# Bearing Solution
# &
# Boundary Condition Sensitivity

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For

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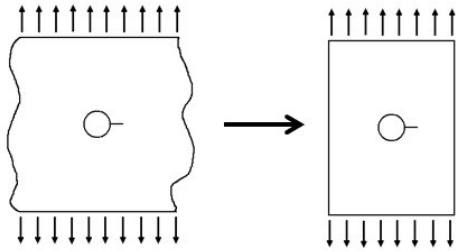
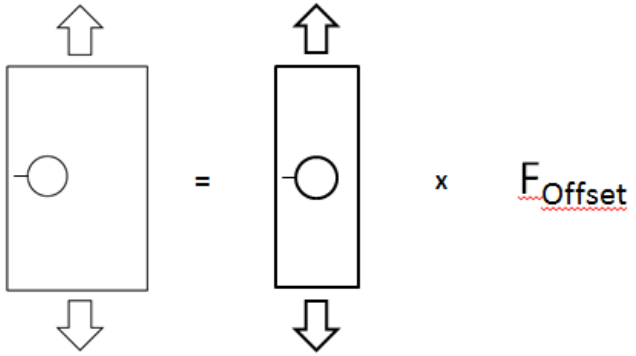
# Here We Go Again……

We have learned that:

The open hole width correction can not be applied to pin loaded holes



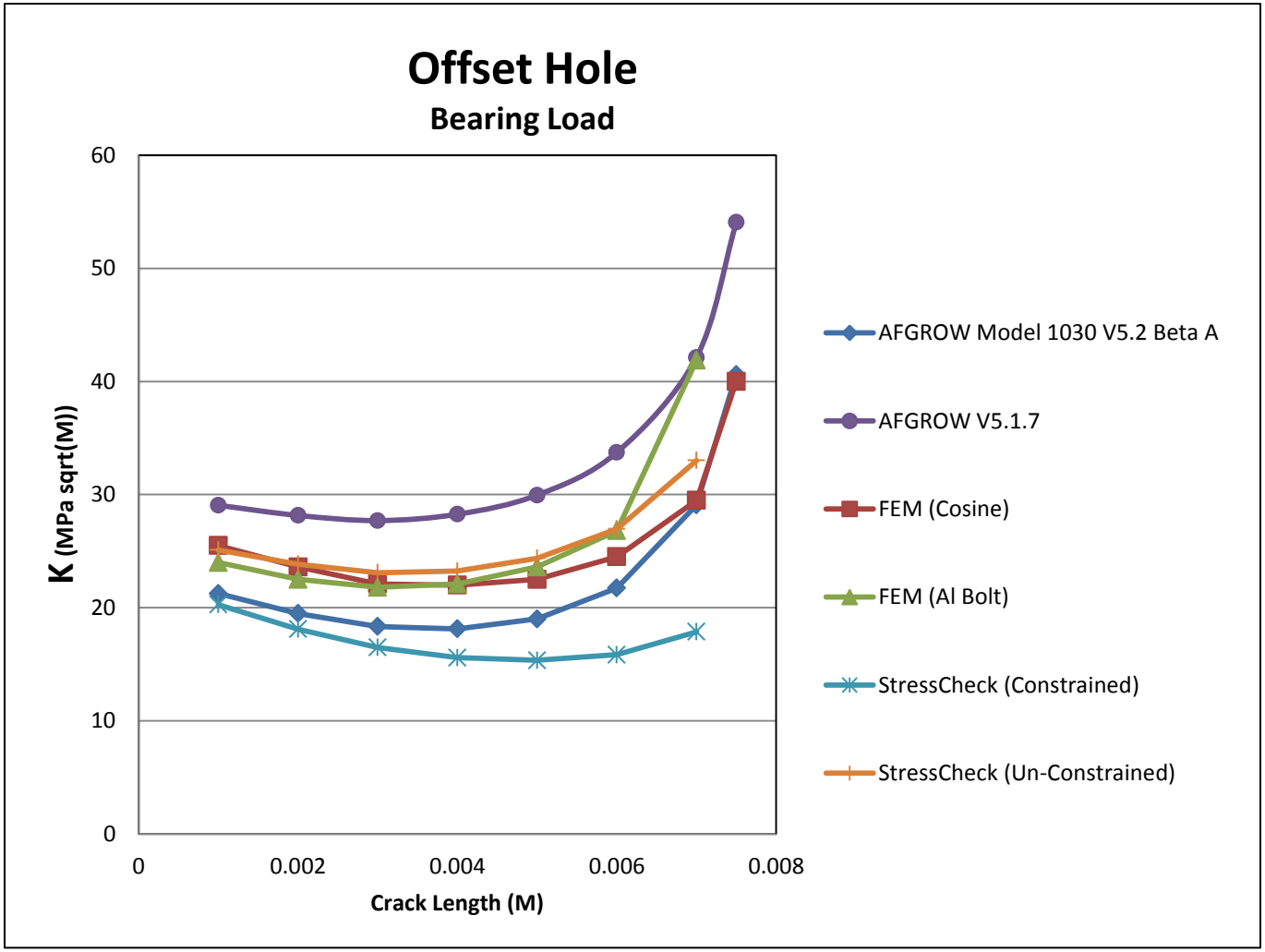
The open hole offset correction can't be applied to pin loaded holes



# Background

- The current Classic AFGROW bearing solution is a tabular solution developed using StressCheck for an un-constrained (in-plane) plate with springs simulating the pin loading
- The new bearing correction was curve fit to StressCheck models for offset/centered holes in constrained plates with springs

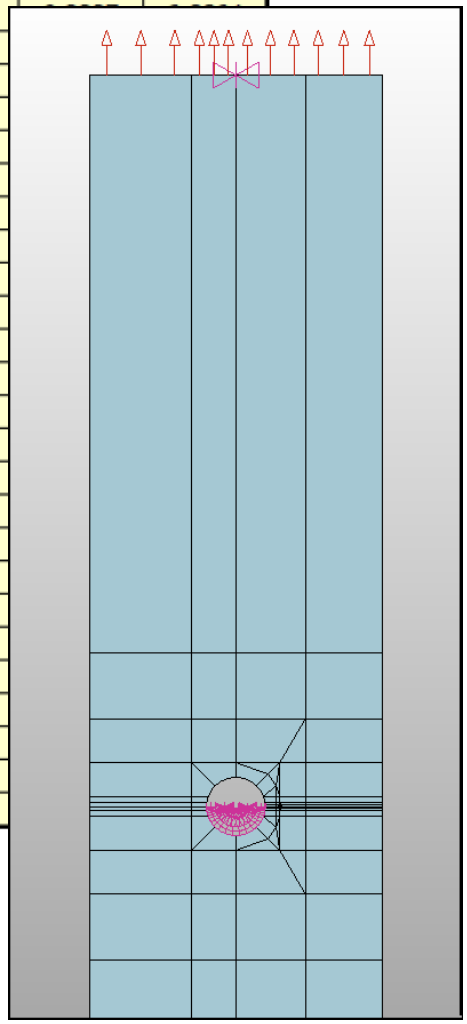
# Bearing Solutions w/Various B.C.s



# Baseline Tabular Bearing Solution

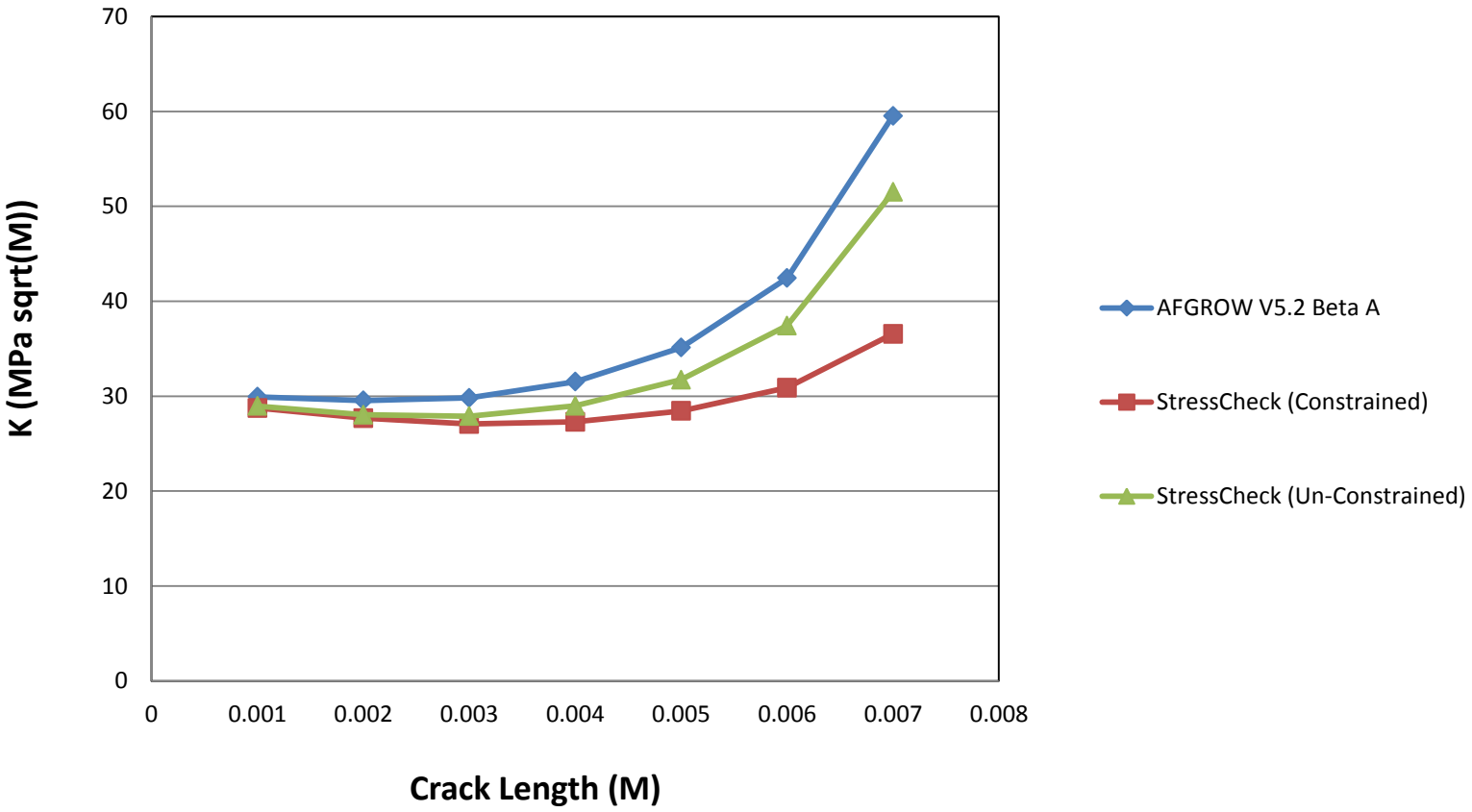
| C/(C+R)* | W/D | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1.3 | 1.5 | 2 | 2.5 | 3 | 4 | 8 | 16 | 40 | 100 | 1000 |
| 0.000 | 4.5150 | 3.2000 | 2.3000 | 1.9050 | 1.7000 | 1.5260 | 1.1970 | 1.0363 | 0.8898 | 0.8787 | 0.8700 |
| 0.025 | 4.4348 | 3.1133 | 2.1487 | 1.7332 | 1.5689 | 1.3885 | 1.1186 | 0.9769 | 0.8433 | | |
| 0.050 | 4.3594 | 3.0331 | 2.0200 | 1.6001 | 1.4500 | 1.2794 | 1.0493 | 0.9186 | 0.7898 | | |
| 0.100 | 4.2414 | 2.9165 | 1.8701 | 1.4564 | 1.2750 | 1.1216 | 0.9293 | 0.8080 | 0.6813 | | |
| 0.150 | 4.1913 | 2.8540 | 1.7914 | 1.3565 | 1.1614 | 0.9983 | 0.8245 | 0.7082 | 0.5855 | | |
| 0.200 | 4.1908 | 2.8098 | 1.7202 | 1.2757 | 1.0821 | 0.9020 | 0.7298 | 0.6222 | 0.5110 | | |
| 0.250 | 4.2037 | 2.7745 | 1.6356 | 1.2060 | 1.0158 | 0.8239 | 0.6424 | 0.5387 | 0.4457 | | |
| 0.300 | 4.2198 | 2.7460 | 1.5612 | 1.1429 | 0.9465 | 0.7532 | 0.5636 | 0.4691 | 0.3908 | | |
| 0.350 | 4.2455 | 2.7228 | 1.4990 | 1.0854 | 0.8795 | 0.6861 | 0.4960 | 0.4131 | 0.3415 | | |
| 0.400 | 4.2876 | 2.7054 | 1.4435 | 1.0333 | 0.8222 | 0.6250 | 0.4380 | 0.3594 | 0.2958 | | |
| 0.450 | 4.3526 | 2.6950 | 1.3959 | 0.9860 | 0.7720 | 0.5729 | 0.3843 | 0.3101 | 0.2549 | | |
| 0.500 | 4.4414 | 2.6935 | 1.3562 | 0.9430 | 0.7266 | 0.5268 | 0.3358 | 0.2673 | 0.2178 | | |
| 0.550 | 4.5460 | 2.7046 | 1.3248 | 0.9037 | 0.6867 | 0.4883 | 0.2928 | 0.2265 | 0.1849 | | |
| 0.600 | 4.6575 | 2.7330 | 1.3025 | 0.8691 | 0.6520 | 0.4560 | 0.2553 | 0.1885 | 0.1539 | | |
| 0.650 | 4.7670 | 2.7829 | 1.2912 | 0.8417 | 0.6227 | 0.4226 | 0.2222 | 0.1572 | 0.1274 | | |
| 0.700 | 4.8895 | 2.8581 | 1.2936 | 0.8257 | 0.5997 | 0.3981 | 0.1954 | 0.1320 | 0.1069 | | |
| 0.750 | 5.1337 | 2.9620 | 1.3151 | 0.8200 | 0.5844 | 0.3798 | 0.1751 | 0.1117 | 0.0873 | | |
| 0.800 | 5.4893 | 3.1043 | 1.3652 | 0.8259 | 0.5800 | 0.3630 | 0.1540 | 0.0920 | 0.0695 | | |
| 0.825 | 5.6639 | 3.2000 | 1.4069 | 0.8399 | 0.5837 | 0.3582 | 0.1445 | 0.0832 | 0.0616 | | |
| 0.850 | 6.0283 | 3.3351 | 1.4654 | 0.8640 | 0.5933 | 0.3586 | 0.1355 | 0.0759 | 0.0539 | | |
| 0.875 | 6.8300 | 3.5963 | 1.5459 | 0.8800 | 0.6113 | 0.3666 | 0.1269 | 0.0700 | 0.0459 | | |
| 0.900 | 8.1821 | 4.0870 | 1.6728 | 0.9026 | 0.6427 | 0.3810 | 0.1205 | 0.0639 | 0.0378 | | |
| 0.925 | 9.9887 | 4.8792 | 1.8506 | 1.1291 | 0.6979 | 0.3970 | 0.1191 | 0.0555 | 0.0316 | | |
| 0.950 | 12.1363 | 5.9209 | 2.2067 | 1.6711 | 0.7968 | 0.4400 | 0.1145 | 0.0470 | 0.0255 | | |
| 0.975 | 14.5111 | 7.1289 | 2.9777 | 2.4350 | 1.0919 | 0.6033 | 0.1473 | 0.0734 | 0.0235 | | |
| 1.000 | 16.9997 | 8.4200 | 3.9000 | 3.3100 | 1.6000 | 0.8510 | 0.2920 | 0.1380 | 0.0670 | | |

Values were normalized as: $\frac{C/(C+R)}{(1-D/W)}$



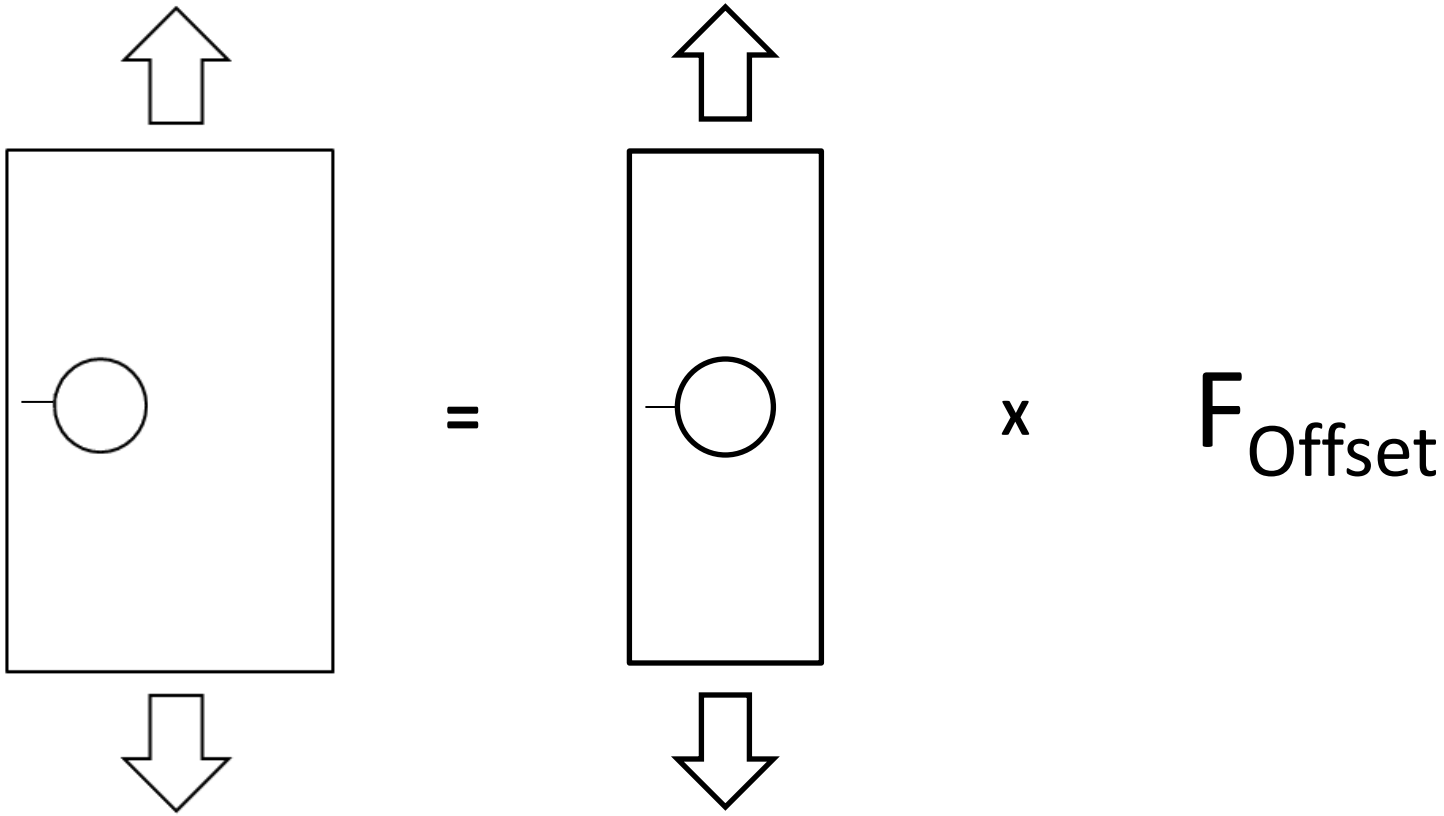
# Centered Hole

W=0.02M, D=0.004M



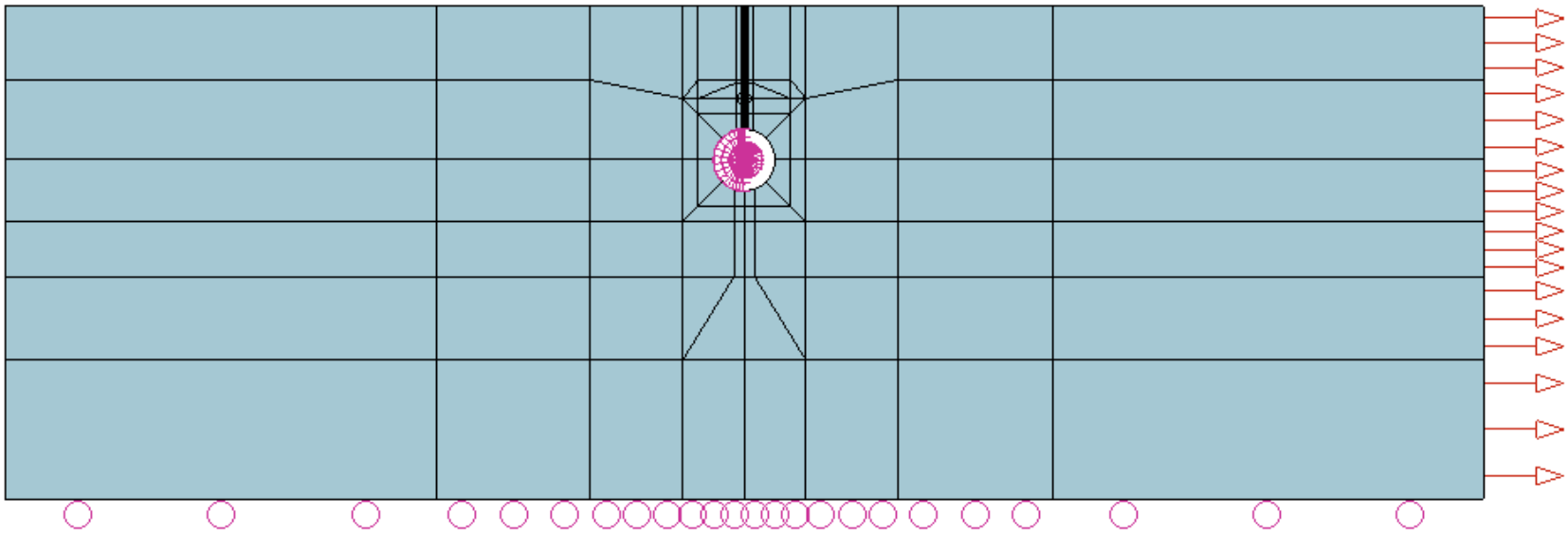

Difference appears to be the result of interpolation error

# Compounded Offset Correction



# New Bearing Offset Correction

## FEM* Boundary Conditions



Model Thickness = 1.0
Loading to produce a unit resultant force at the hole (1/W)
Spring ($E_{Spring}$ = 3X $E_{Plate}$) B.C. along ½ hole

* StressCheck (ESRD, Inc.)

# Discussion

- Our original thinking was biased by axial load case behavior (much less bending for the axially loaded single cracked, centered hole case)
- Curve fitting was more difficult for the un-constrained cases
- Assumed that most practical cases are constrained by sub-structure
- Although the new solution is improved, it may be conservative in some cases (fully constrained cases)
- The spline interpolation used to interpolate the solution for the baseline centered hole solution can introduce some error. Adding one or two more W/D solutions would improve the results (I have completed this work)
- Underscores the need to continue moving to real-time K-solutions using an external solver for specific geometries
- This issue warrants more consideration depending on user interest