Stress Intensity Solution Development for Through Cracks at Expanded Holes

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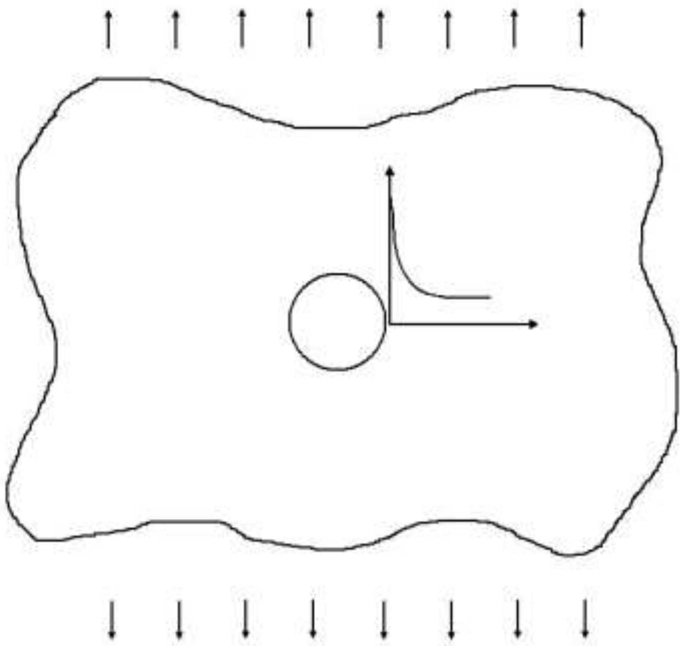
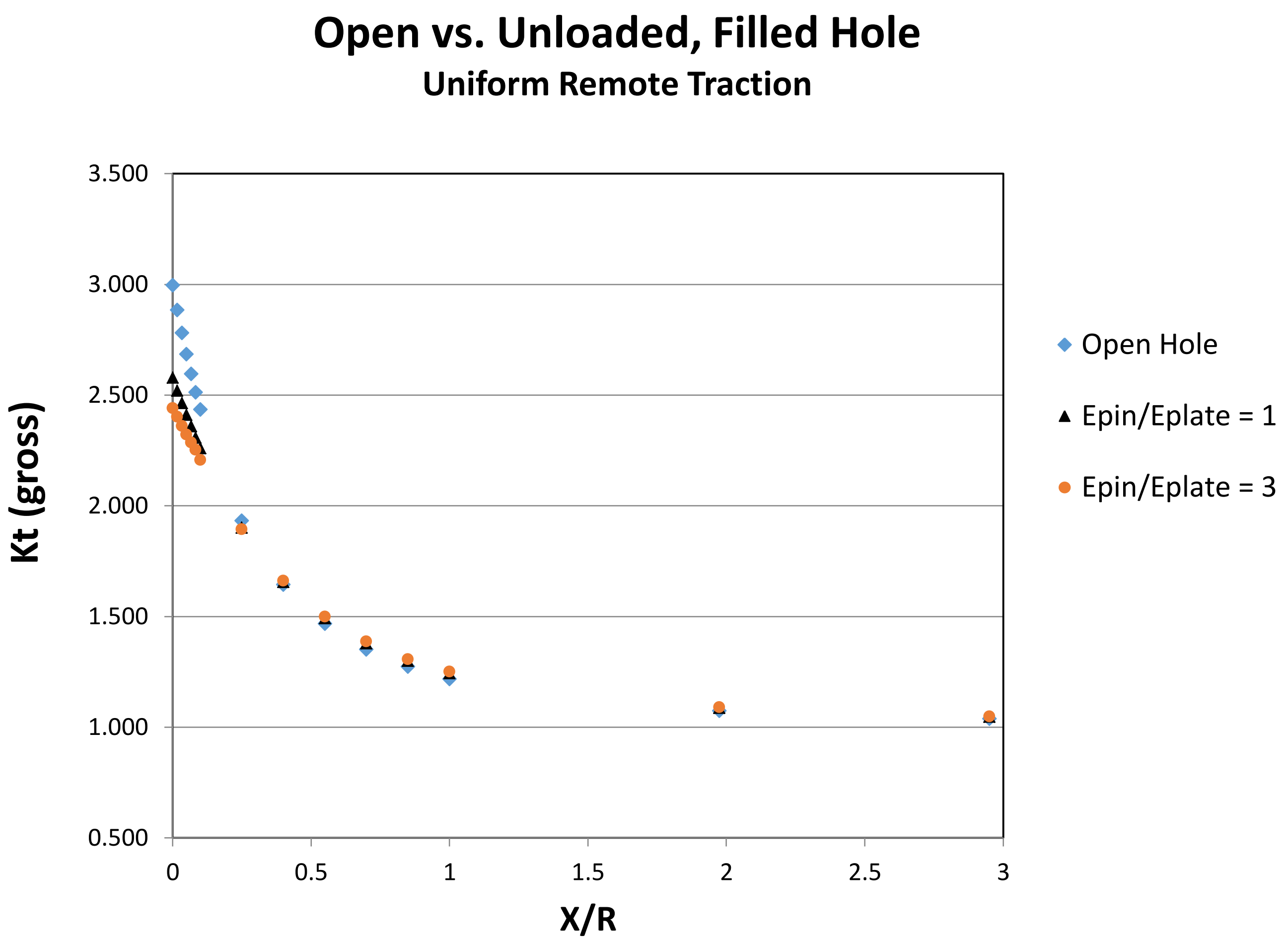
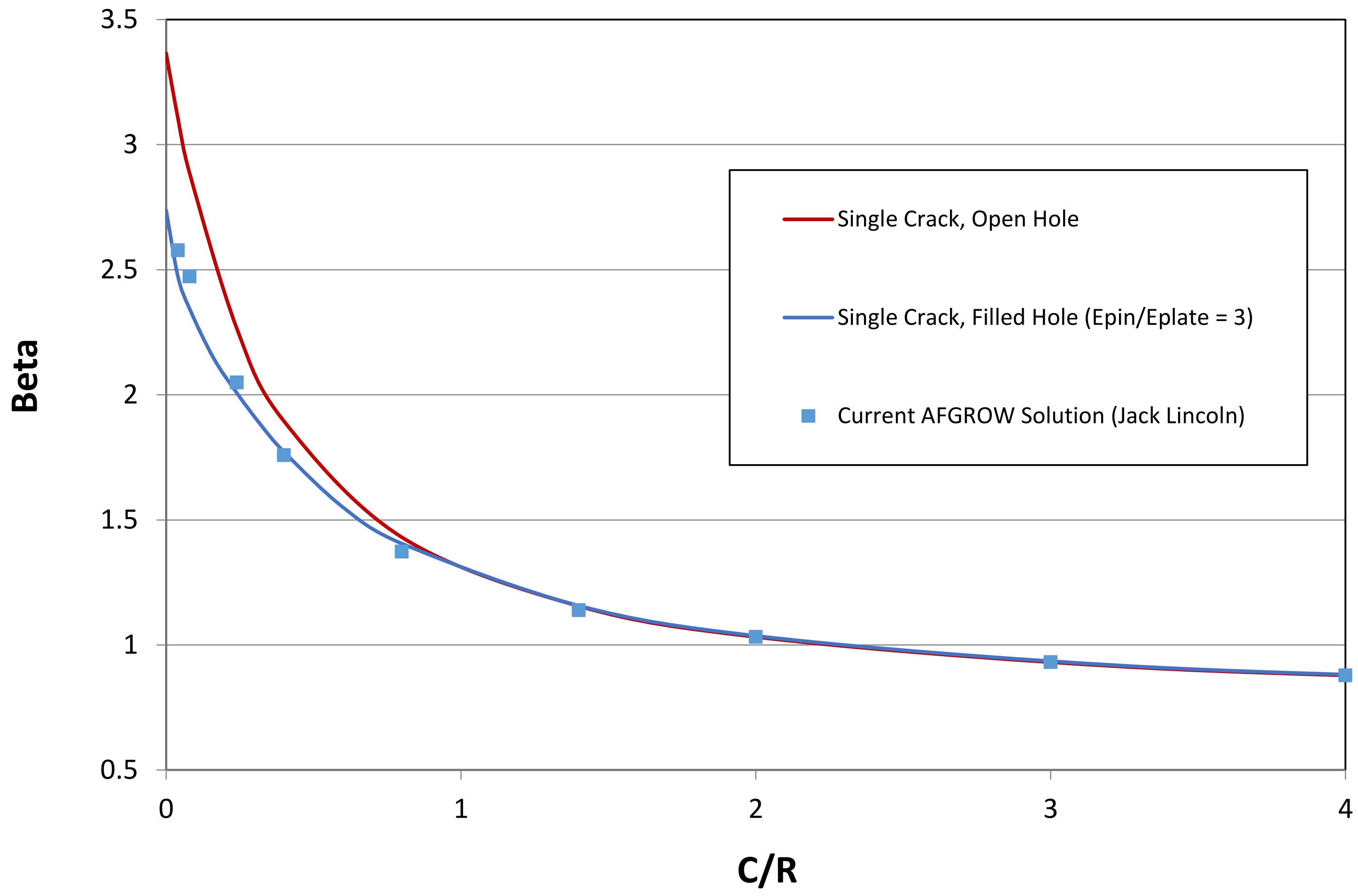
Stress Distribution from the Edge of a Hole



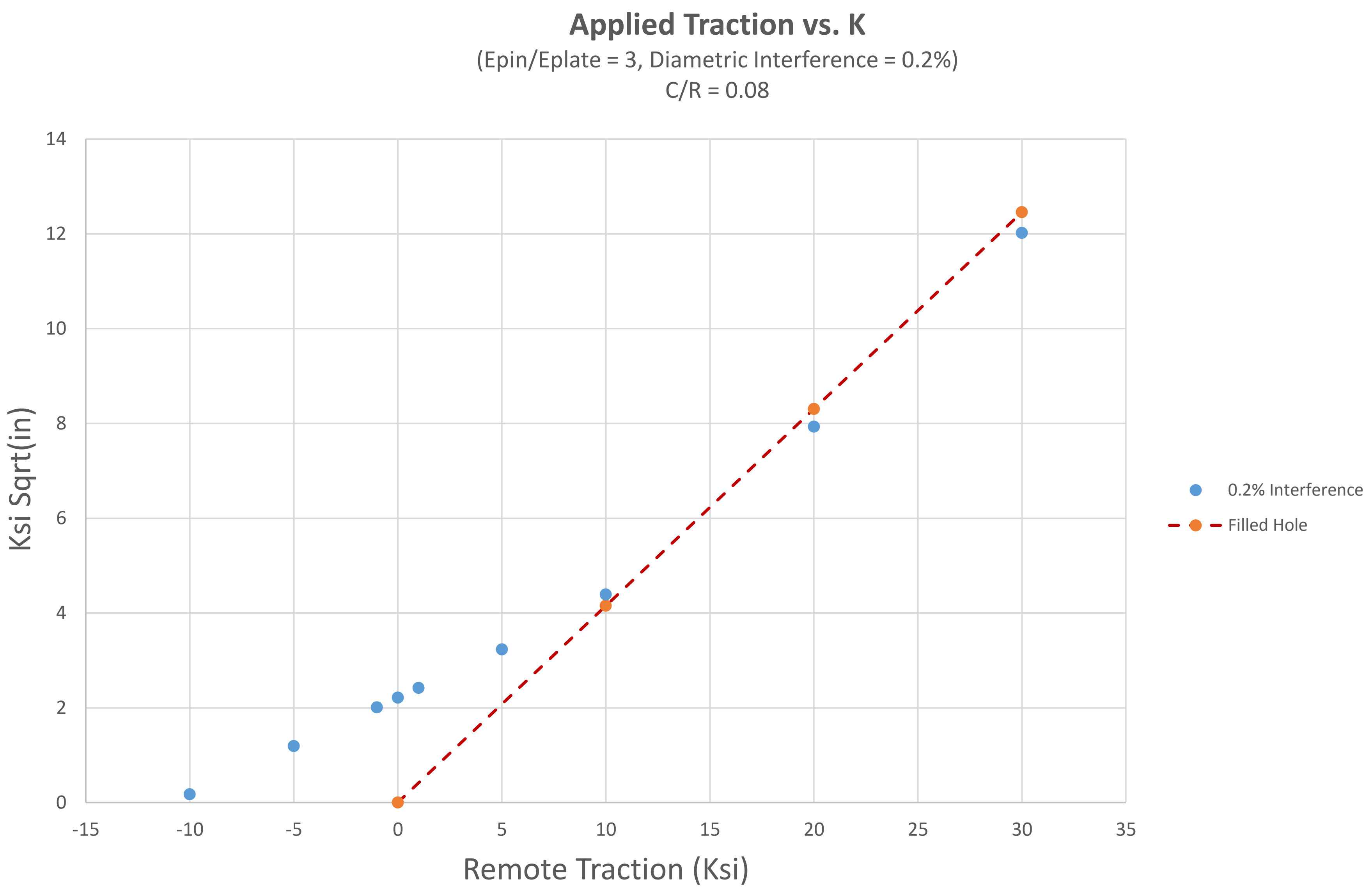


Single Through Cracked Hole

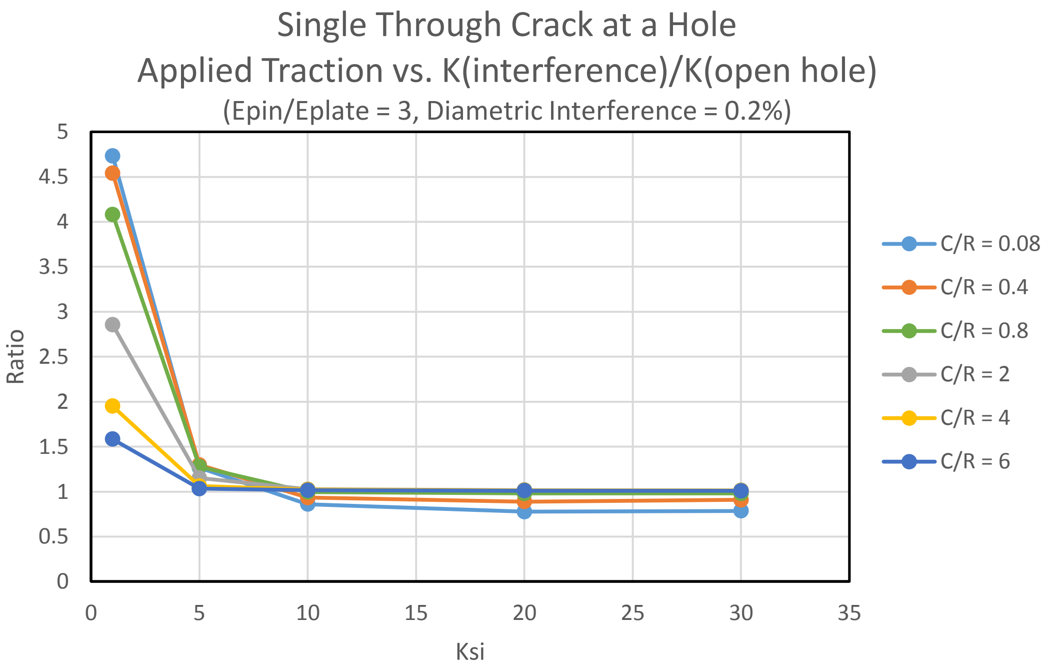
Infinite Plate, Remote Traction Reference

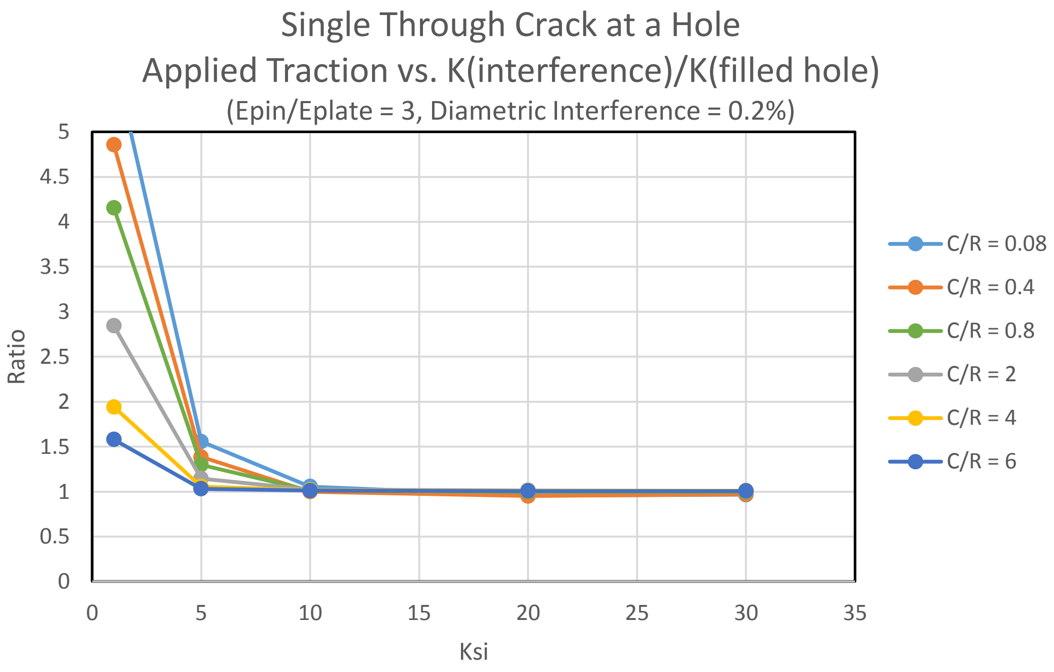


Effect of Hole Interference



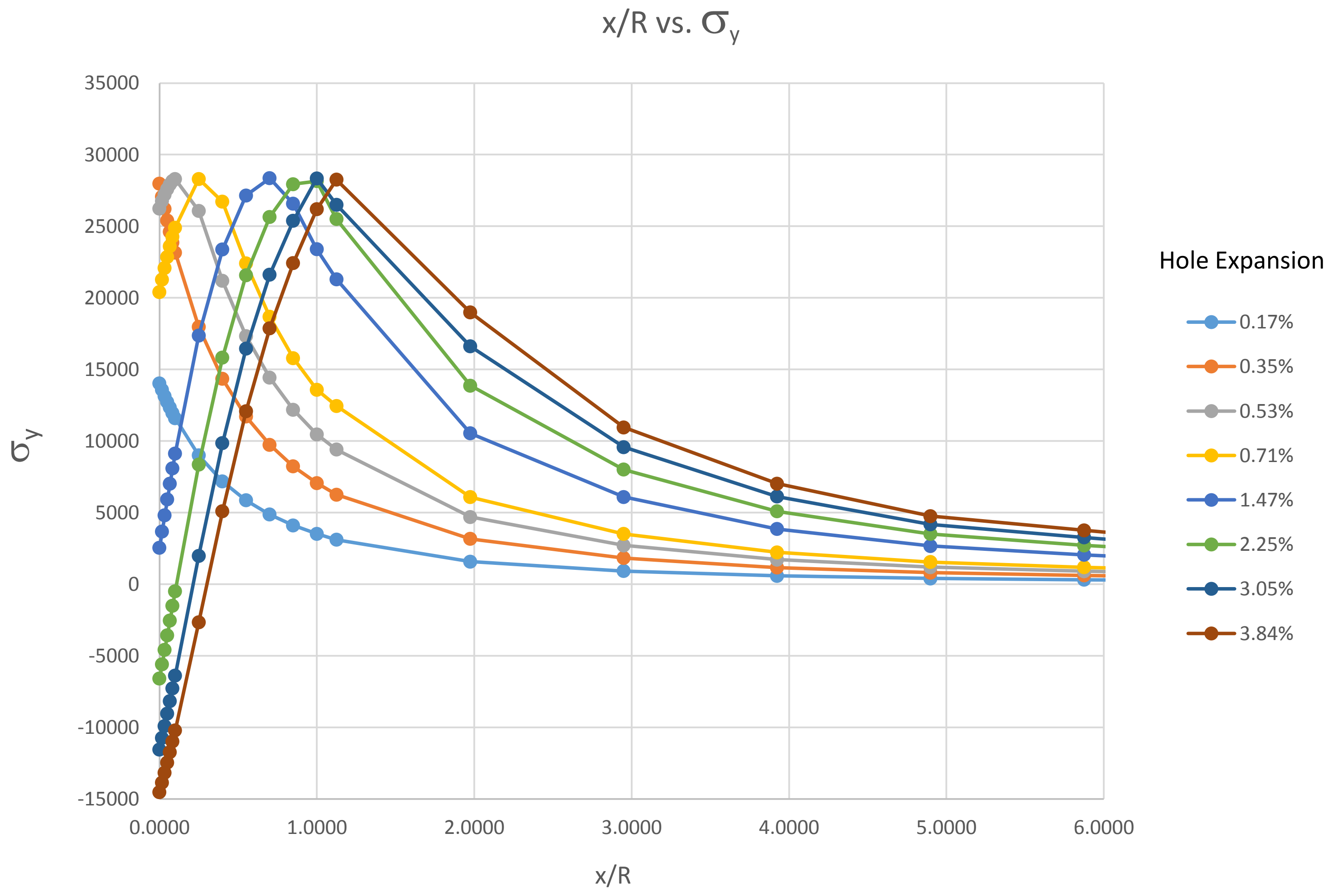
Using an Open Hole vs. Filled Hole Reference Solution





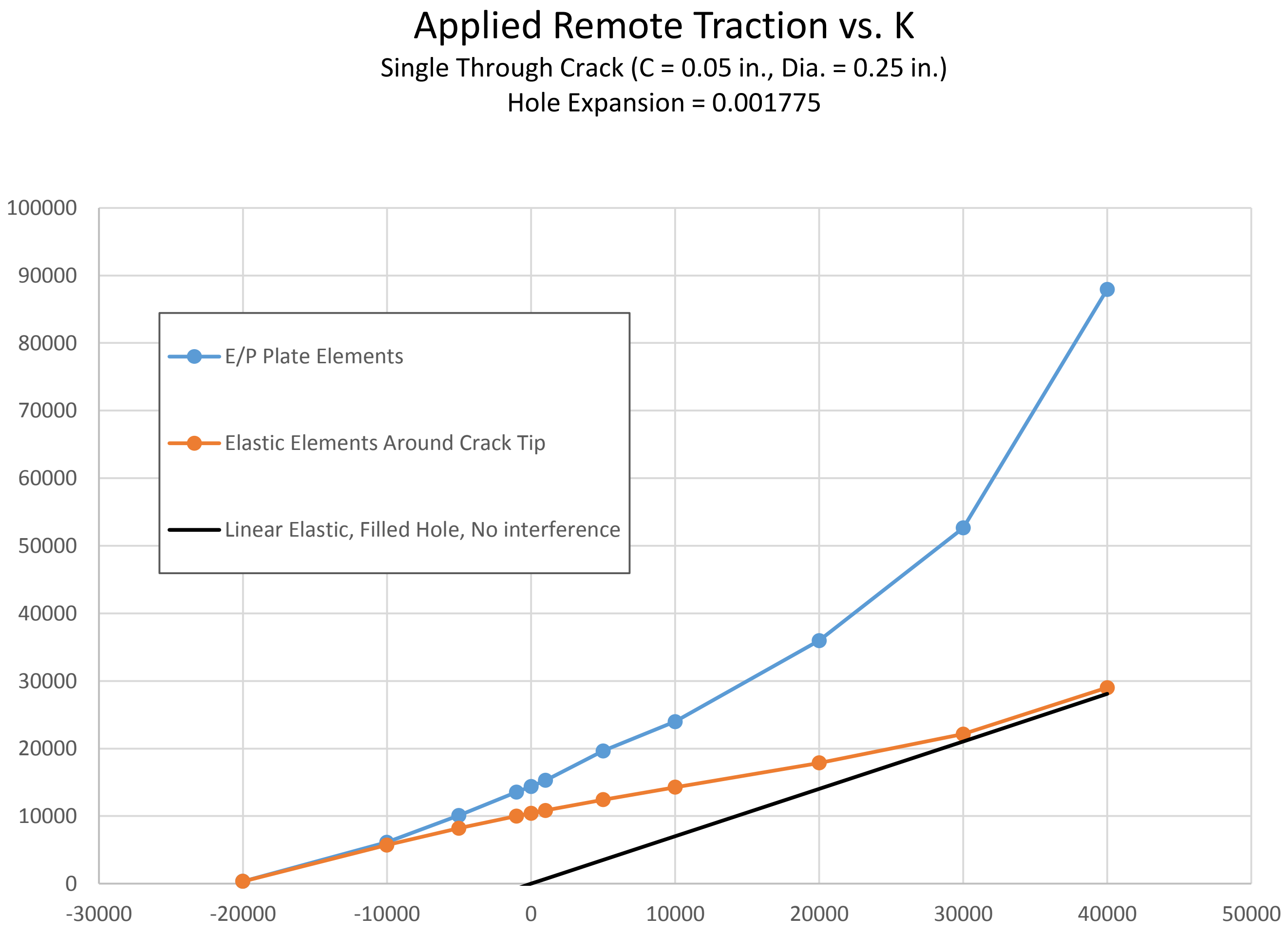
The expanded hole solution converges to the filled hole solution for all crack lengths

Un-cracked Model Results



The hole expansion values were determined from u_x after gen, non-linear iterations. I verified the results were the same for steel and aluminum for the same resulting hole expansion.

Problem

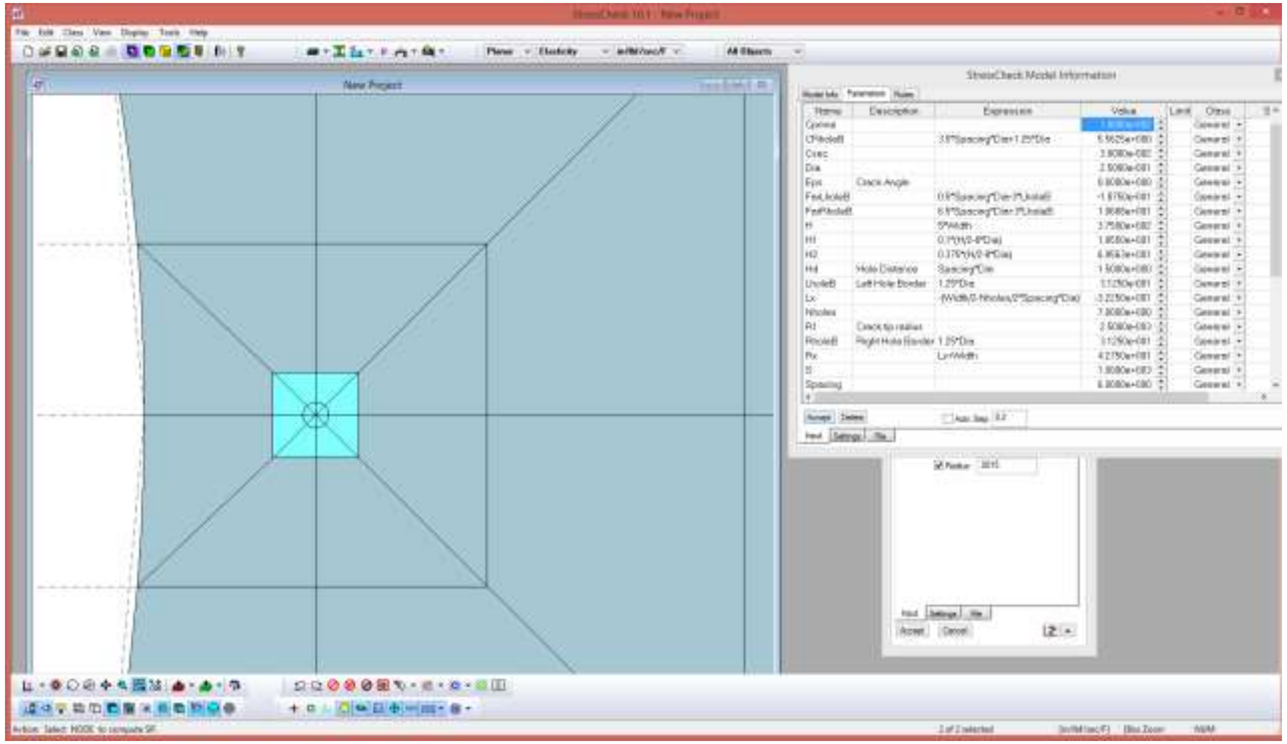


For hole interference cases that are locally plastic, there appeared to be a problem with the resulting stress intensity values shown here for different remote applied tractions. The solutions are diverging. Perhaps this is because the K extraction is ignoring the higher order terms in the J-integral. However, we need to find a way forward.

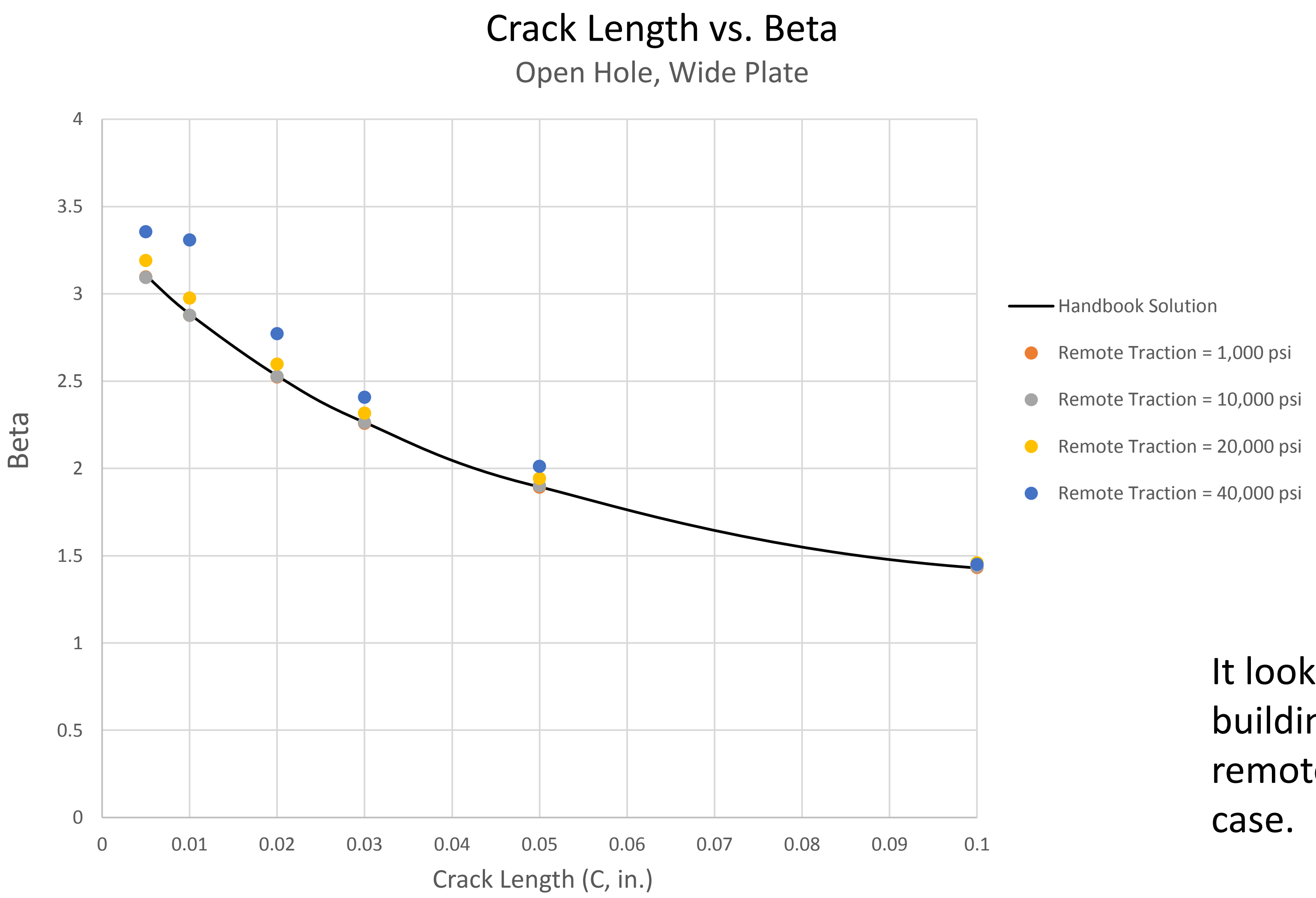
One idea is to use elastic elements immediately around the crack tip so that the overall effect of the hole expansion is captured, and K extraction is performed in the elastic area at the crack tip. This may help to delay the divergence.

Hypothesis

Using elastic elements around the crack tip will result in reasonable K’s until the displacement/stress discontinuities at the element boundaries become significant.

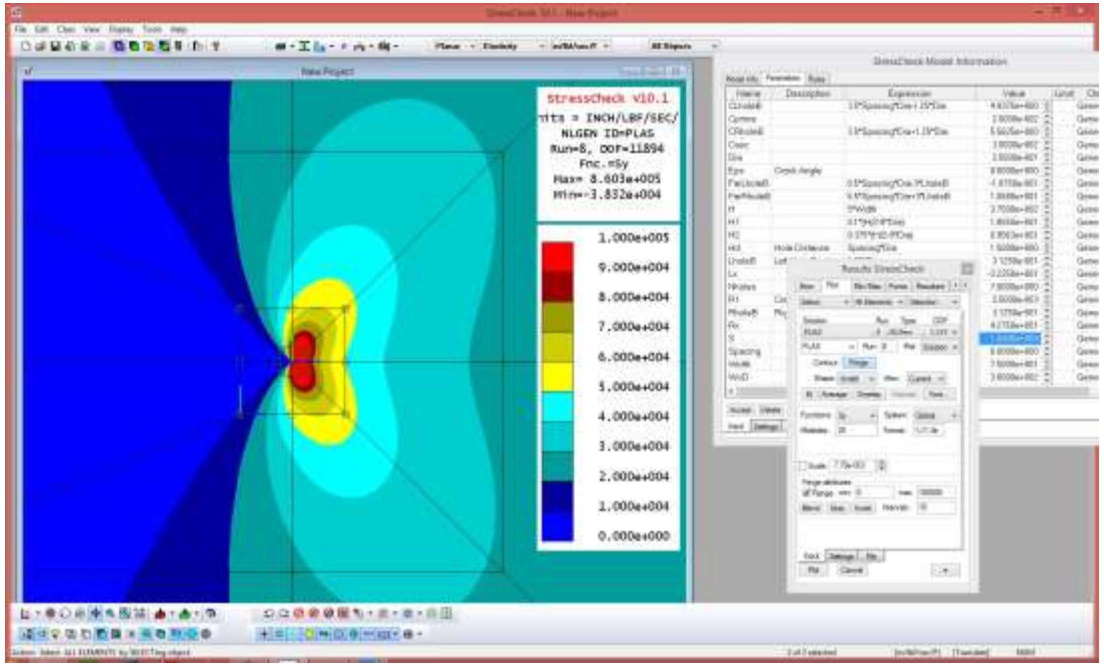


Verification

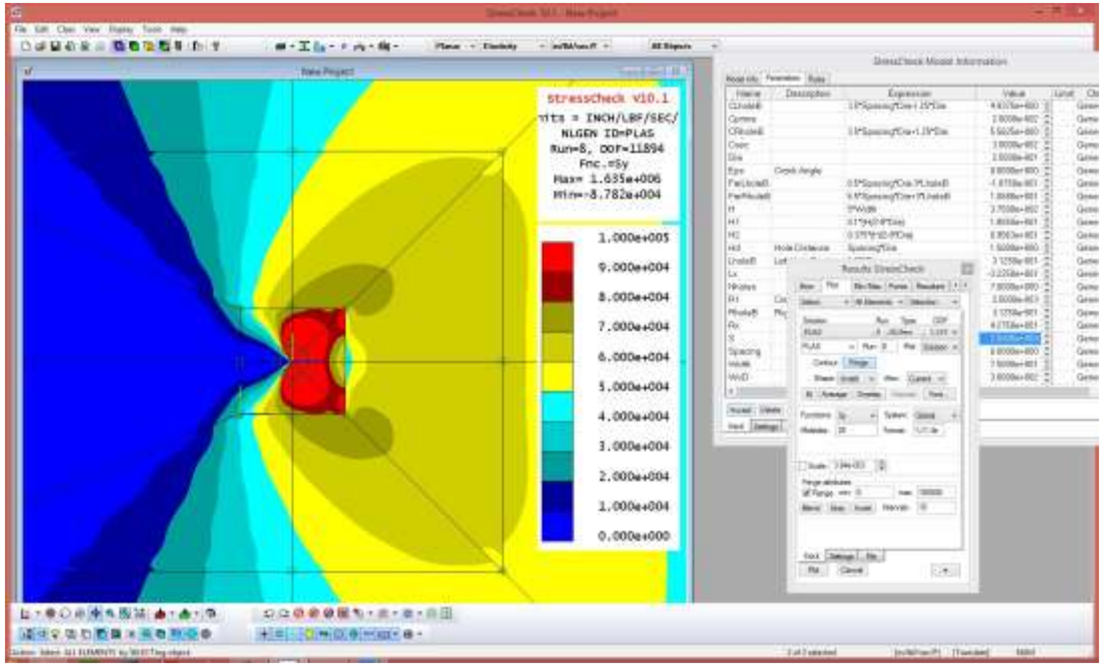


It looks like “Elvis has left the building” at about 20,000 psi applied remote traction for the open hole case.

Can I Quantify This?



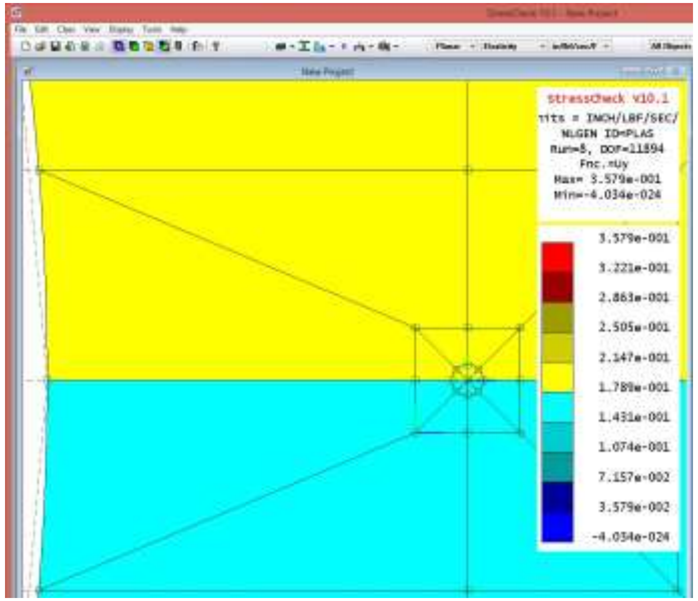
1,000 psi



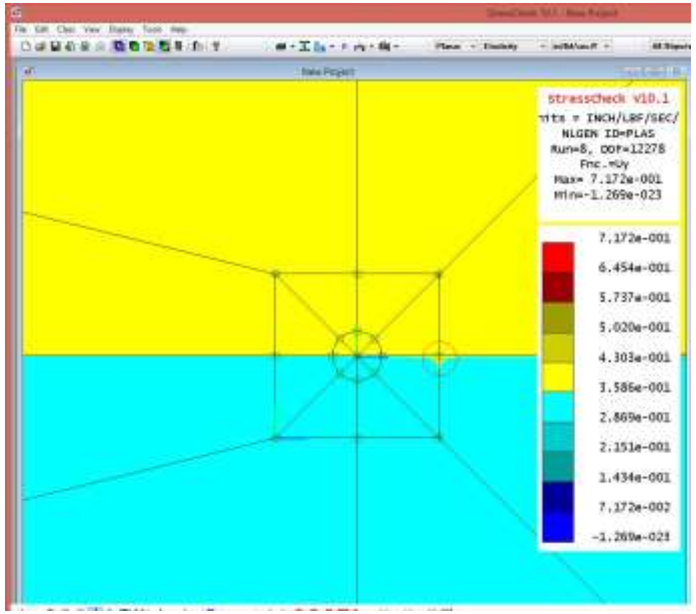
20,000 psi

Now, “Ugly” is generally a relative thing……….

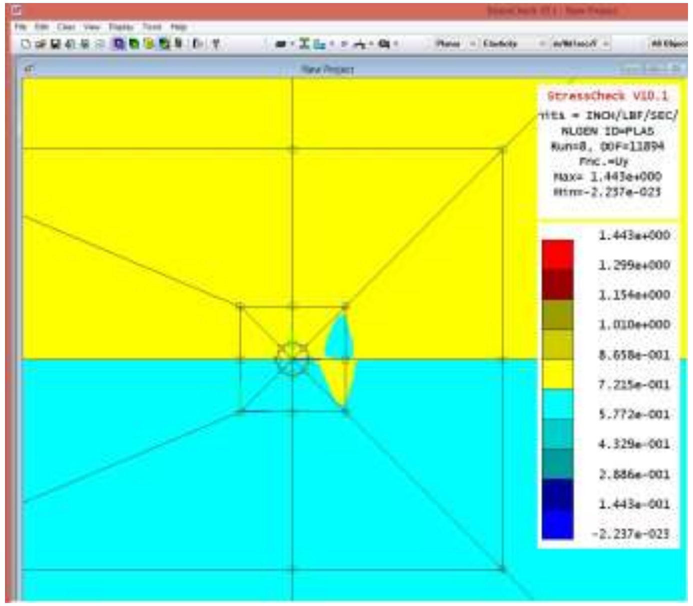
Now, this looked promising……



10,000 psi



20,000 psi



40,000 psi

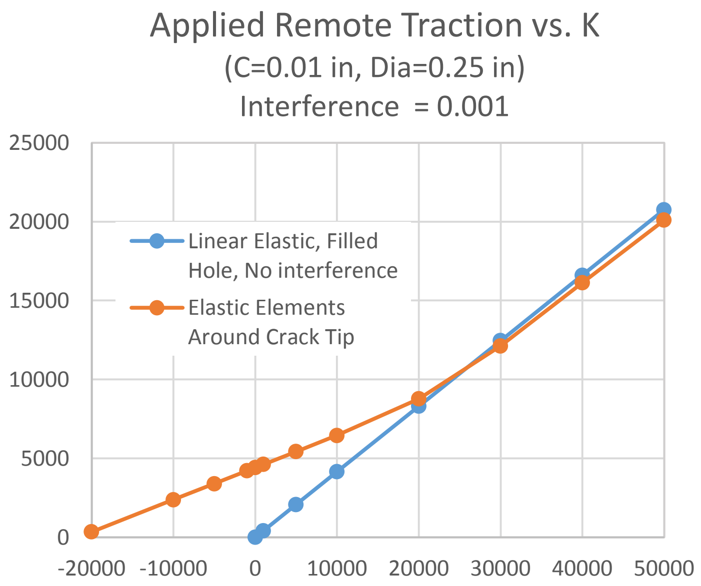
I used the default scaling for u_y in the fringe plots since StressCheck breaks the fringe at the crack plane. You can see the “bobble” in the u_y fringe plot is just visible at 20,000 psi (circled on the graphic)

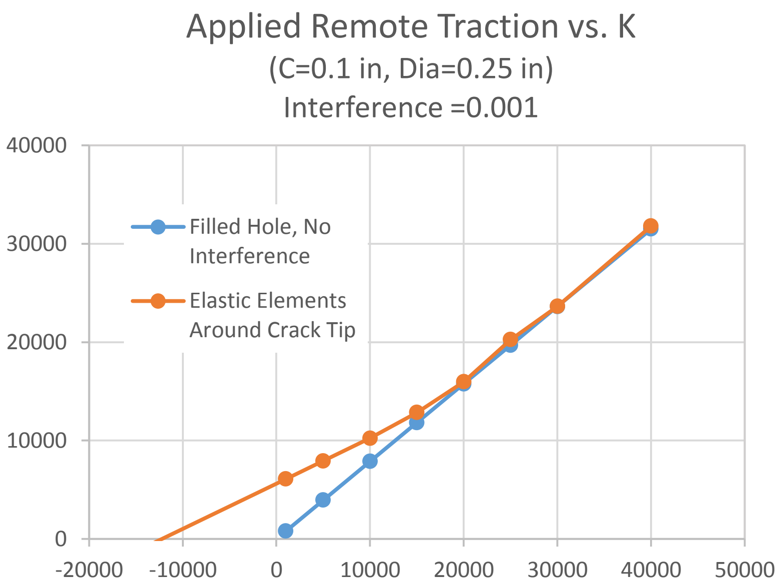
We Currently Have K-Solutions for:

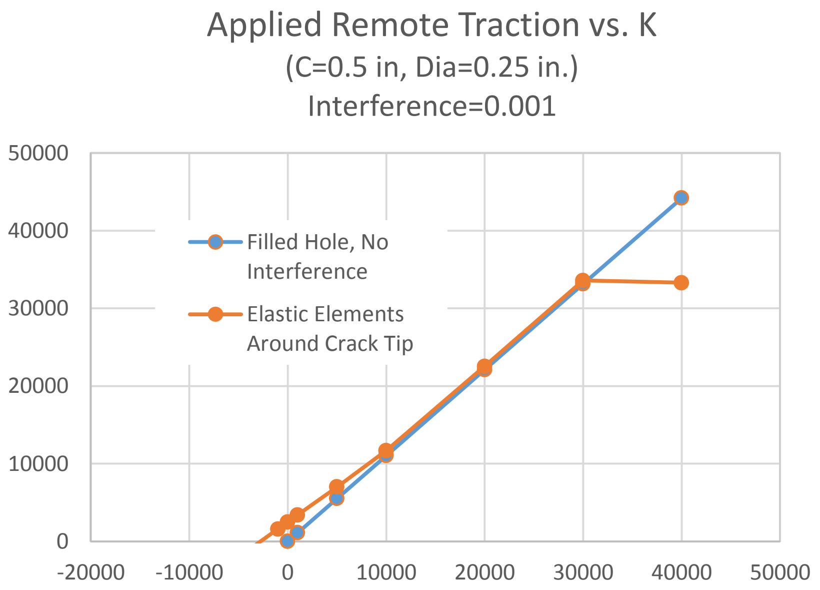
Interference Levels: 0.4, 0.8, 1.6, 2.4, 3.2, 4.0, & 5.0%

Through Crack Lengths: 0.01 – 0.5 in.

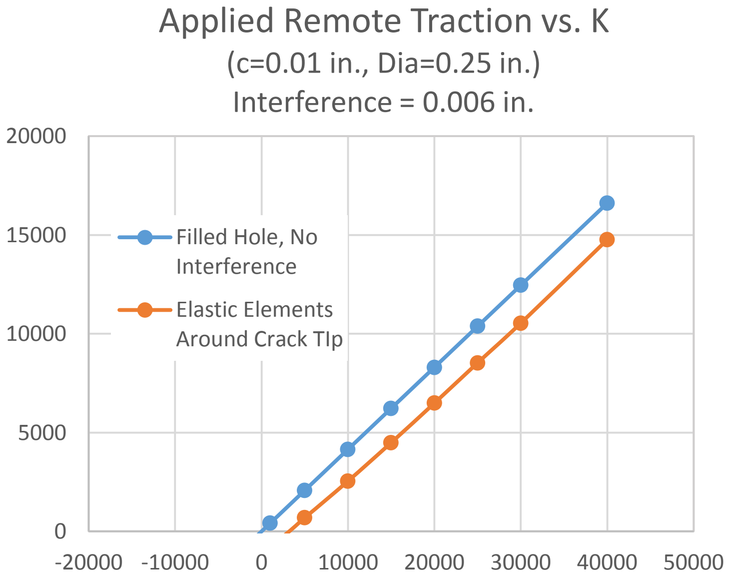
Low Interference Case (0.4%)

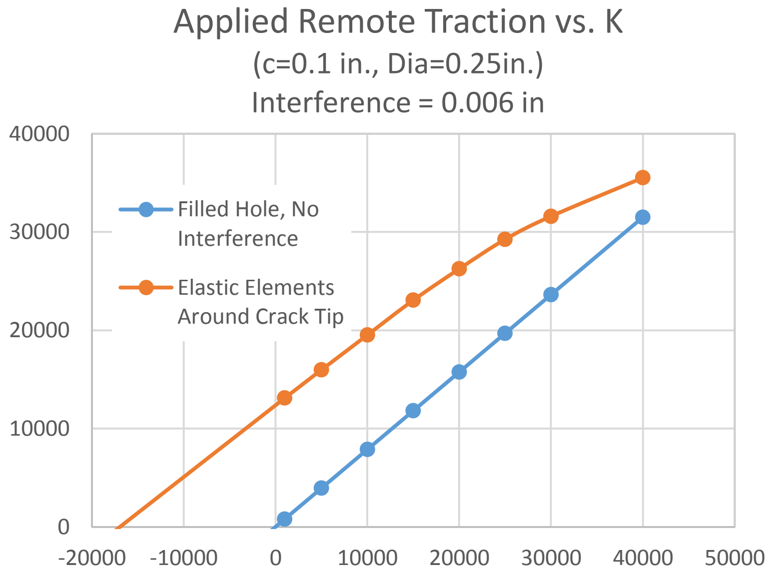


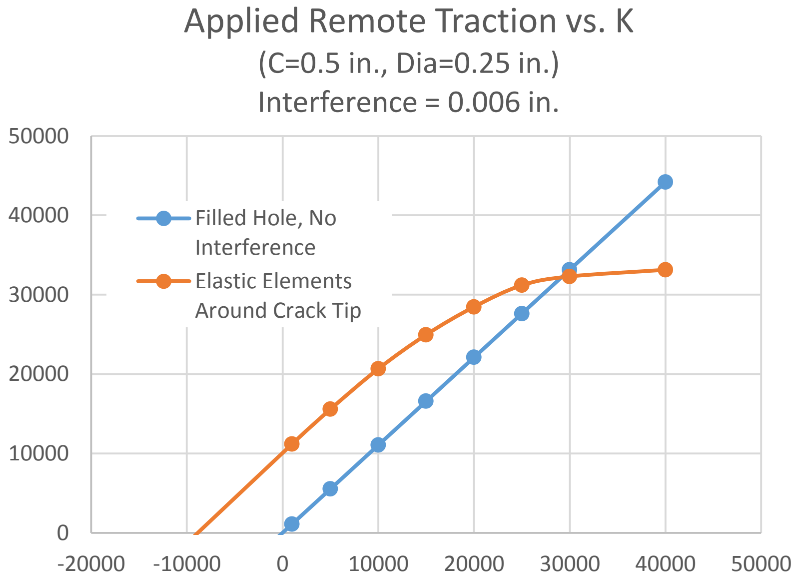




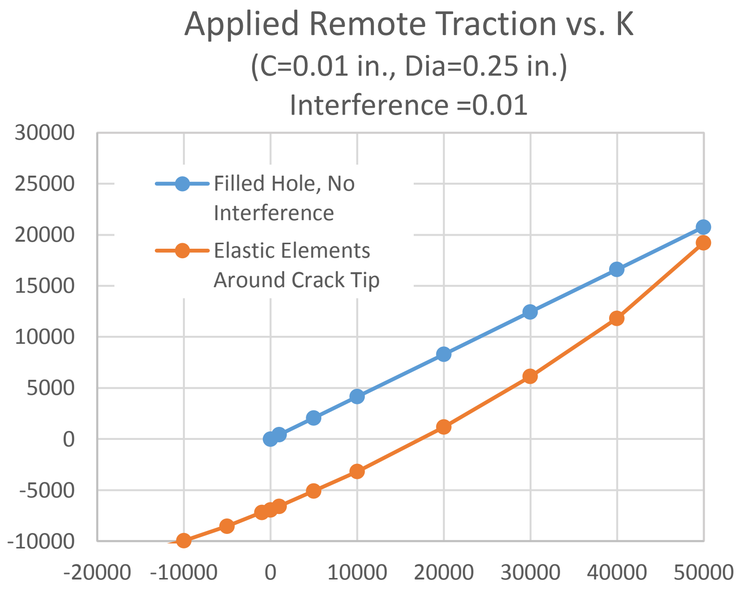
Moderate Interference Case (2.4%)

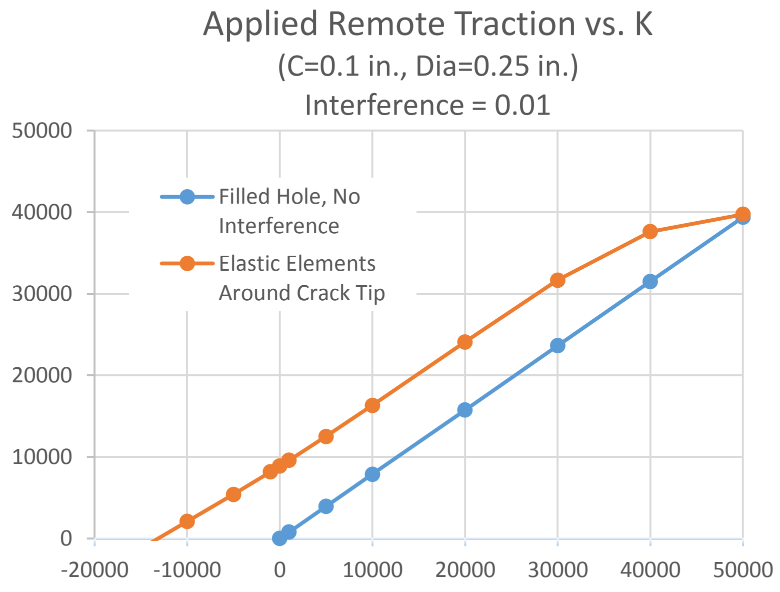


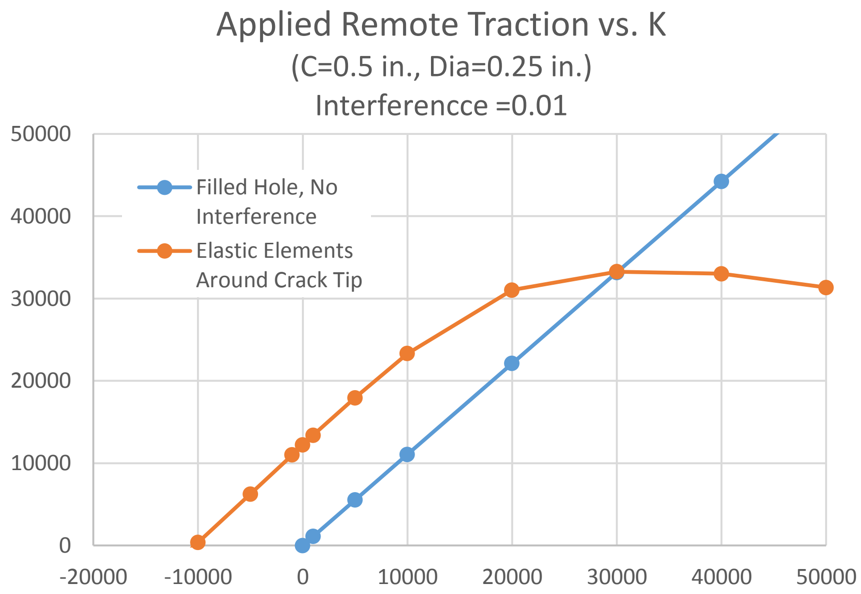




Moderate Interference Case (4.0%)







Discussion

Is this something that should be investigated further so that a solution for cracks at expanded holes can be added to AFGROW?