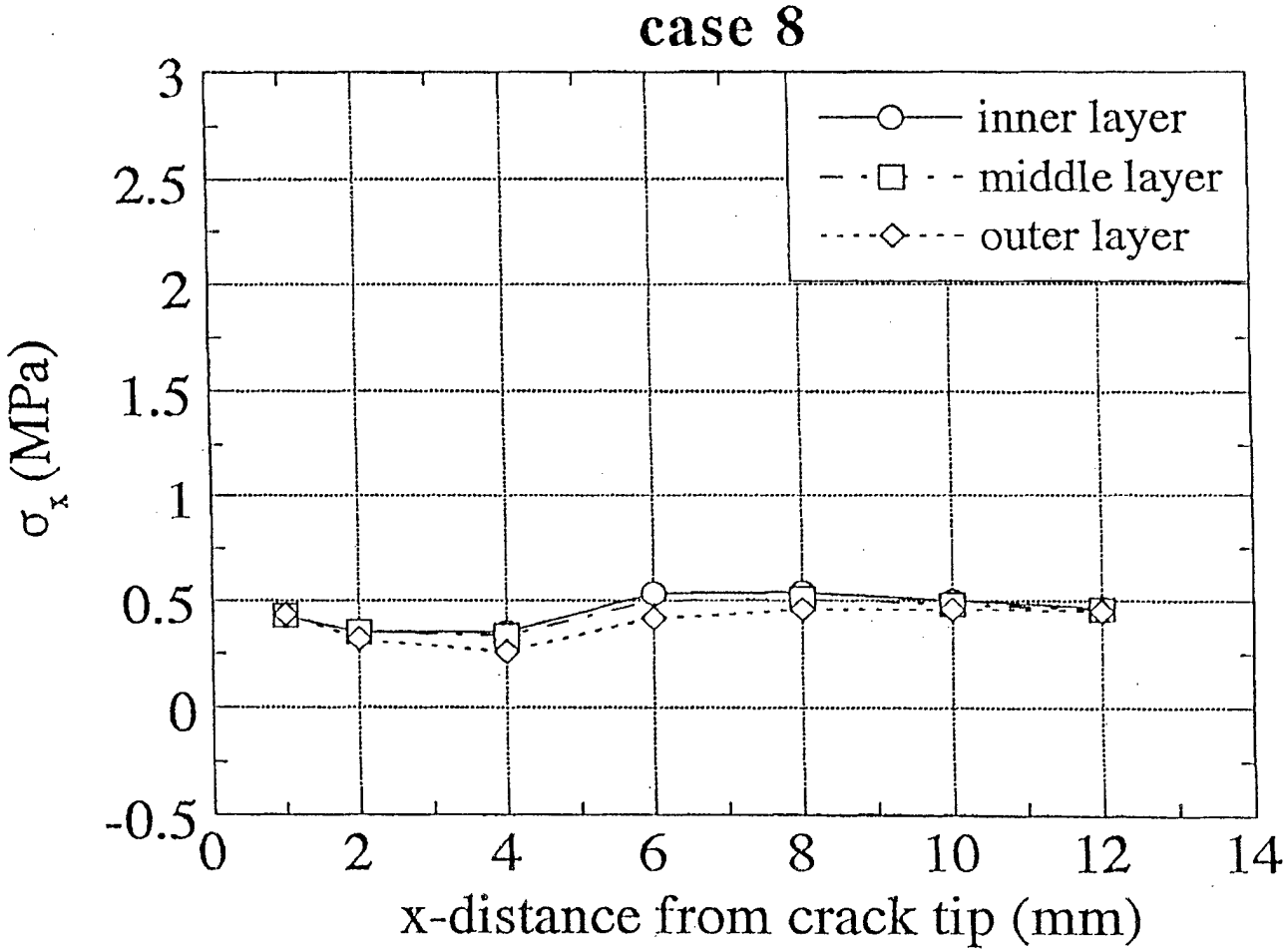
Stress Distributions in the Vertical Direction



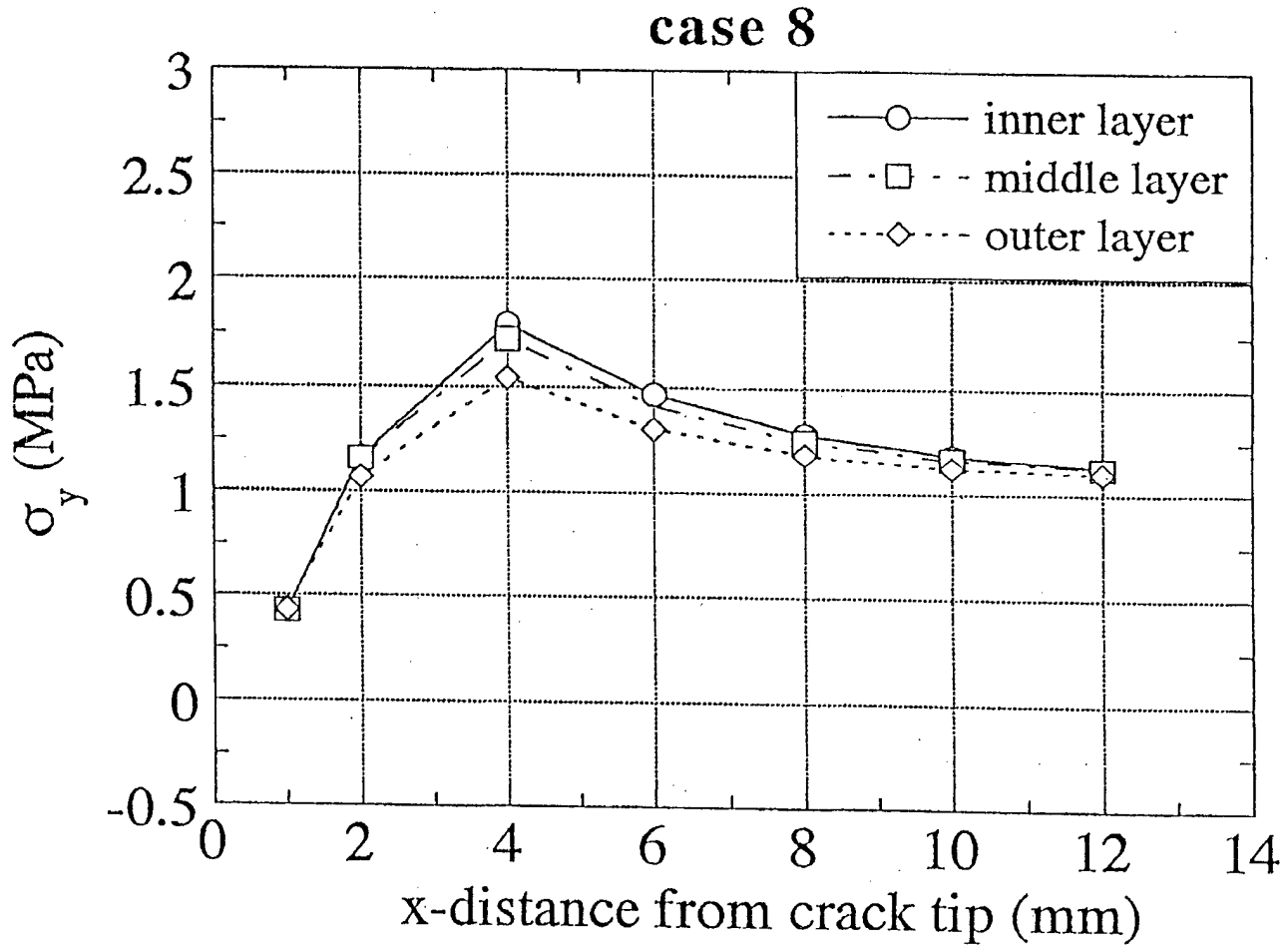
Stress Distributions in the Thickness Direction



Stress Distributions in the Horizontal Direction



Stress Distributions in the Vertical Direction



Stress Distributions in the Thickness Direction