Ogden Air Logistics Center

U.S. AIR FORCE

Comparison of Advanced Continuing Damage Model & Classic Single Edge Through Crack Model

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- James A. Harter, AFRL/VASM
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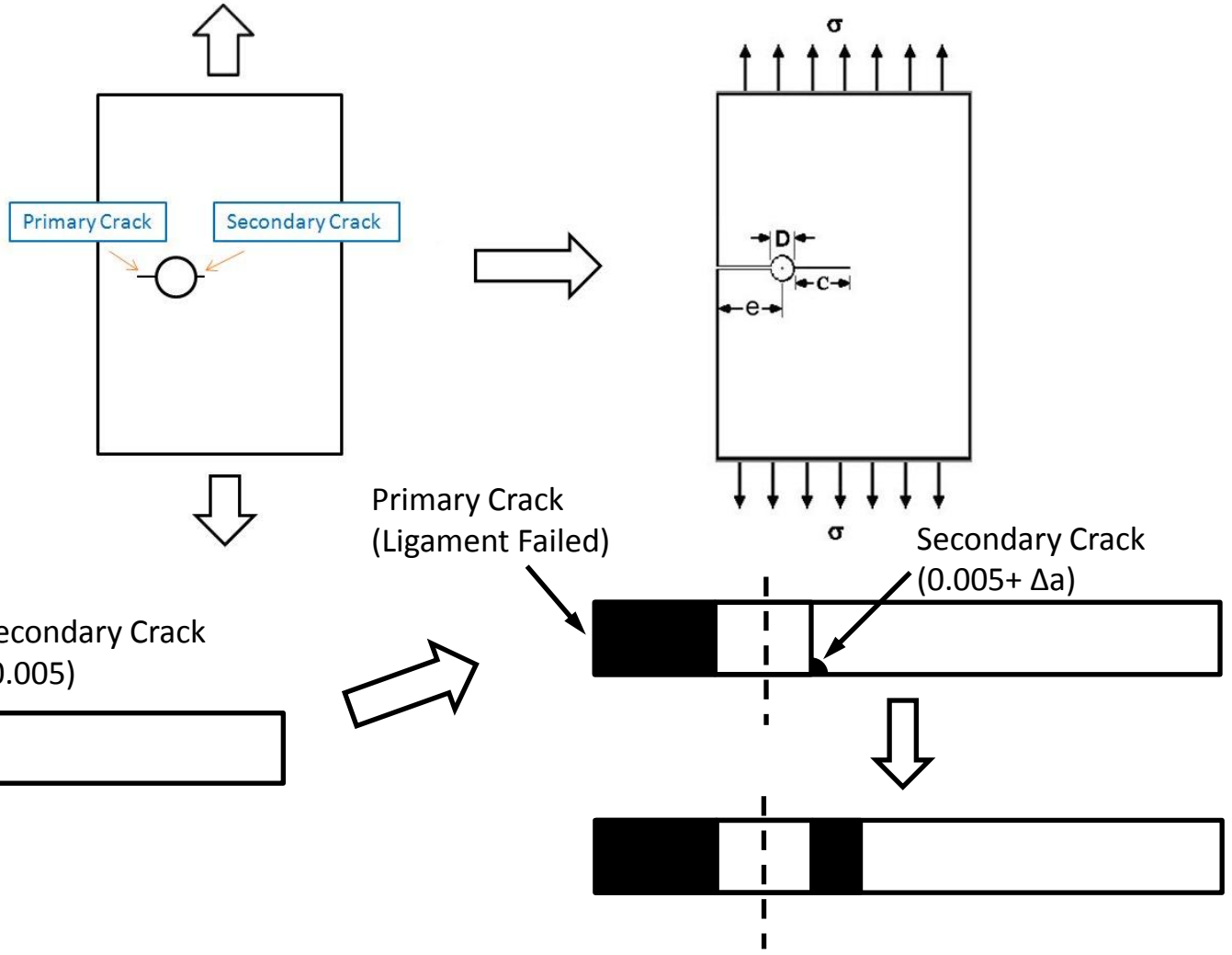
- A-10 ASIP Group

Overview

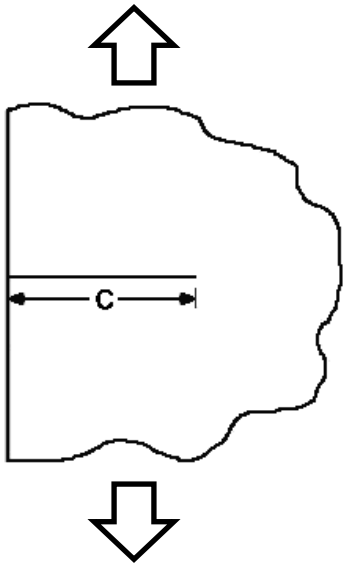
- AFGROW Models
  - Advanced Continuing Damage Model
  - Classic Single Edge Through Crack
- In Plane Bending
- K Solution Comparisons
- FEM Constraints
- Conclusions and Recommendations

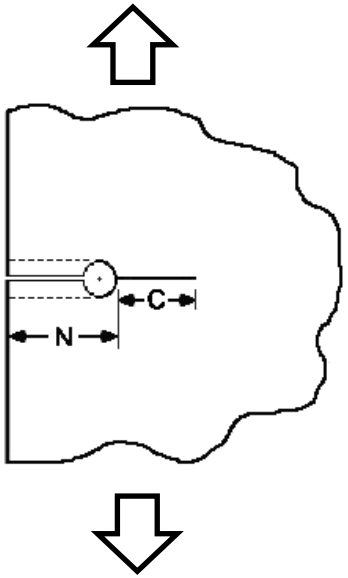
Continuing Damage



Equivalent Edge Crack Solution

Solution for Continuing Damage Model converges with
Edge Crack Solution when C ≥ Hole Radius
(Semi-Infinite Plate)





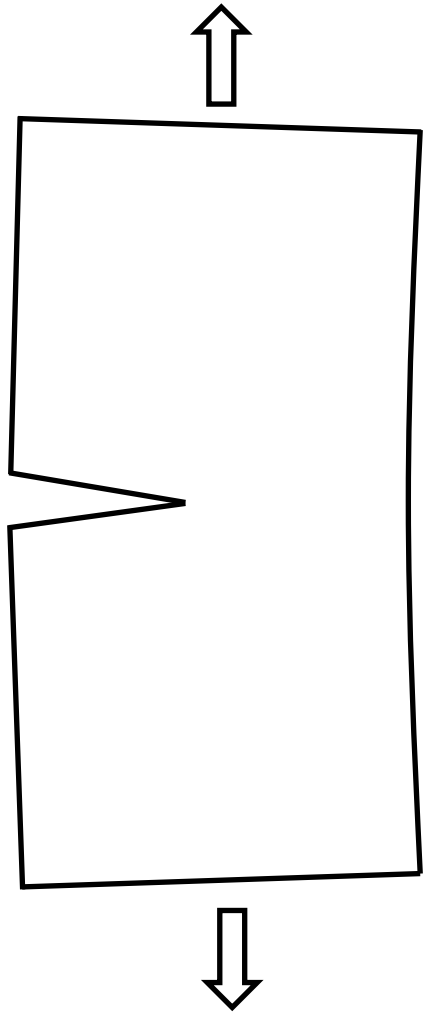
$$K = \sigma \sqrt{\pi C}\, \beta$$

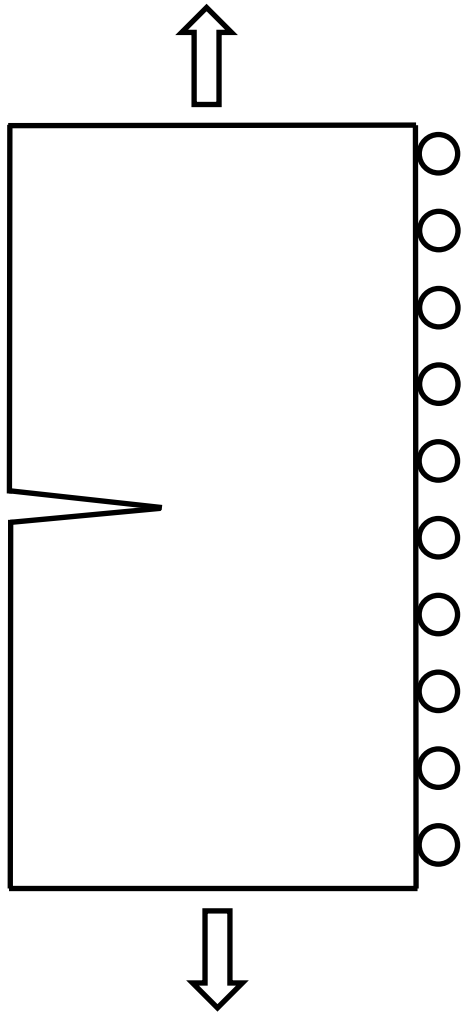
$$\beta = 1.1221$$

$$\sigma \sqrt{\pi\,(C+N)}\,(1.1221) = \sigma \sqrt{\pi\, C}\, \beta$$

$$\beta = \frac{1.1221}{\sqrt{C/(C+N)}}$$

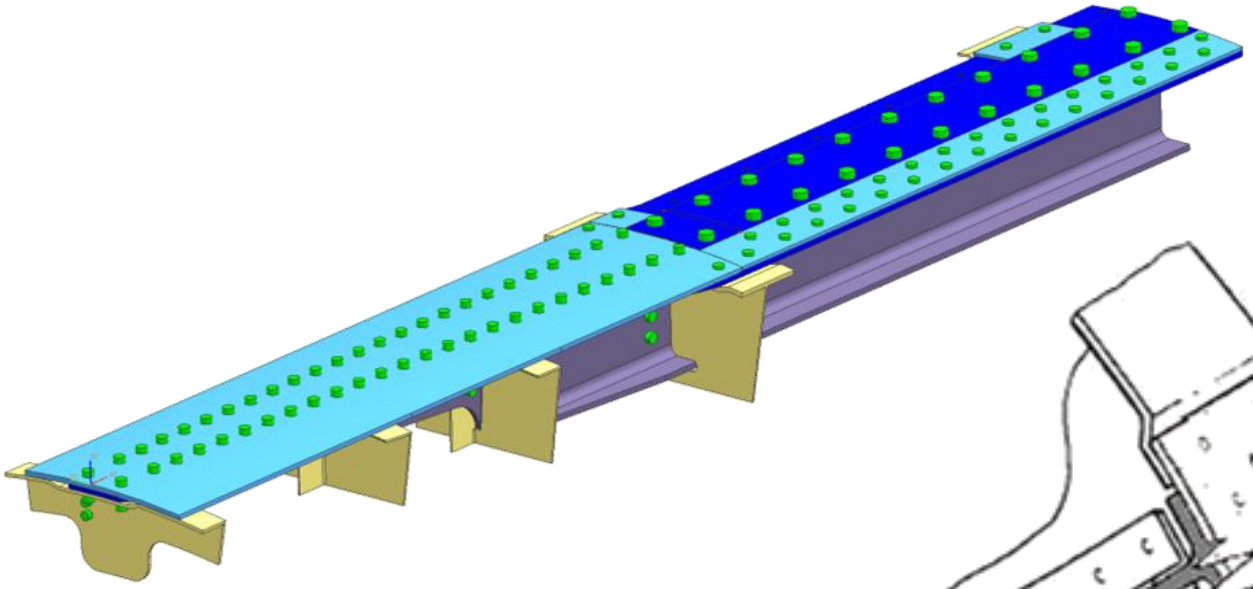
Finite Width Plates
In Plane Bending

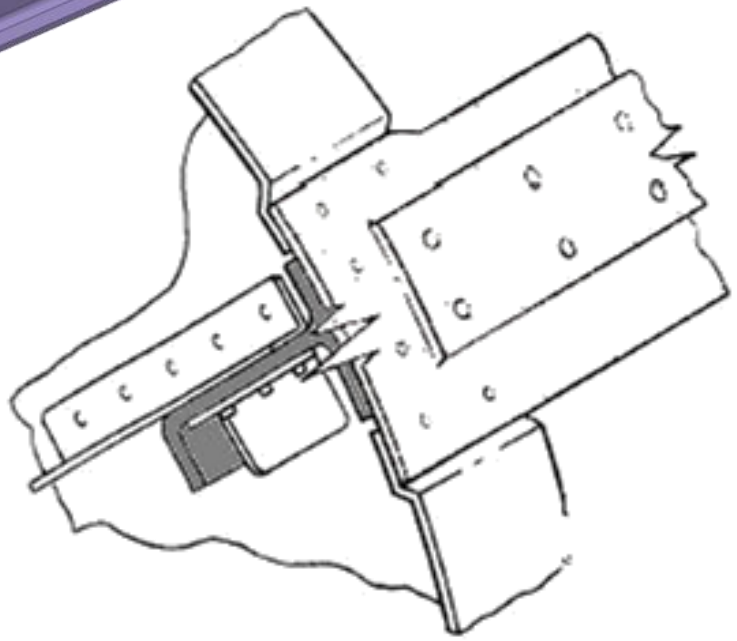




In Plane Bending Constraint

Built Up Structure on Aircraft



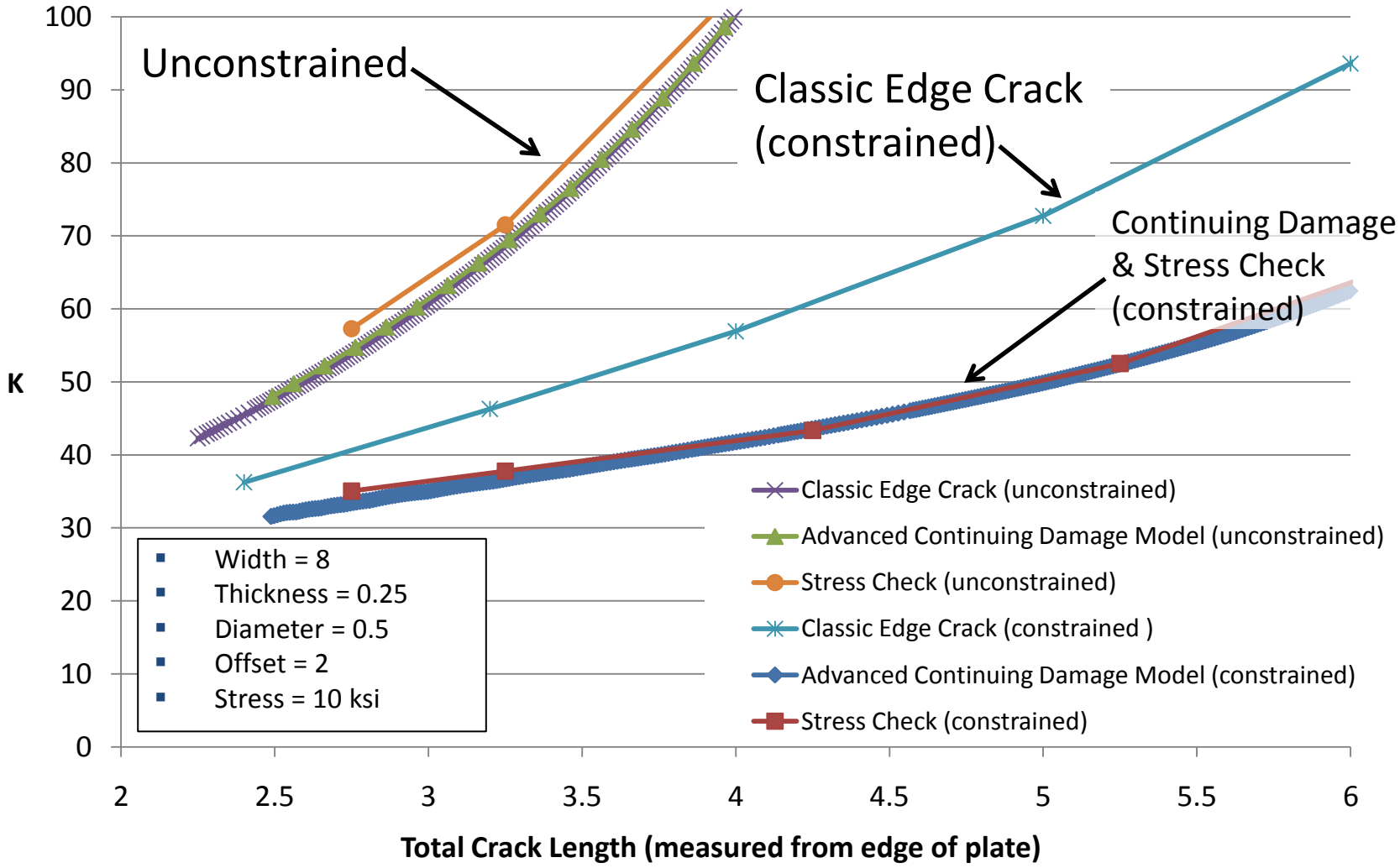


Stress Intensity Solutions

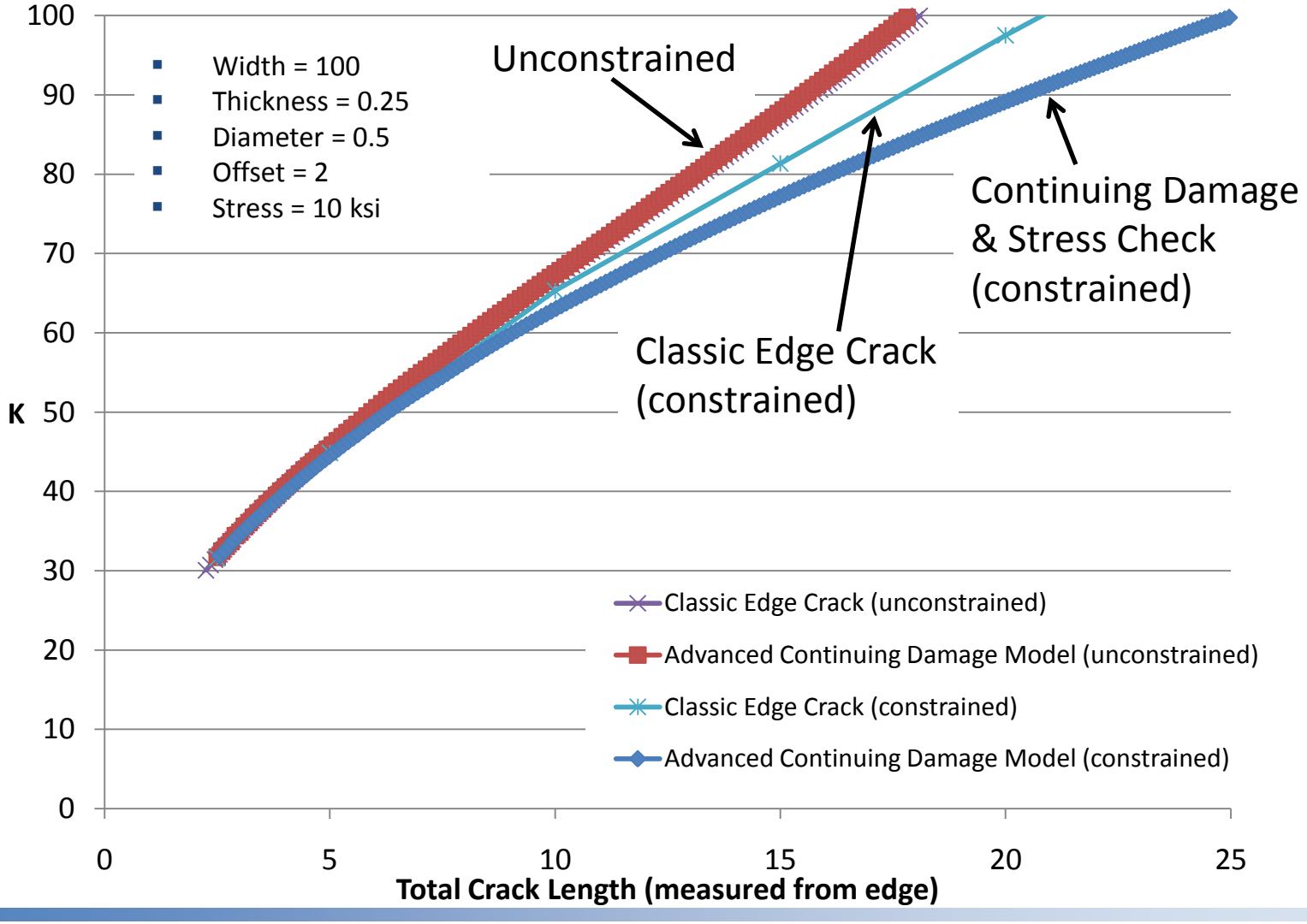
Model	In Plane Bending Constrained ?	Solution Source	Ref
Advanced Continuing Damage	X	FEM (ABAQUS w/ FRANC3D/NG)	Harter
Classic Single Edge Through Crack	X	FEM (FRANC2D)	Taluk
Advanced Continuing Damage		FEM (ABAQUS w/ FRANC3D/NG)	Harter
Classic Single Edge Through Crack		??	Tada, Paris, Irwin

References:
-Harter, James A, AFRL/VASM, 2009
-Taluk, Deviprasad, Eagle Aeronautics, Inc., 1998
-Tada, H., Paris, P.C., and Irwin, G.R., "The Stress Analysis of Cracks Handbook," Second Edition, p. 2.11, Paris Productions, Inc., St Louis, MO, 1985

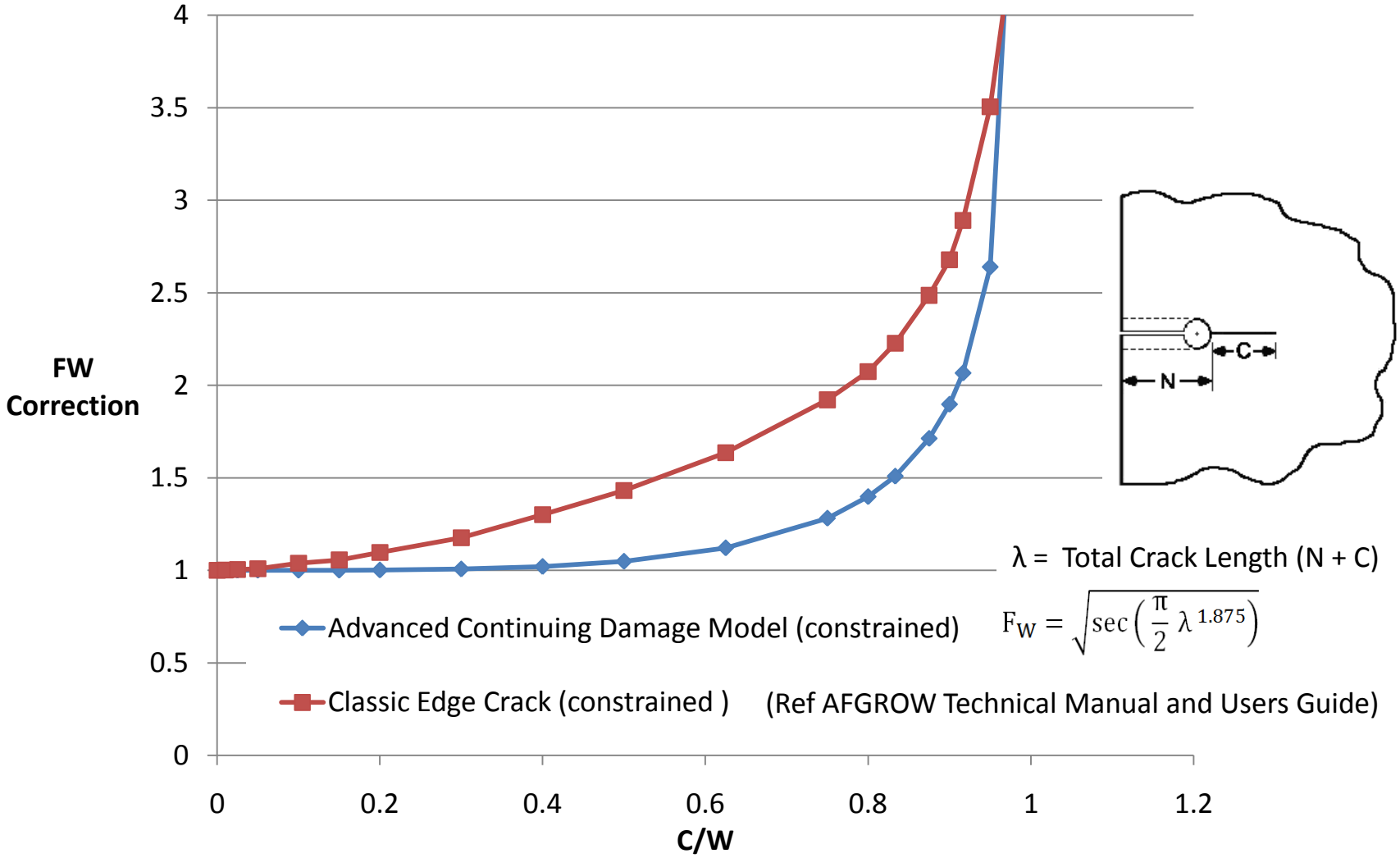
AFGROW Finite Width Plate K Solutions



AFGROW Large Width Plate K Solutions



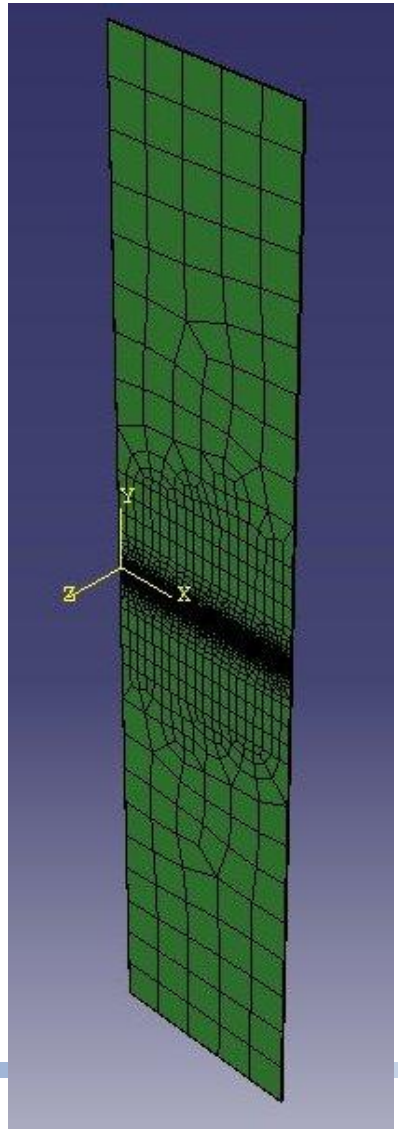
Finite Width Correction

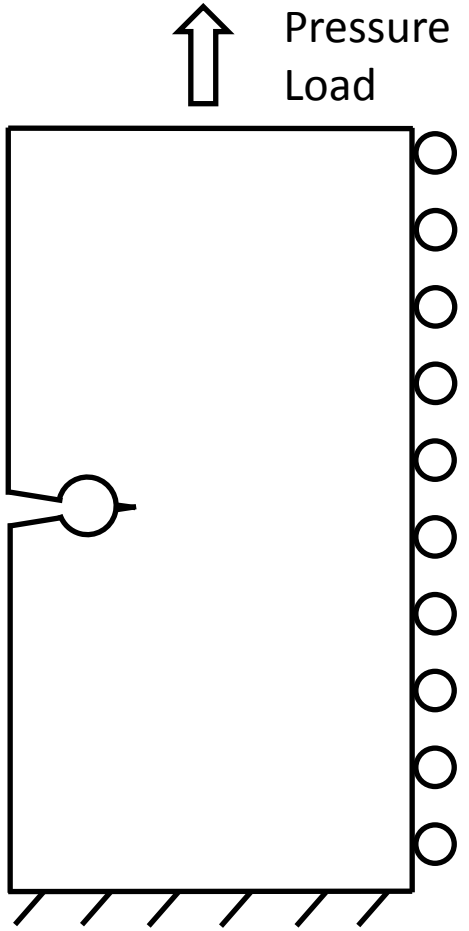


Continuing Damage FEM Constraints

- FEM:
  - ABAQUS w/FRANC3D/NG
- Dimensions
  - Width = 100 * N
  - Thickness = 1
  - Total Height = 500 * N
- Loading
  - Top Edge: Pressure Load
- Boundary Conditions:
  - Bottom Edge: Fixed in Y-Dir
  - Bottom Edge: Mid-Plane in Z-Dir
  - Right Edge: Fixed in X-Dir (Counteracts In-Plane Bending)

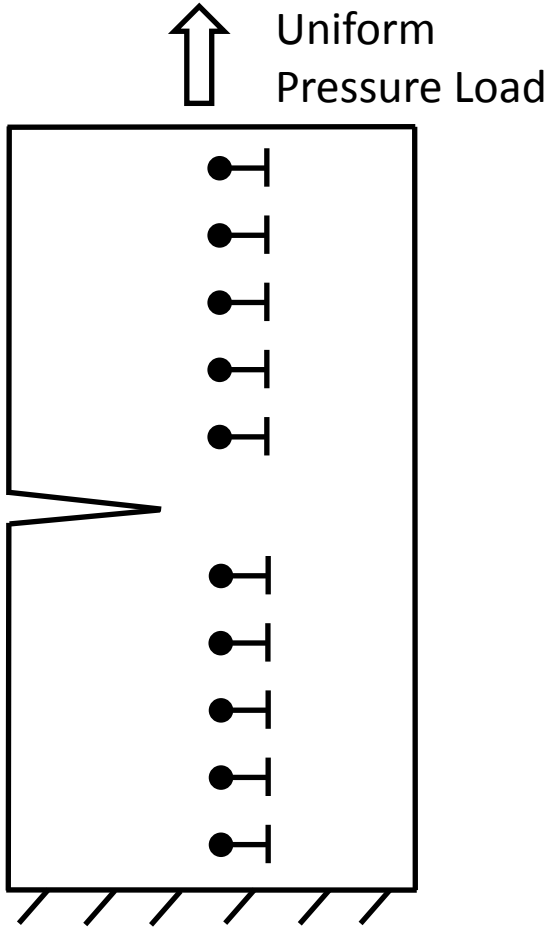
Ref: Harter, James A, AFRL/VASM, 2009





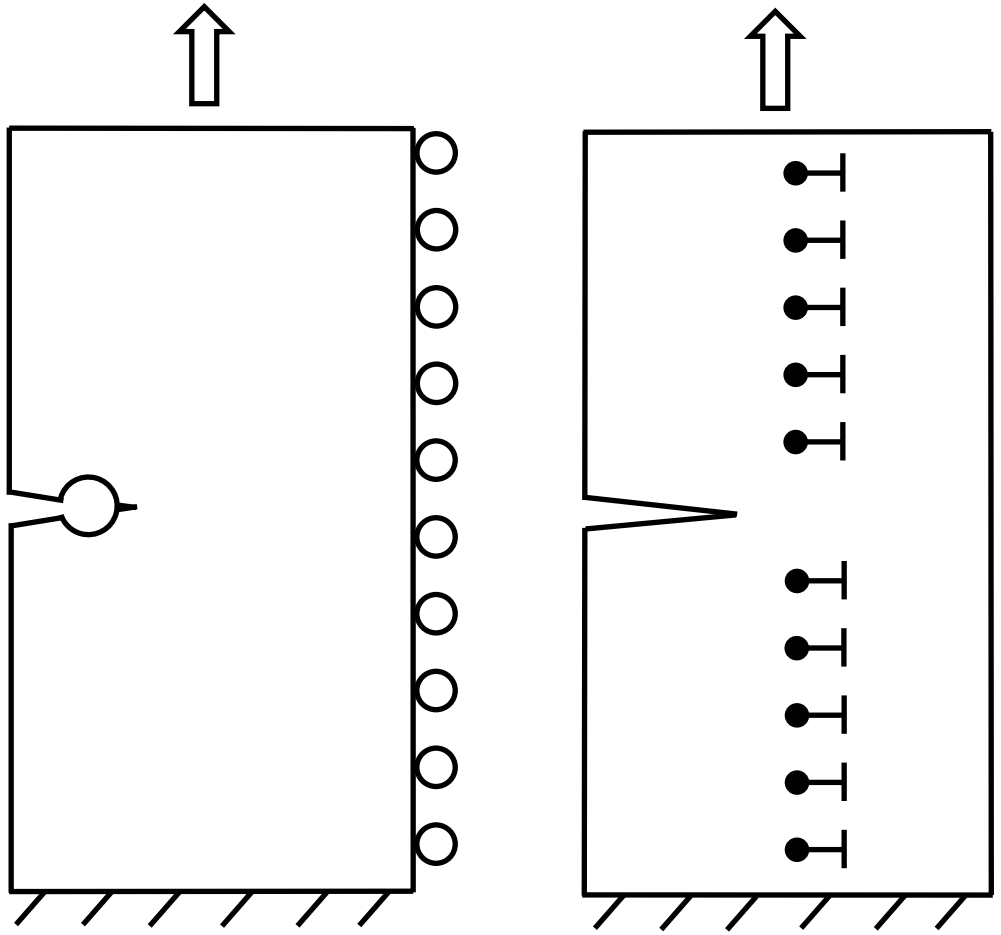
Classic Edge Crack FEM Constraints

- FEM:
  - FRANC2D
- Loading
  - Top Edge: Pressure Load
- Boundary Conditions:
  - Bottom Edge: Fixed in Y-Dir
  - Mid-Plane Nodes: Fixed in X-Dir
    - upper and lower portions of the plate only
    - Nodes in the area of the crack plane not constrained



Appropriate Constraints?

- Comparison to Actual Structure
  - Fasteners constrain structure



Conclusions & Recommendations

- Conclusions:
  - Stress Intensity Solutions are significantly different when comparing Continuing Damage Model and Classic Edge Crack Model (In-Plane Bending Constrained)
  - Differences originate with FEM (constraints)
  - How much does it matter?
    - Continuing Damage Life (especially through crack) is typically small
      - Constraint assumption would also affect corner crack continuing damage life
    - Critical Crack Size
- Recommendations:
  - Replicate Edge Crack FEM and verify solutions
  - Investigate different constraint assumptions
  - Test data for a continuing damage case