



New Stress Intensity Factor Solutions

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Background



USAF Academy Center for Aircraft Structural Life Extension (CAStLE)

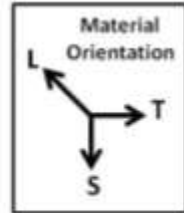
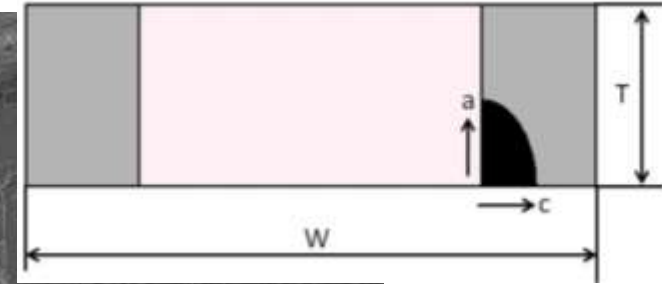
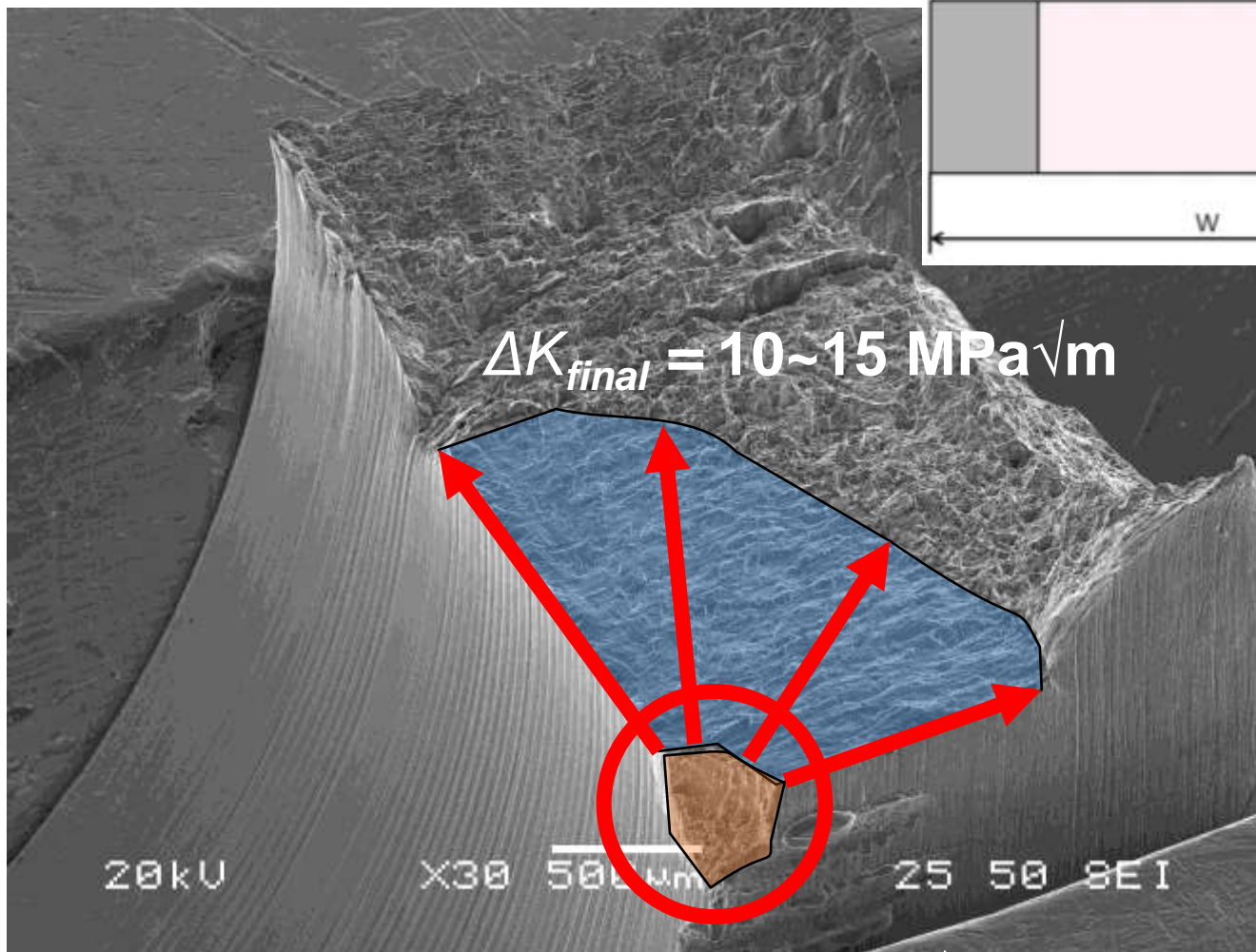
- **Current stress intensity factor solutions (K) for**
 - **Corner cracks in narrow finite width plates are inaccurate**
 - **Through edge cracks don't consider height effect**
- **Can improve**
 - **Correlation of predicted vs. measured**
 - **Crack shapes**
 - **Crack growth lives**
 - **Fleet management decisions**
 - **Inspection intervals**
 - **Part repair/replacement**



Experimental Results – Corner Cracks



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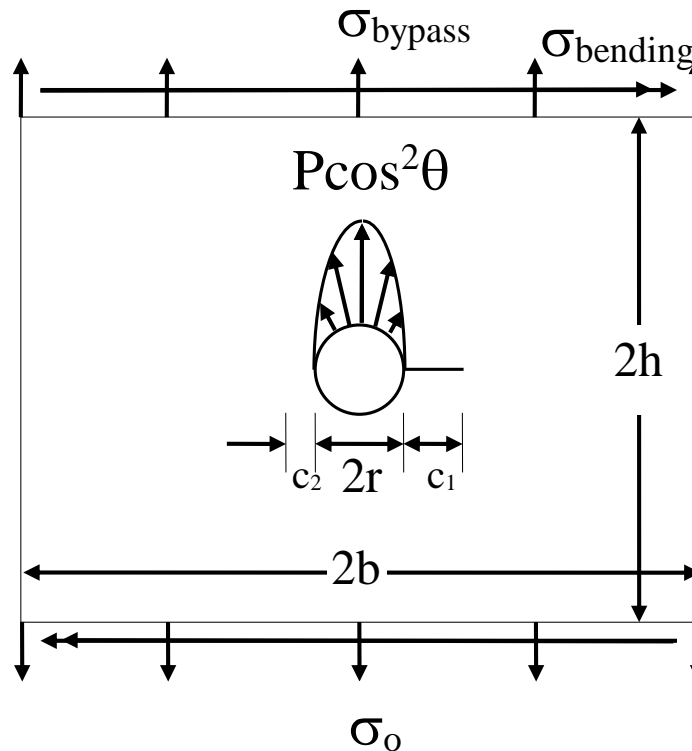


Solution Space



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- **Single corner crack at a centrally located hole in a plate of varying width \rightarrow new finite width correction factor**
- **Three load types are considered**



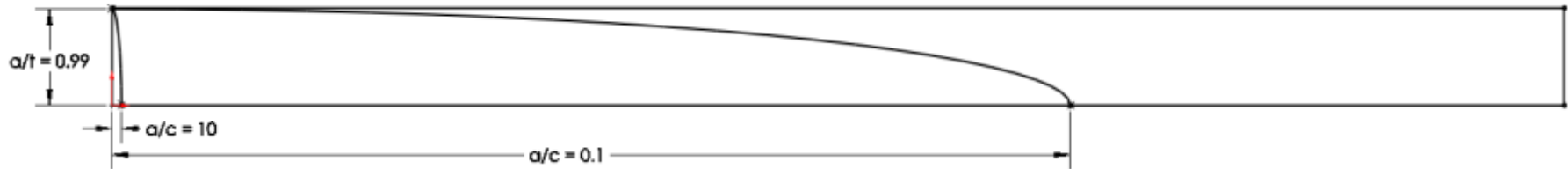


Solution Space - Crack Geometry



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- $a/t \in [0.01, 0.99]$
 - $a/t = [0.01, 0.05, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 0.95, 0.99]$
- $a/c \in [0.1, 10]$
 - $a/c = [0.1, 0.111, 0.125, 0.1428, 0.1667, 0.2, 0.25, 0.333, 0.5, 0.667, 0.75, 0.8, 1, 1.25, 1.333, 1.5, 2, 3, 4, 5, 6, 7, 8, 9, 10]$





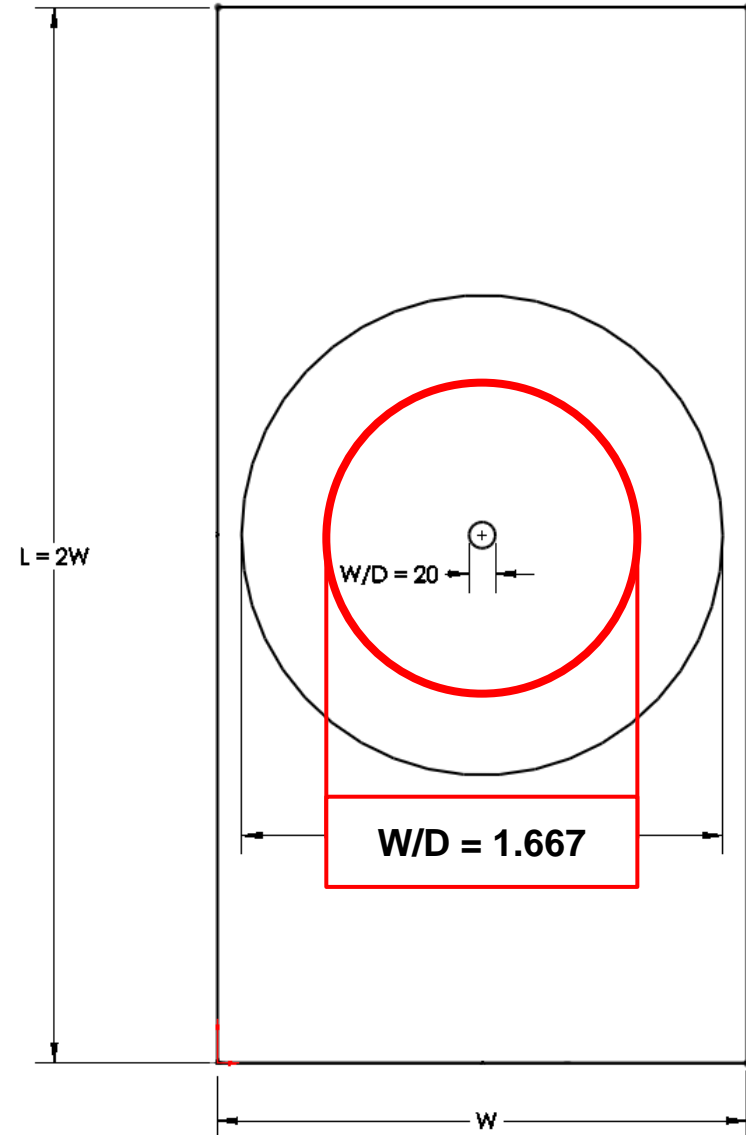
Solution Space - Plate Geometry



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- $L/W = 2$ (fixed)
 - Eliminate finite height effect
- $W/D \in [1.1, 20]$
 - $W/D = [1.1, 1.25, 1.5, 1.667, 2, 3, 4, 10, 20^*]$

* Large W/D ratio used for comparison to existing AFGROW solutions



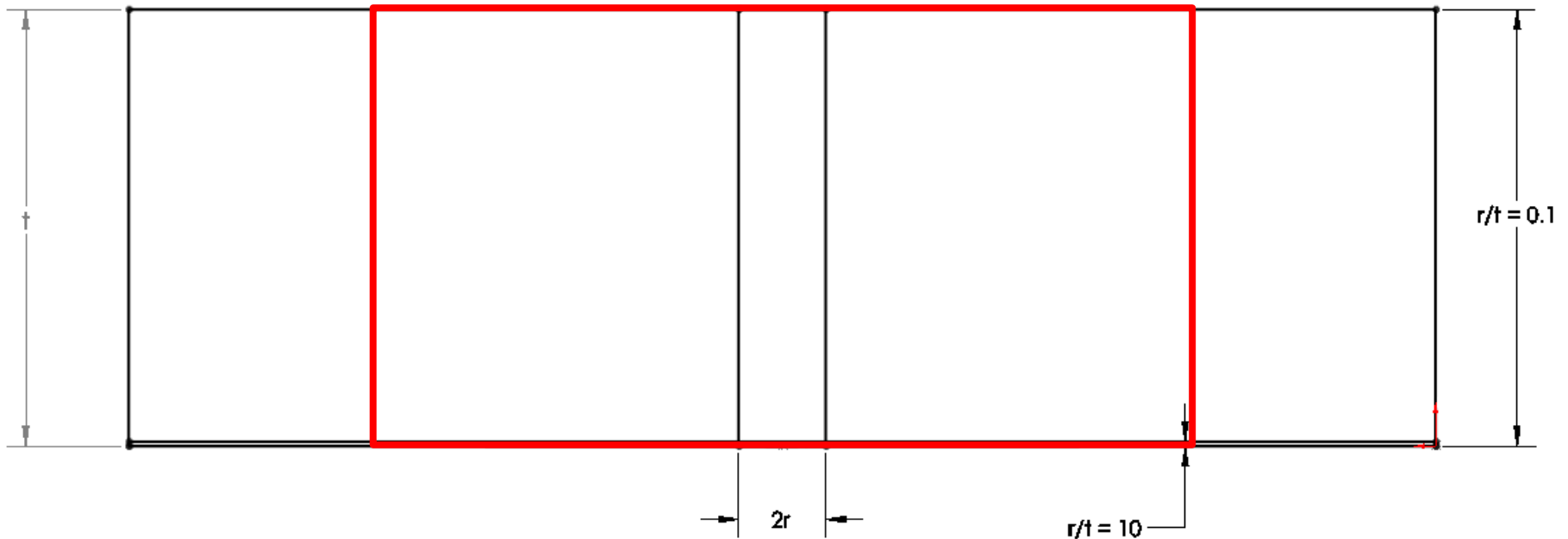


Solution Space - Plate Geometry



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- $r/t \in [0.1, 10]$
 - $r/t = [0.1, 0.111, 0.125, 0.1428, 0.1667, 0.2, 0.25, 0.333, 0.5, 0.667, 0.75, 0.8, 0.9375, 1, 1.25, 1.333, 1.5, 2, 3, 4, 5, 6, 7, 8, 9, 10]$





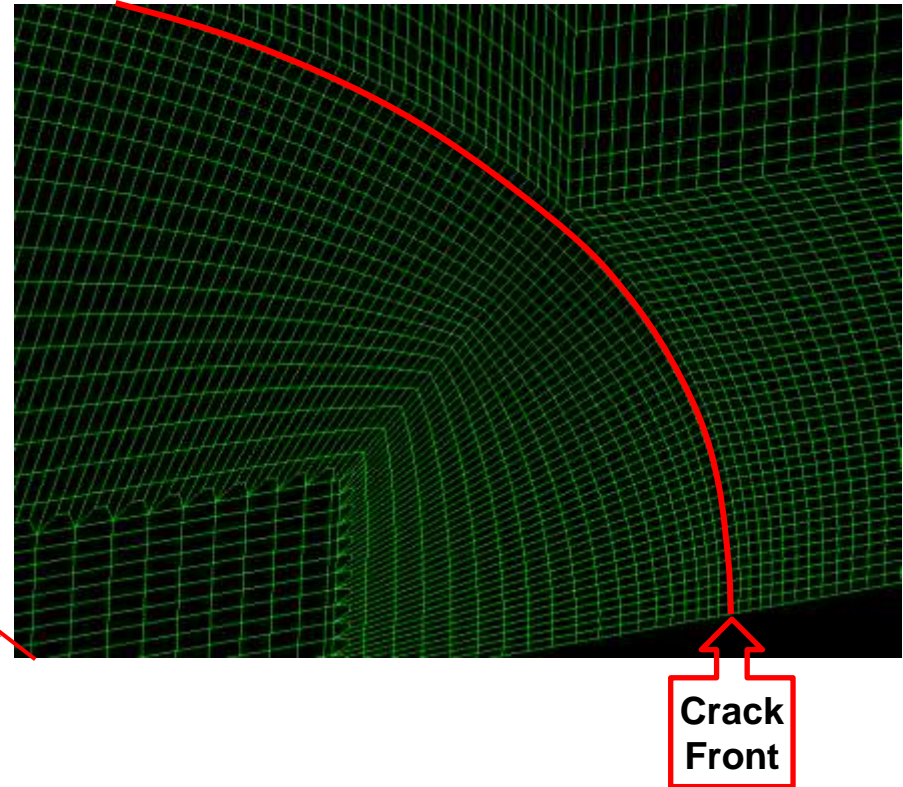
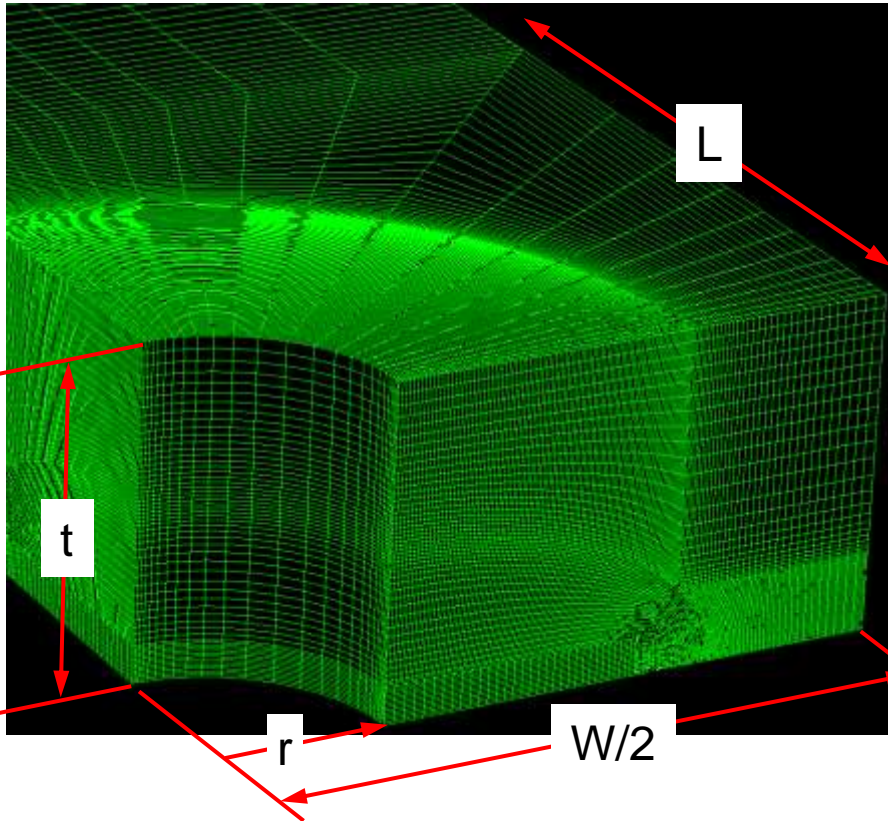
FE Automatic Mesh Generation



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Crack Plane w/ Auto-Mesh

Crack Front w/ Auto-Mesh

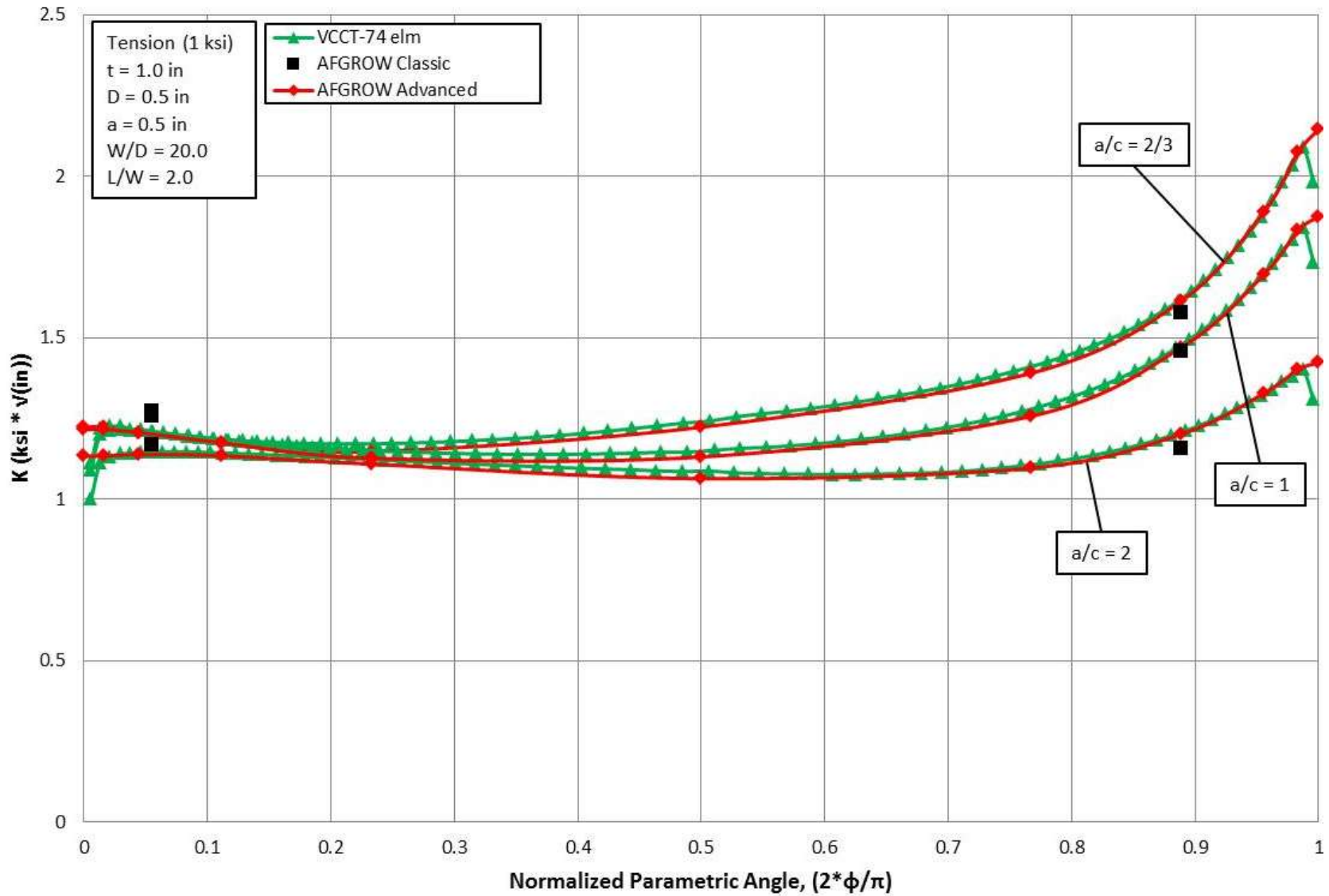




Verification / Correlation



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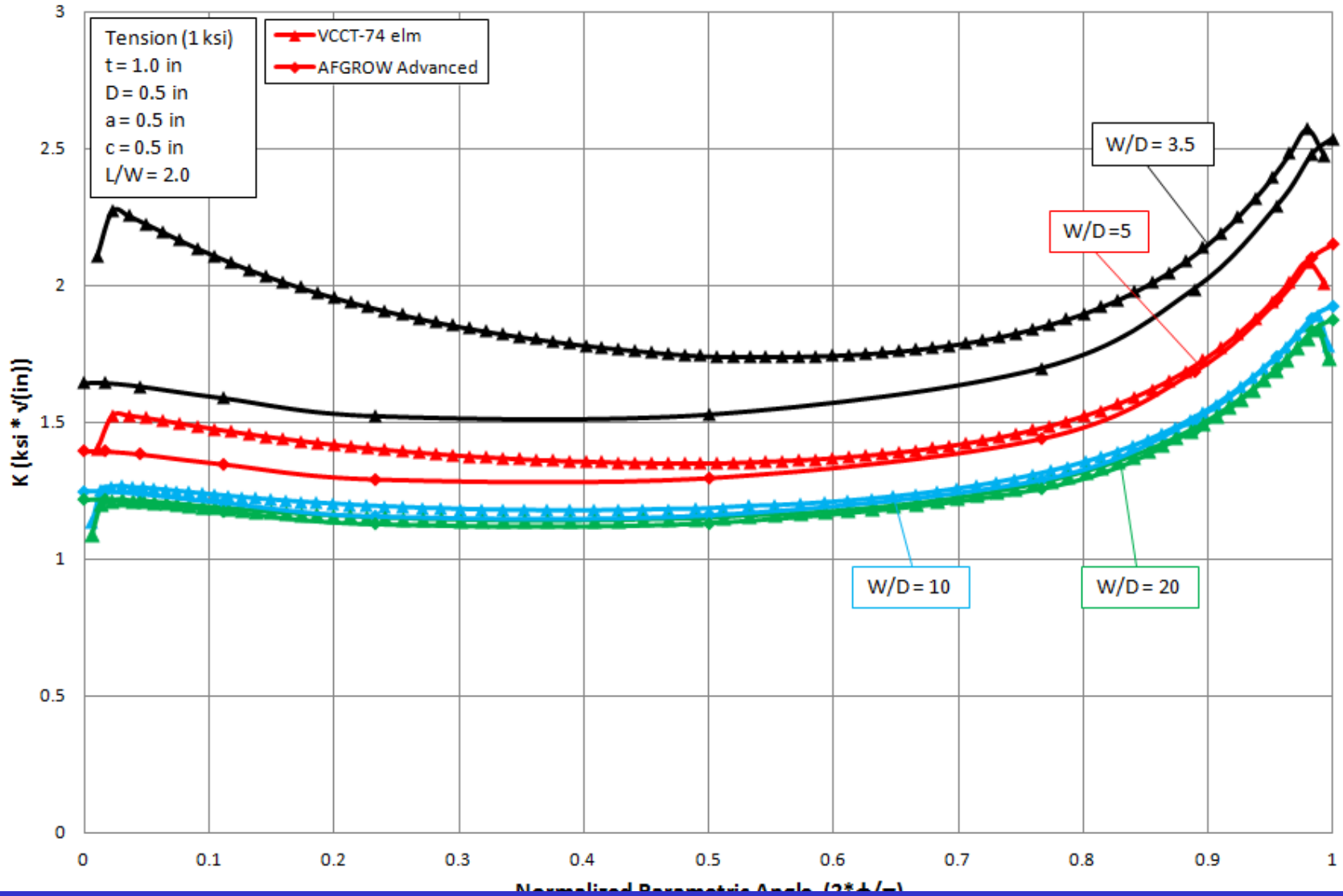




Finite Width Effect: $a/c = 1$



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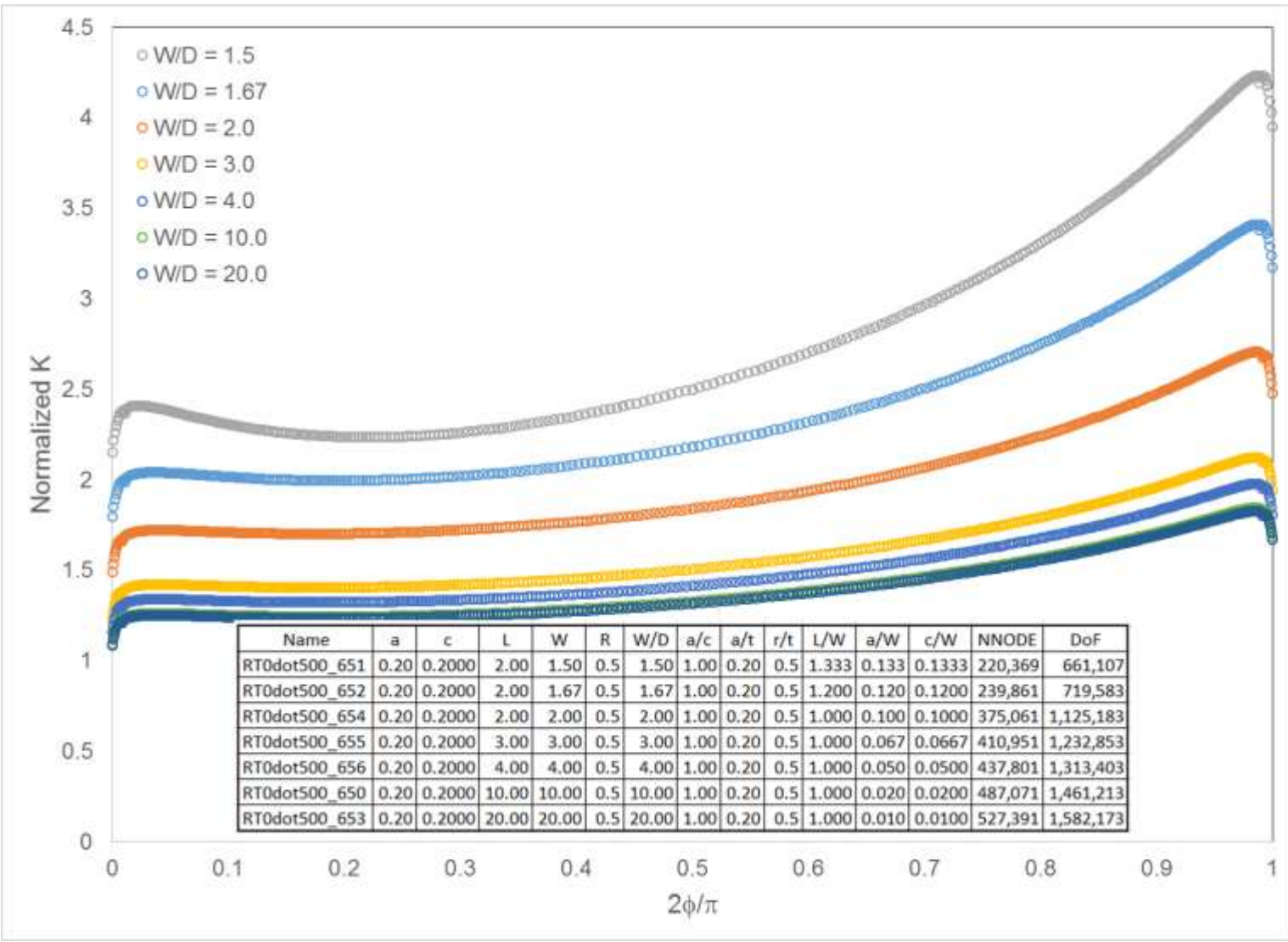
Compare well with wide plates, differences with narrow plates



Finite Width Effect



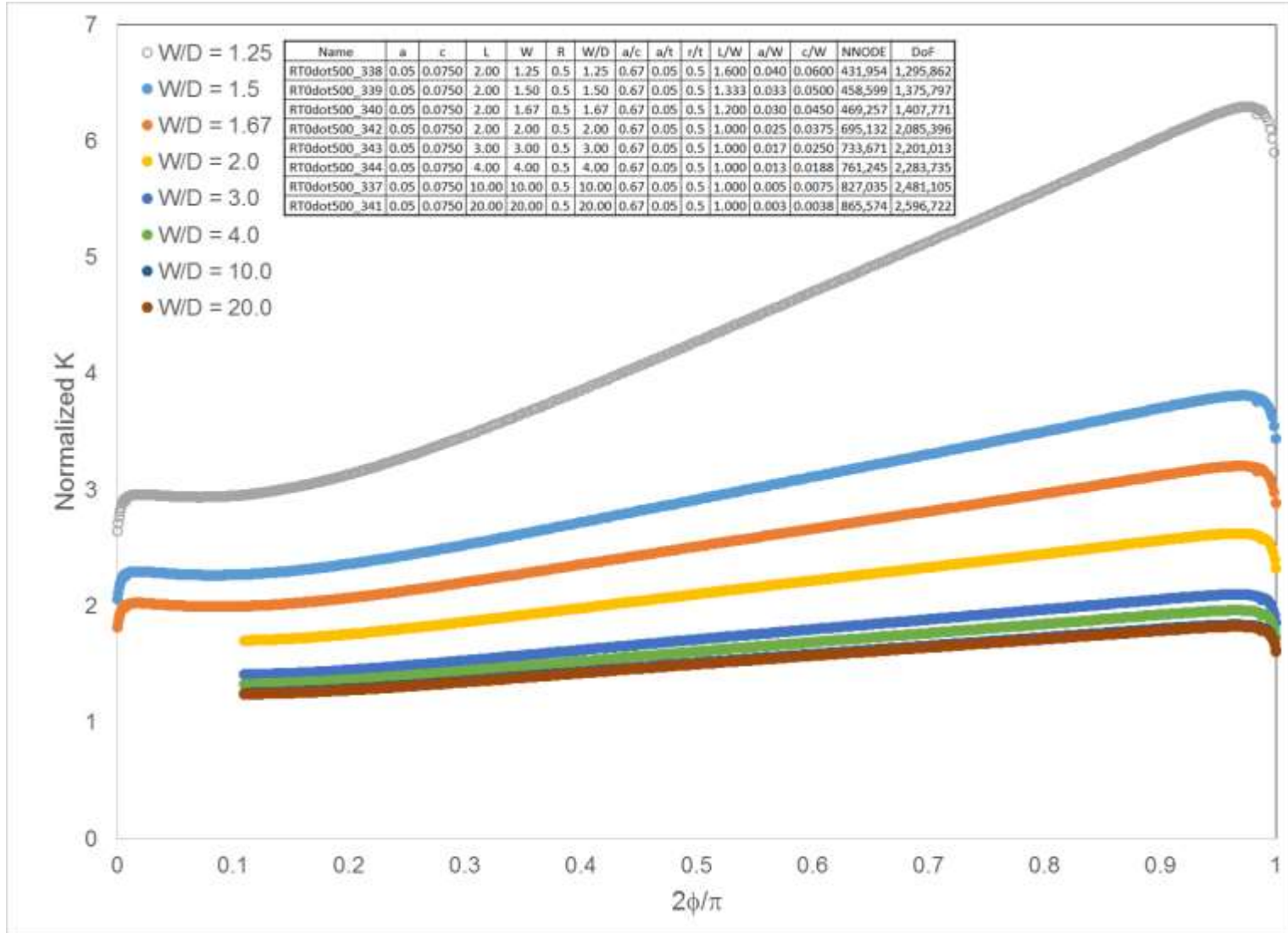
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Finite Width Effect

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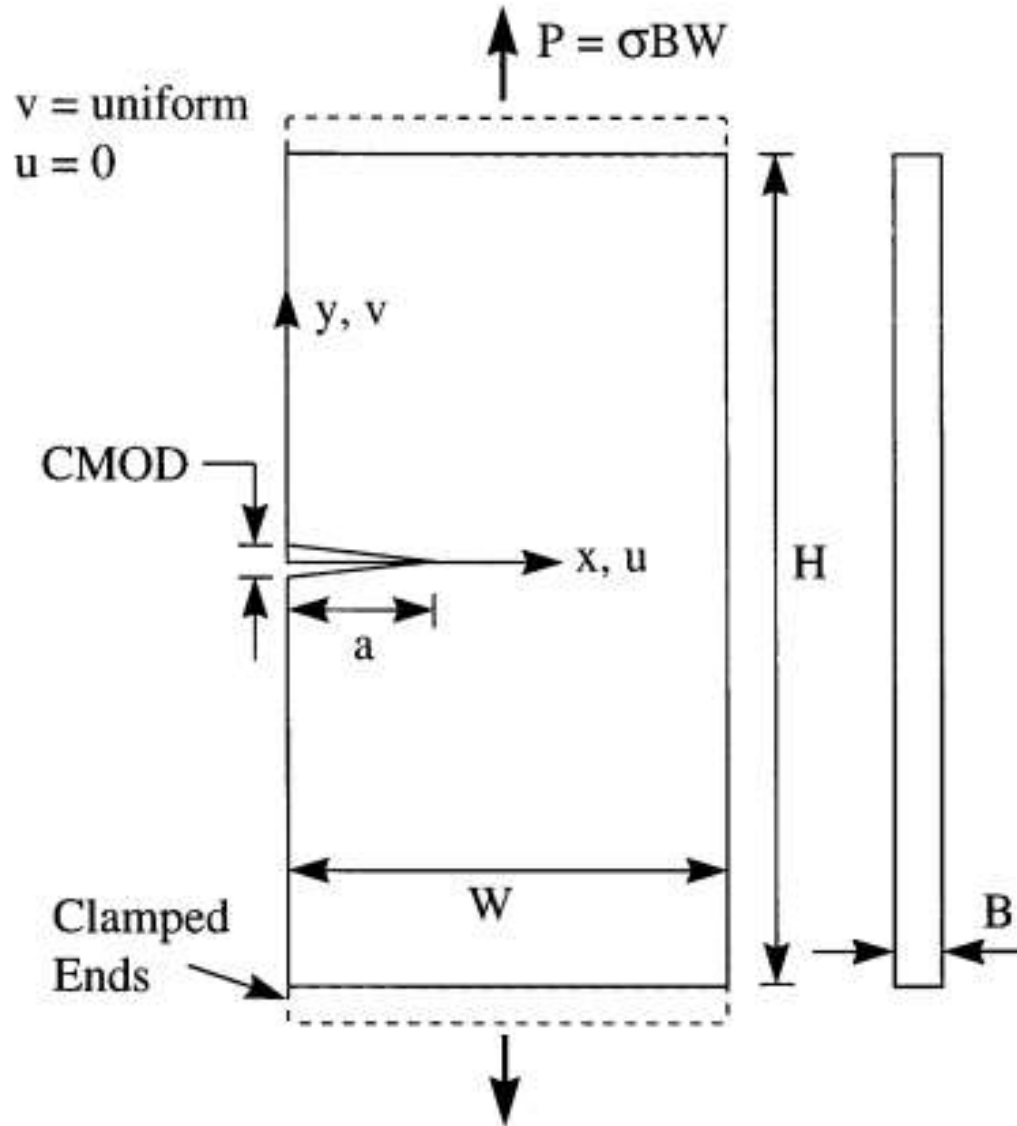




Edge Cracks



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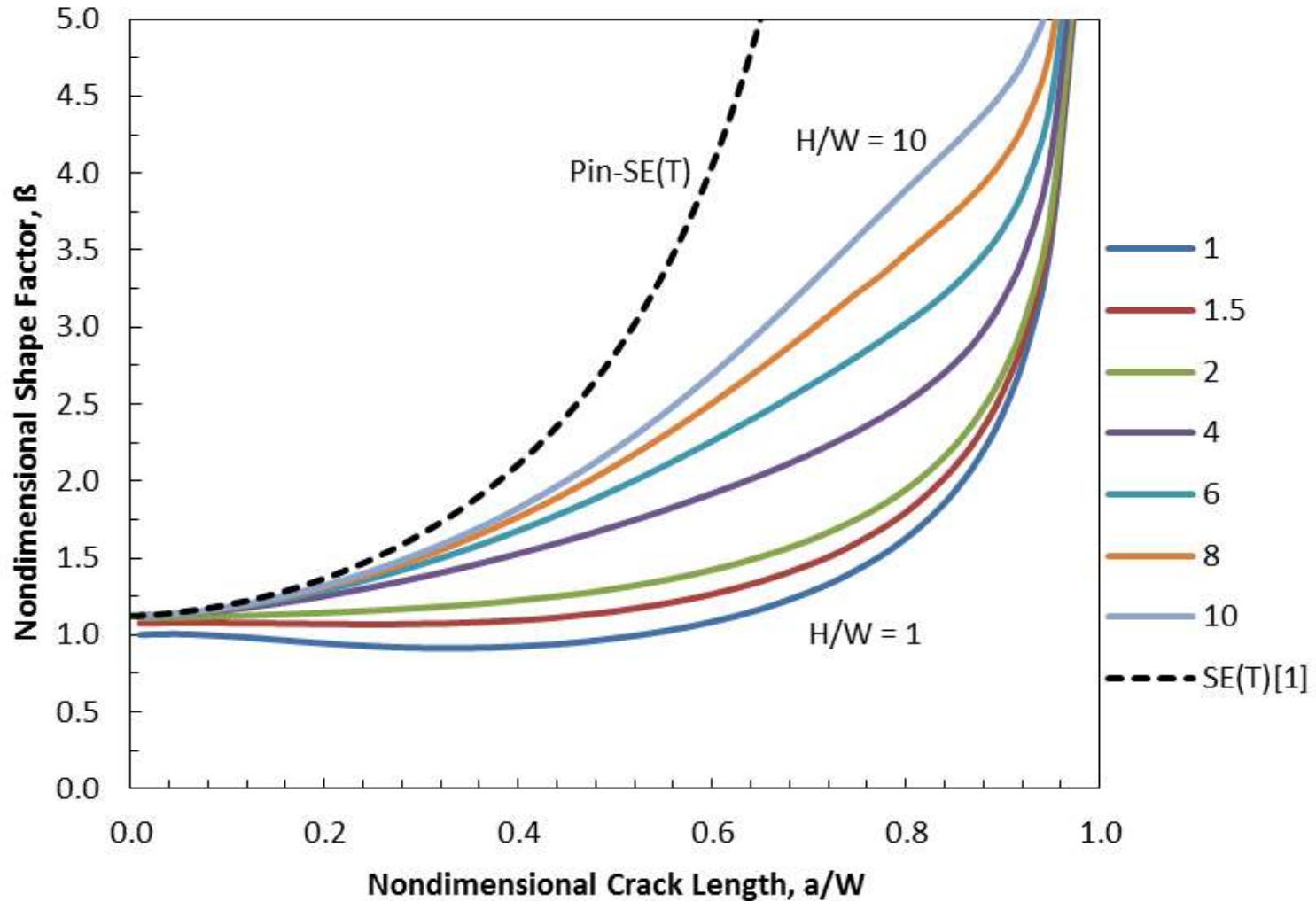




Edge Cracks - Results



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Conclusions



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- **Corner Cracks**
 - **Initial results indicate that part-through crack finite width corrections can be improved**
 - **Improvement relevant to any life prediction code (AFGROW, NASGRO, OEM methods) using the Newman/Raju corner crack K solutions**
 - **Finite width correction factor is embedded in these solutions**
 - **Status: 31,500 of ~50,000 solutions**
- **Edge Cracks**
 - **New solution space considers all relevant crack sizes and length/width ratios**
- **Technology Transition**
 - **AFGROW implementation**