LexTech

AFGROW.NET

AFGROW Workshop 2010 - Layton, UT

Lessons Learned While Developing K-Solutions for Pin Loaded Holes

James A. Harter

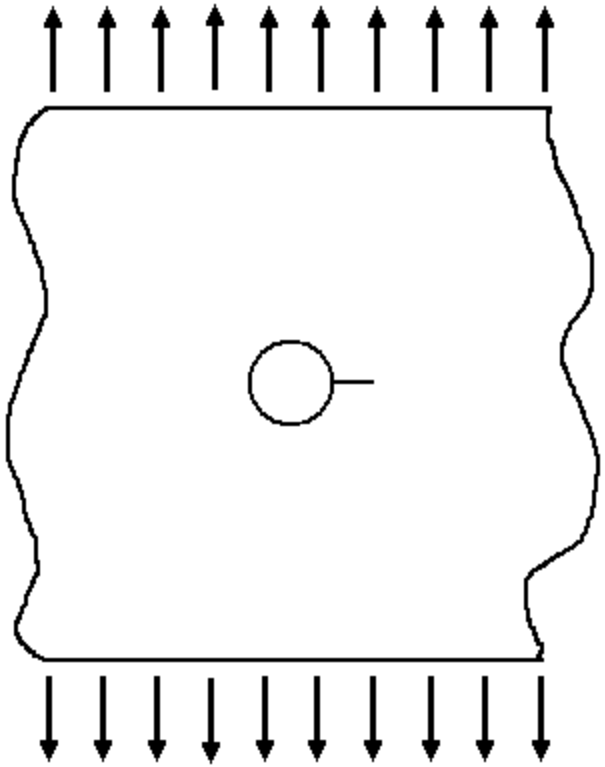
for

LexTech, Inc.

Outline

- Historical Background
  - Closed Form and Handbook K-Solutions
  - Advanced Solution Database
- Compounding/Superposition Methods
- Finite Width Correction for Axial and Bearing Loads
- Offset Hole Correction
  - Axial Loading
  - Bearing Loading
- Status of the New Offset Correction for Bearing Load

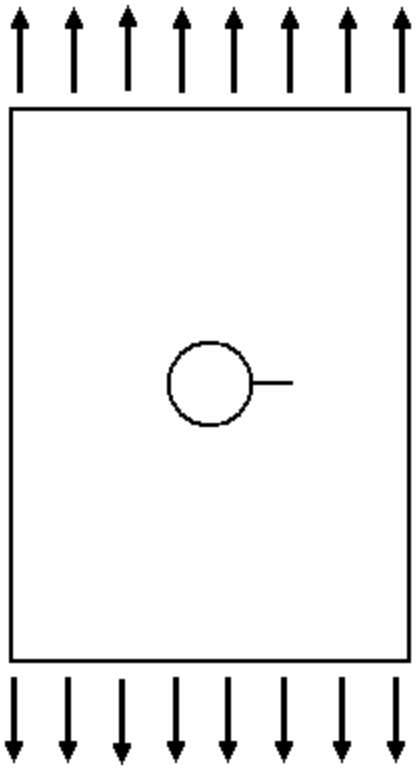
Typical Closed-Form/Handbook Solution



$$\beta_{ref} = 0.7071 + 0.7548\,(R/(R+C)) + 0.3415\,(R/(R+C))^2 + 0.642\,(R/(R+C)^3 + 0.9196\,(R/(R+C)^4$$

Accounts for the effect of the hole on the stress intensity at the crack tip

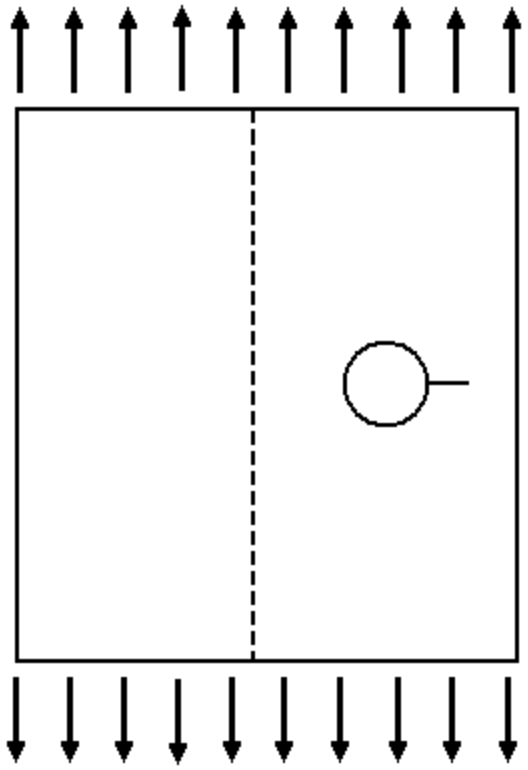
Finite Width Correction



$$\beta = \beta_{ref} \; F_w$$

Accounts for the finite width effect on the stress intensity at the crack tip

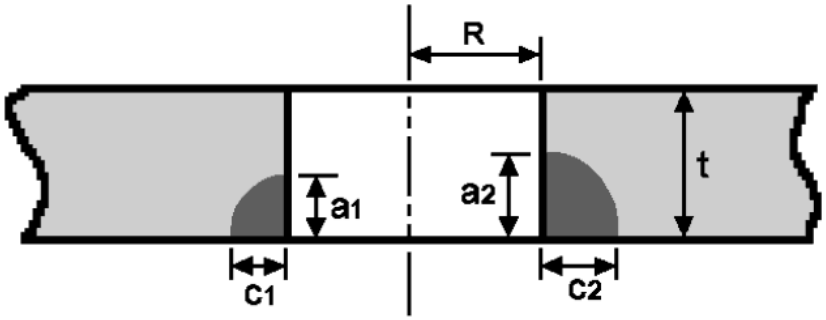
Hole Offset Correction



$$\beta = \beta_{ref} \; F_w \; F_{offset}$$

Accounts for the hole offset effect on the stress intensity at the crack tip

Fawaz Non-Symmetric Corner Crack FEM K-Solution Database



Load Cases: Axial, Bending, & Bearing

W/D : 100 (approximates an infinite plate)

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, 1.0, 1.25, 1.33, 1.5, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0

a_1/c_1, a_2/c_2: 0.1, 0.111, 0.125, 0.1428, 0.1667, 0.2, 0.25, 0.333, 0.5, 0.667, 0.75, 0.8, 1.0, 1.25, 1.33, 1.5, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0

a_1/t, a_2/t: 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 0.95, 0.99

75,625 models per load case

How Can This Database be Used to Obtain K-Solutions for Finite Plates w/Offset Holes?

COMPOUNDING

$$\beta = \beta_{ref} \; F_w \; F_{offset}$$

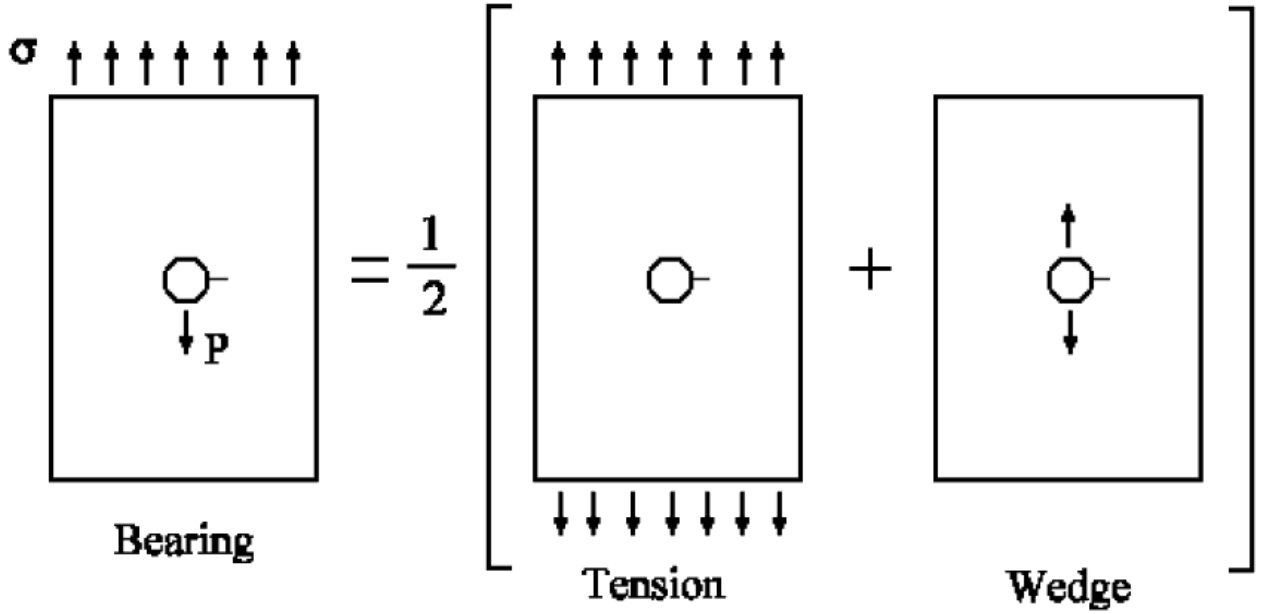
Applicability Issue

Finite width & offset corrections were developed for the axial load case

Are they applicable to the bending and bearing load cases?

Not for the bearing case

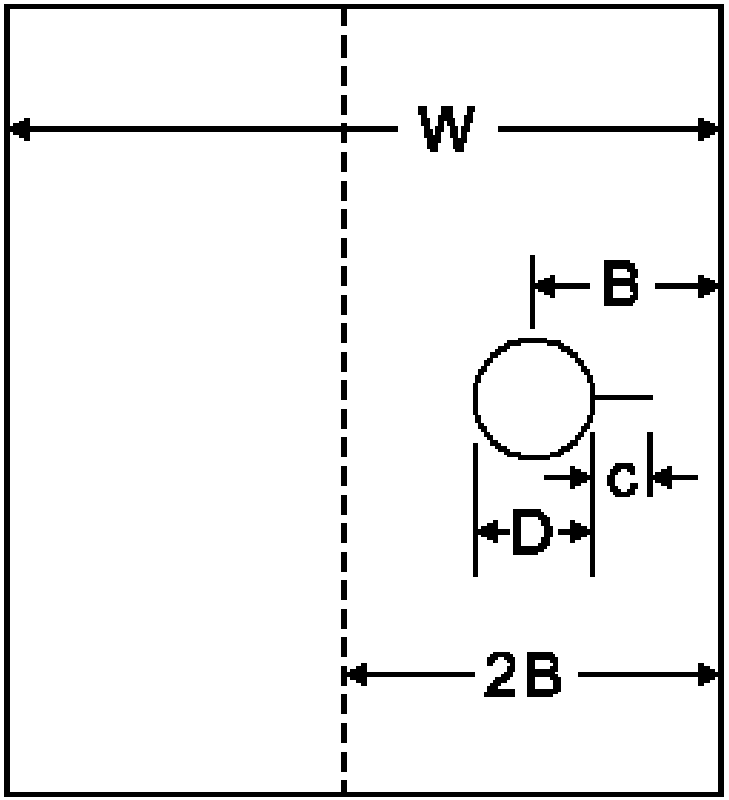
Bearing (Pin) Load Solution by Superposition



$$\beta_{Bearing} = \left(\frac{D}{2W}\right) \beta_{Axial} + \beta_{Bearing(W/D=100)} * F_{wp} \text{ ; (for any given plate width)}$$

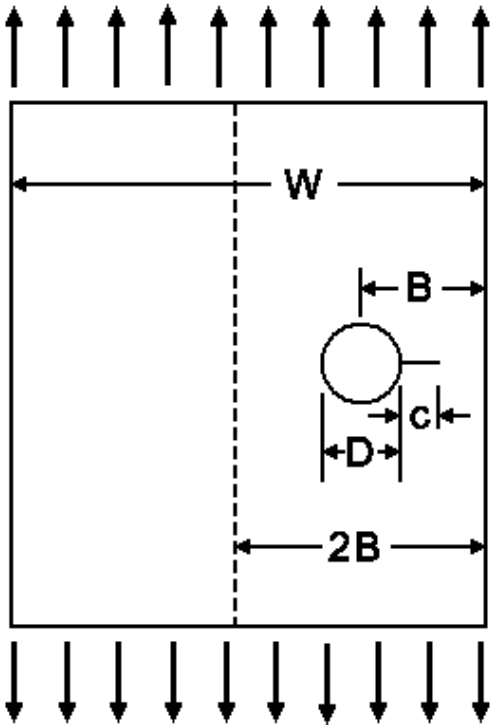
Where, F_{wp} = Finite Plate Correction for the infinite plate bearing solution

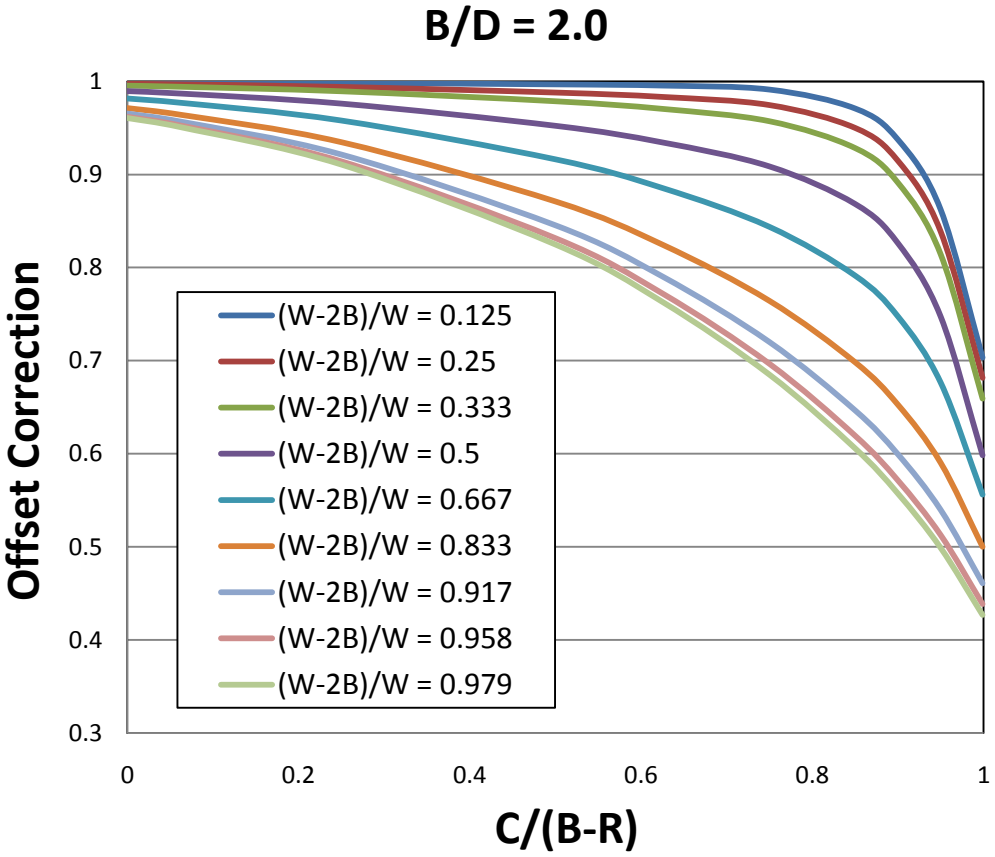
Offset Correction



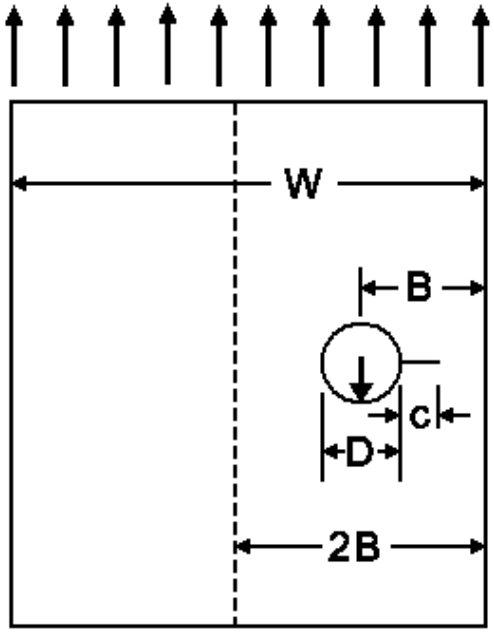
$$F_{Offset} = \frac{K_{Offset}}{K_{Centered\ Hole\ (W=2B)}}$$

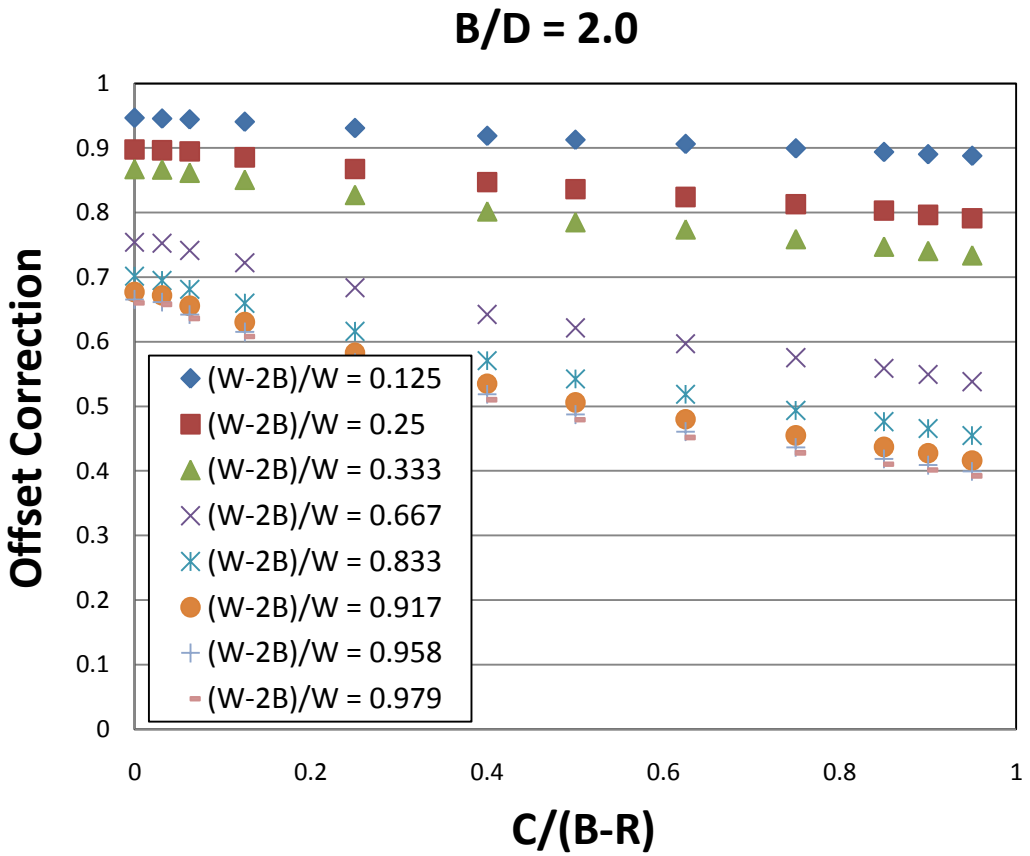
Axial Load Case



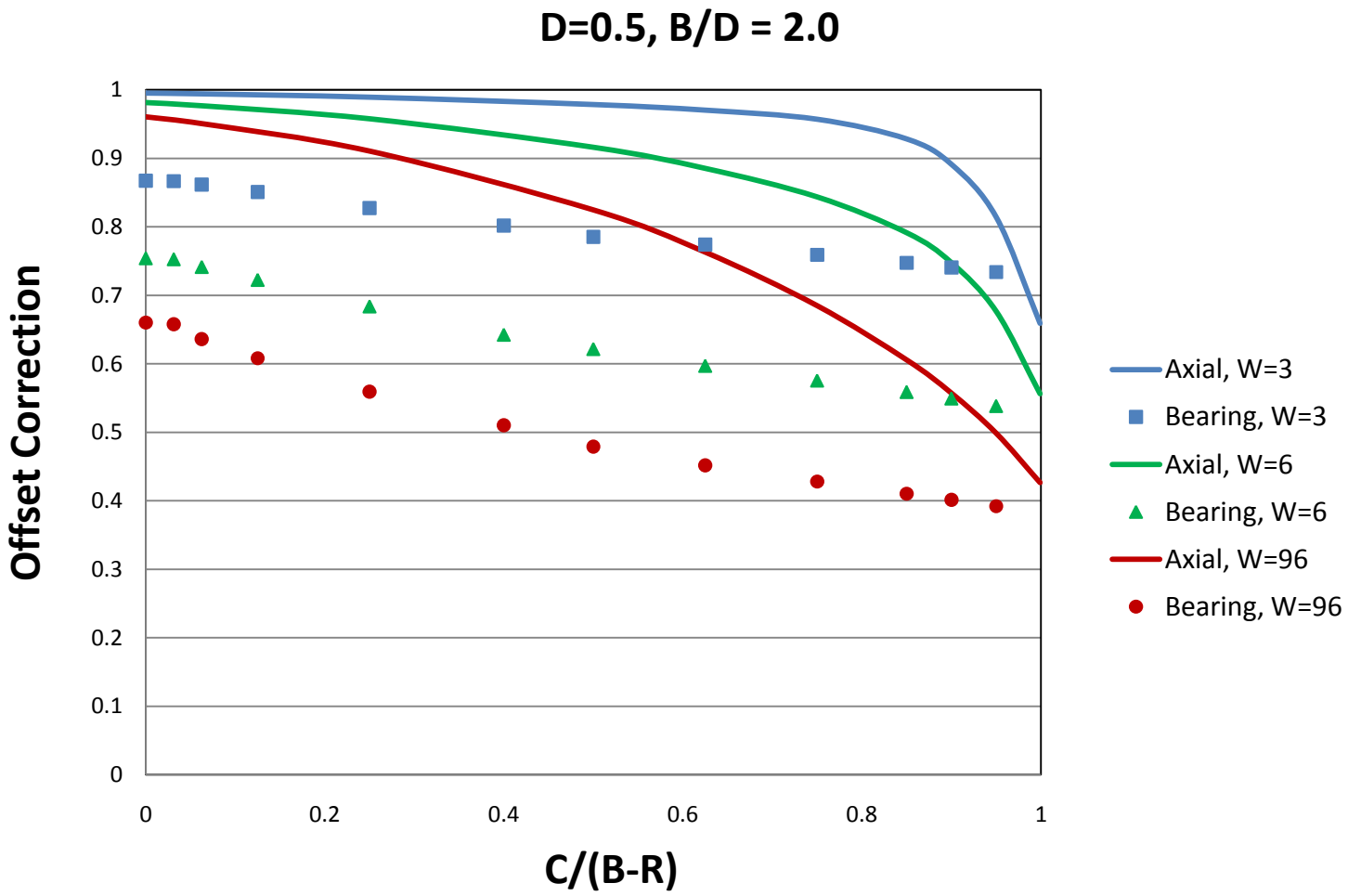


Bearing Load Case

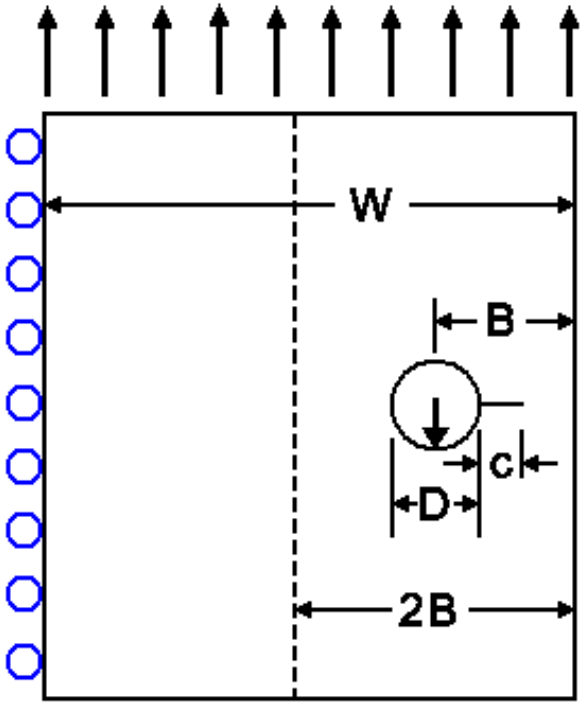




Direct Comparison



Bearing Offset Correction Status



FEM Solutions Completed

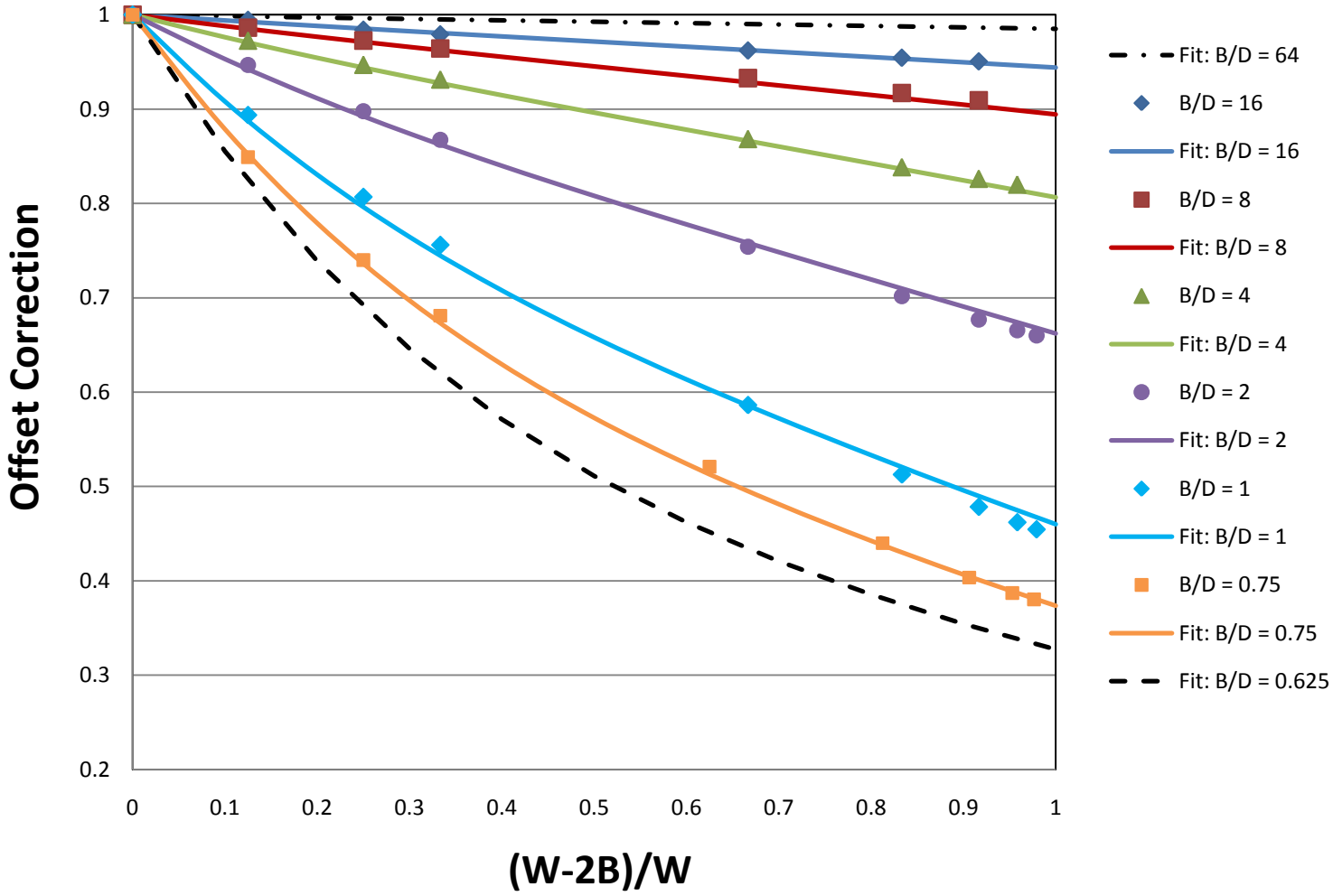
B/D = 0.75, 1, 2, 4, 8, 16

(W-2B)/W = 0.125, 0.25, 0.333, 0.667, 0.833, 0.917, 0.958, 0.979

C/(B-R) = 0.0* – 0.95 (depending on B/D)

* Offset correction determined by: $\mathbf{K_{T(offset)}/K_{T(center)}}$

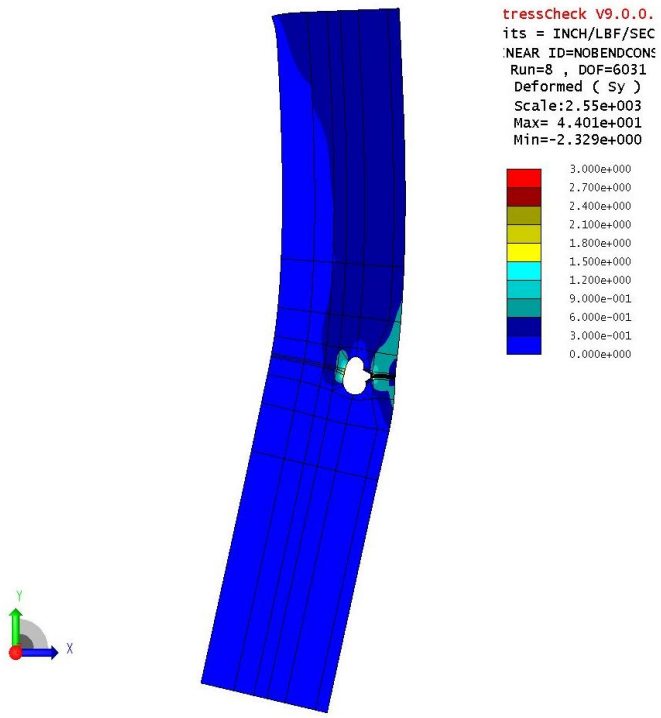
Bearing Offset Correction for Zero Crack Length



Work to be Completed

- Extend Curve Fit to Account for Crack Length
- Model Cases for a Crack Growing to the Far Edge
- Develop Curve Fit for the Far Edge Solution
- Beta Testing
- Incorporate in Next Major Release

Off the Record



Boundary Condition Issues Can be Very Problematic for the Bearing Offset Correction