Modeling Bearing Load in Wide Panels Using AFGROW

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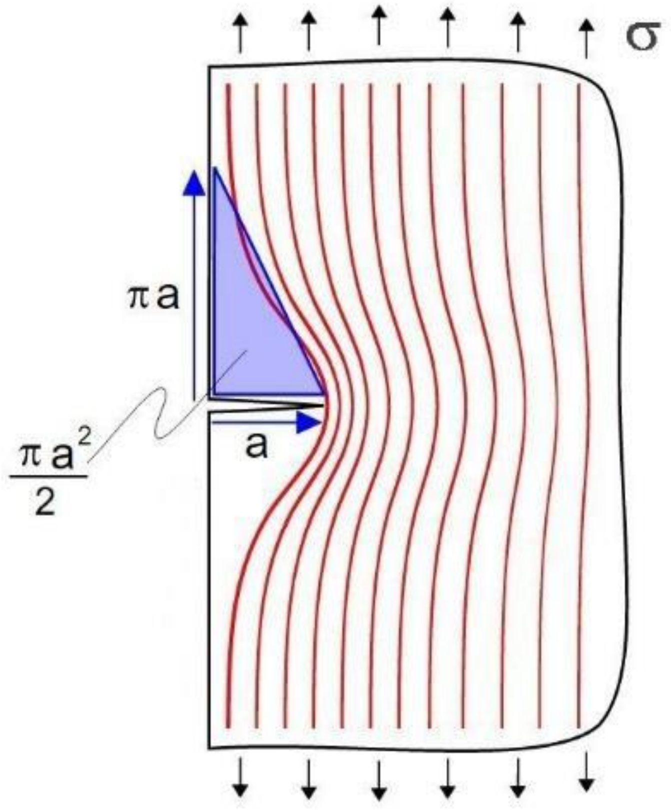
Stress Distribution Near a Bearing Loaded Hole

- When bearing load is applied at a hole, the distribution that is concentrated near the hole may not react uniformly – depending on where the reaction is measured as a function of the distance from the hole.

- As a rule of thumb, locally applied loads tend to flow from the point of application at approximately 35 degrees (total angle). This can be illustrated by the work of Charles Inglis (1913) for stress flow around an elliptical notch. This work was also used by A.A. Griffith to develop his strain energy release concept.

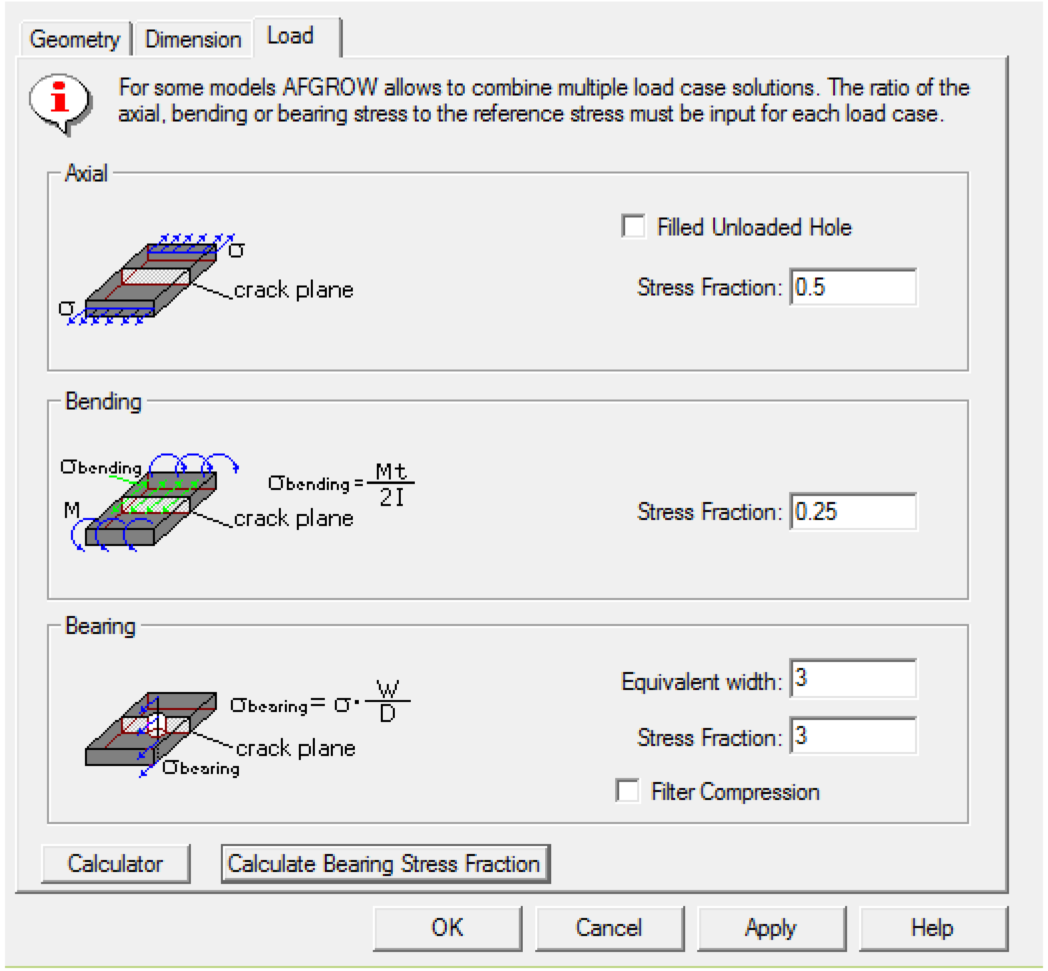
Charles Inglis' Stress Flow Around an Elliptical Notch

- Inglis showed that stress flow around the notch could be approximated by a turning angle of arc tan (1/pi) = 17.66 degrees. It may also be interesting to note that it is similar to the maximum turning angle for sub-sonic air flow.



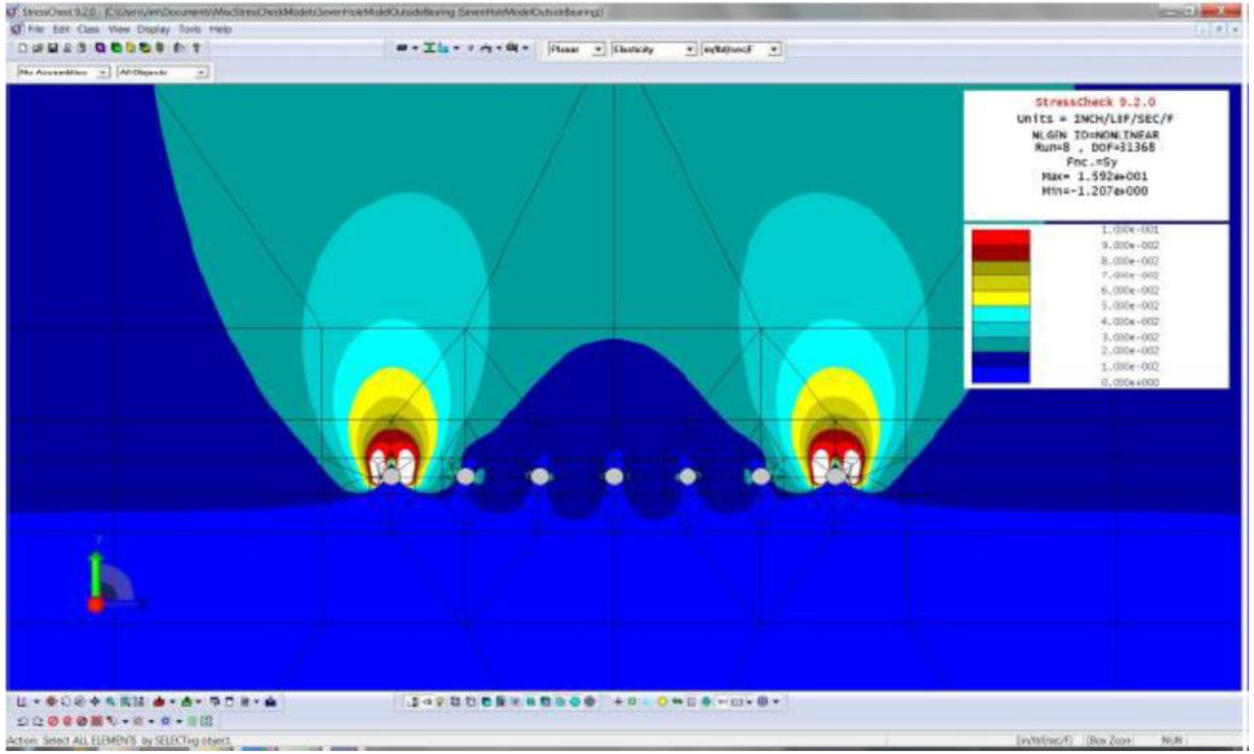
How AFGROW Calculates Beta values for Bearing Loaded Holes

- AFGROW's basic stress intensity solutions assume an "infinite" plate height
- The Current version of AFROW does not use different total width values to calculate beta values for each load case.
- AFGROW solution currently has the option to calculate the "equivalent" bearing stress fraction



Using “Effective” width

- The “effective” width is used to calculate the “effective” bearing stress fraction by assuming the bearing stress fraction is only reacted across this width .
- Modeling a row of fastener holes in a relatively wide plate under combined loading requires the user to estimate the “effective” width of the bearing portion



Calculate Stress Fractions for Combined Loading

A 0.25 in. dia. fastener hole in a 0.125 in. thick x 1.0 in. wide plate has a pin load of 200 lbs. The bypass stress is 10 ksi. The bending stress is 5 ksi. If you choose to use the remotely applied gross stress (bypass stress + bending stress + pin load/(width * thickness)) as the reference stress, then the total gross remote stress is:

10 ksi + 5 ksi + 200/(0.125 * 1.0) * 0.001 = 16.6 ksi

Therefore,

The axial stress fraction is: 10/16.6 = 0.6024

The bending stress fraction is: 5/16.6 = 0.3012

The bearing stress fraction is: (200/(0.25 * 0.125) * 0.001)/16.6 = 0.3855

Note: The AFGROW bearing solution is based on bearing stress, so the bearing stress fraction must take this into account. The multiplier, 0.001, converts the bearing stress to the standard ksiunits (when the English system of units are used in AFGROW)

The resulting K-solution becomes:

K = reference stress * (bearing stress fraction * bearing beta + bending stress fraction * bending

beta + axial stress fraction * axial beta) * SQRT (pi * crack length)

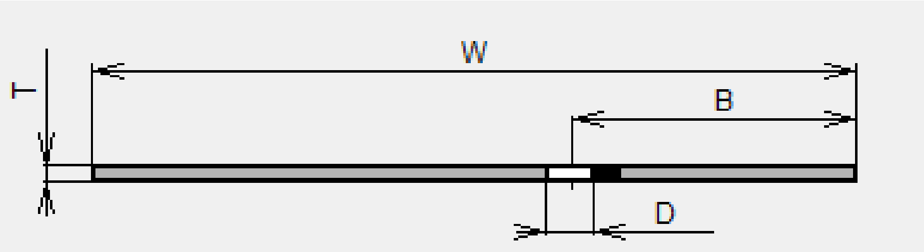
Problem

- AFGROW Bearing solut*ion for an offset hole is not appropriate for wide plates that can't be assumed to have an "infinite" height.*
- *For the "infinite" height, offset hole models, the bearing load moves very quickly to the wider side of the plate as the offset increases. For a crack on the near side of the plate, the contribution of the bearing load will quickly go to zero. This resulted in predicted lives that were higher as the bearing fraction increased.*

AFGROW and FEM Results comparison For Extreme Offset Case

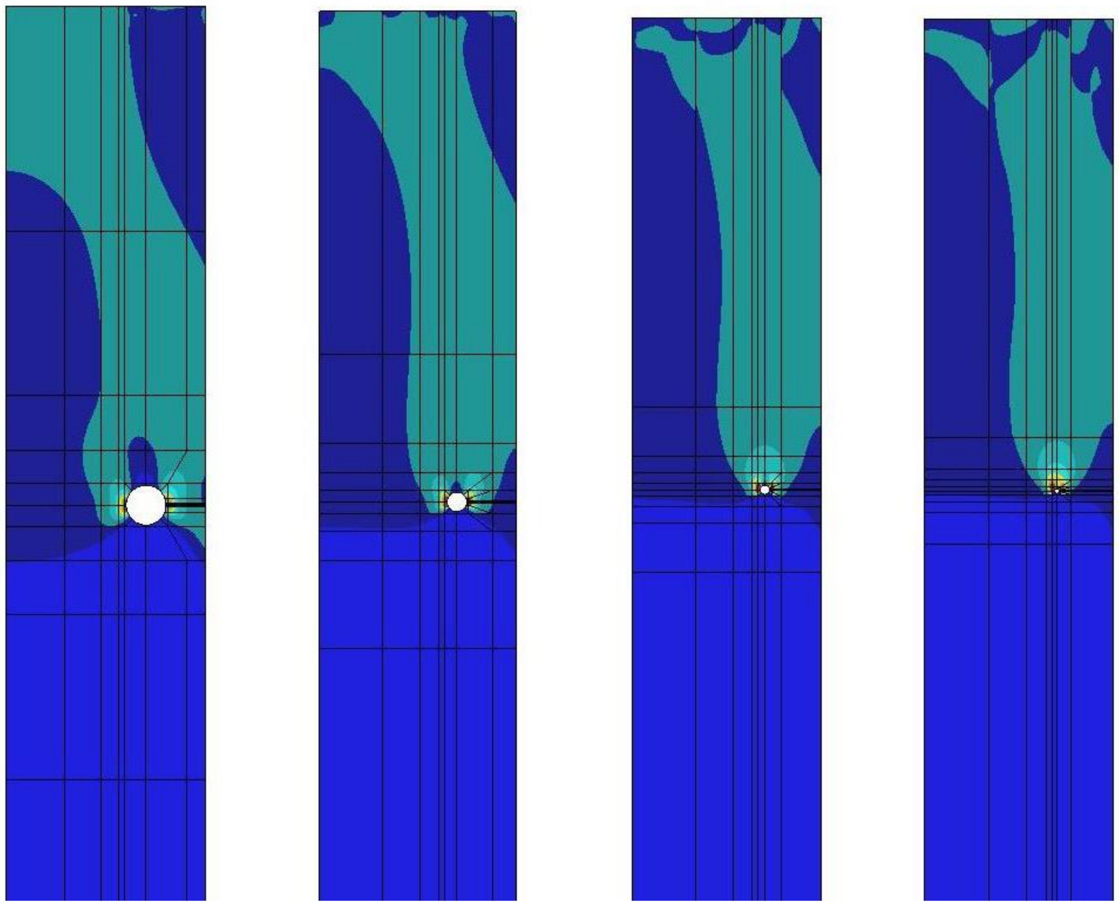
Width	Dia	B	W/D
8	0.25	1.2	32

Left	Right	AFGROW		Advanced Vs FEM % Difference		FEM Results	
C1	C2	Beta 1	Beta 2	Beta 1	Beta 2	Beta 1	Beta 2
0.050	0.050	0.52990	0.53110	-204.016	-235.290	0.1743	0.1584
0.125	0.125	0.31640	0.29850	-75.000	-79.928	0.1808	0.1659
0.200	0.200	0.24520	0.22380	-40.194	-41.377	0.1749	0.1583
0.400	0.200	0.14760	0.25700	3.655	-40.131	0.1532	0.1834
0.400	0.125	0.13530	0.35630	4.986	-74.486	0.1424	0.2042
0.500	0.050	0.10270	0.69480	19.766	-191.565	0.1280	0.2383



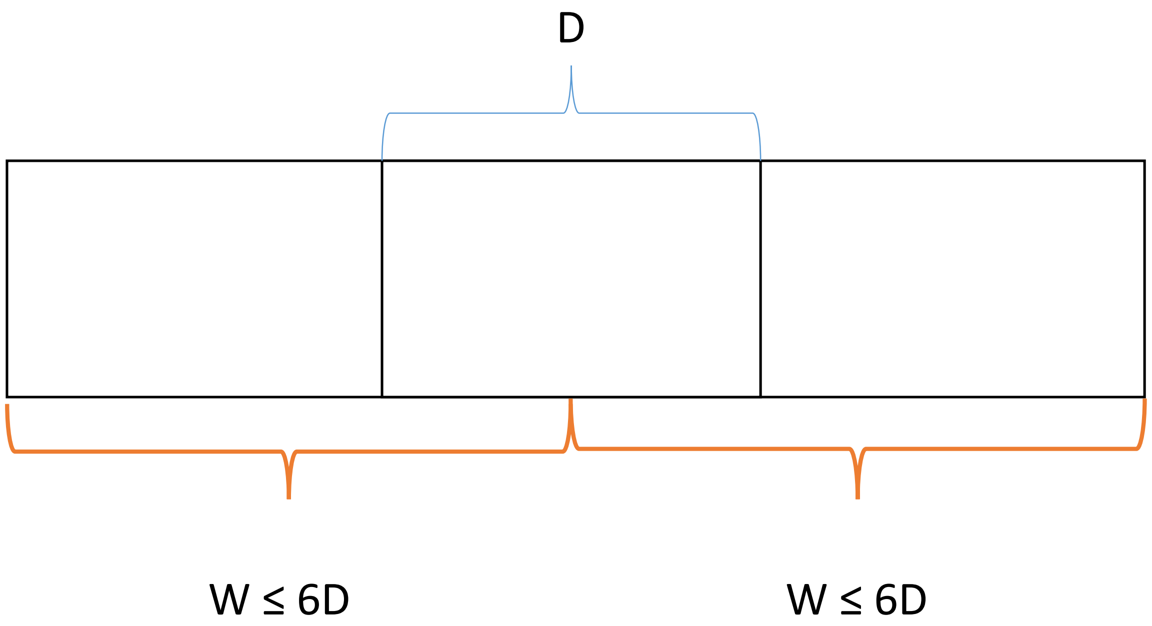
Fringe Plots for Bearing load Cases

- These models are constrained to prevent in-plane bending
- The fringe plot boundary between the dark blue and the turquois represents the bearing load reacted across the total panel width
- Plate height in these models are 5*W



Recommendation When modeling wide/offset plates with combined loading

- Adjust panel width so that the hole is not more than 6D from either edge.



Future Plans

- Incorporate a better method to handle this problem
- Possibly add the ability to set a different plate width for the bearing load solution for combined loading cases