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AFGROW Users Workshop 2024

Overview of New and Updated Advanced Model Solutions

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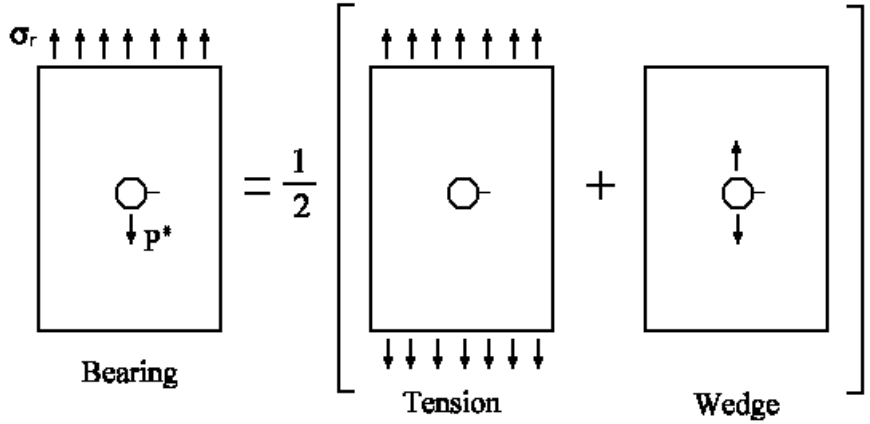
Introduction

- This presentation will overview
  - The updated bearing finite width correction for part-through/through cracks in AFGROW 5.4.5
  - Three updated solutions coming to the AFGROW Advanced Models toolbox in AFGROW 5.5
  - The beginning stages of development for the updated countersunk at hole solution
  - All four new and updated solutions include an expanded solution range and higher data resolution resulting in increased fidelity and decreased reliance on interpolation for most solutions use cases.

Advanced Model Part-Through/Through Cracks – Bearing Finite Width Correction

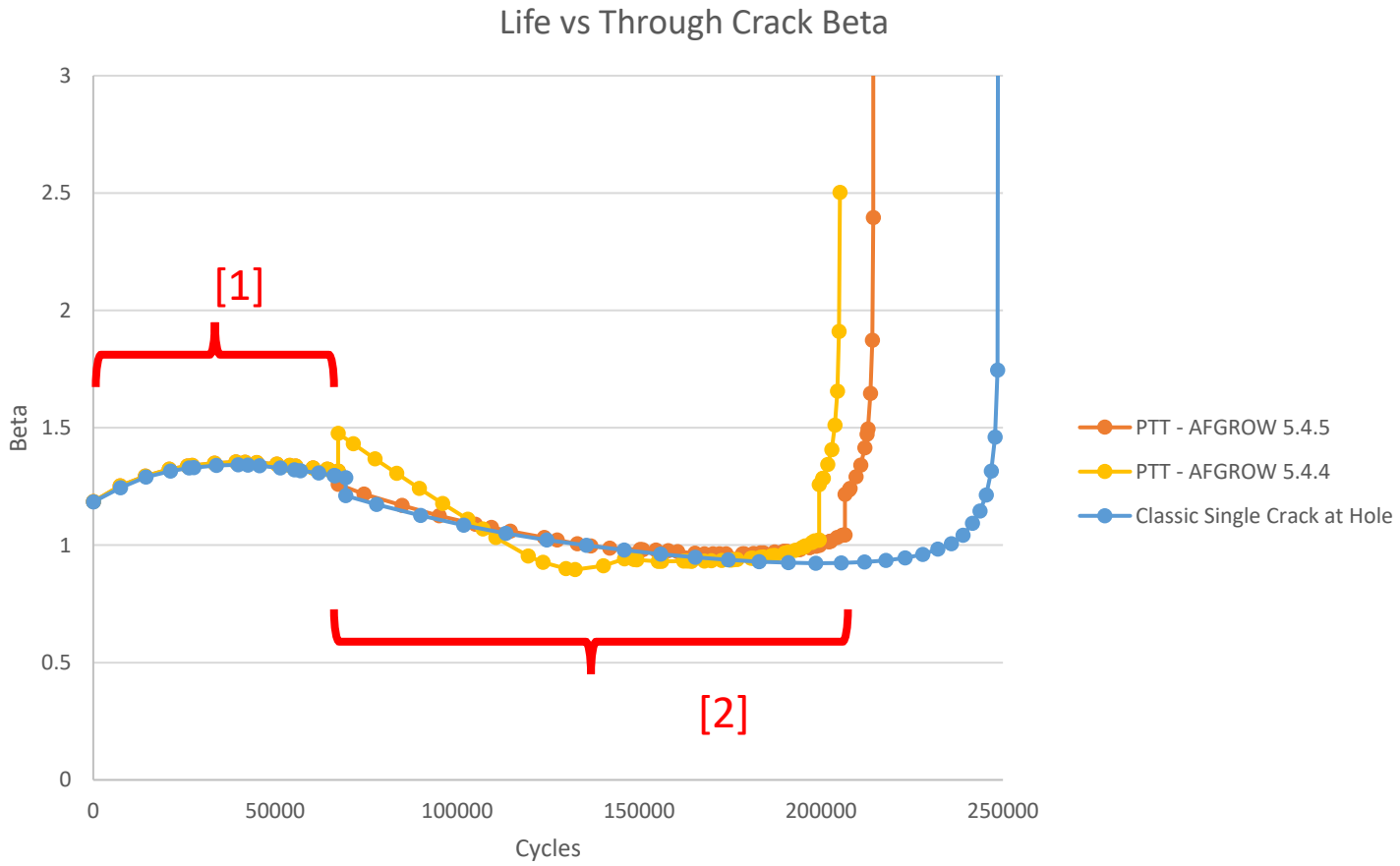
- The original bearing solution involved superimposing tension and wedge solutions to approximate the pin loading solution for a through crack at a hole. The finite width correction for the wedge loading was developed using a limited number of FE analyses for two non-symmetric corner cracks.



Advanced Model Part-Through/Through Cracks – Bearing Finite Width Correction

- This year, a jump in beta values were observed when a crack transitioned from a corner crack to a through crack. This jump in betas can be attributed to the method of superposition being used, as well as the finite width effect for the wedge loading being originally developed for non-symmetric corner cracks, not through cracks.
- Using the newer finite width through crack at hole solution developed with FEA data, we were able to make a general finite width effect that can be applied directly to the bearing vertex betas (instead of using the superposition approach).

Through Crack Finite Width Correction - Bearing



Beta C

Beta C

Symmetric Oblique Cracks

- An updated symmetric oblique solution will be included with AFGROW 5.5
- This solution was generated using a subset of BARE's Corner and Oblique crack data set
- The new solution includes a wider range of model dimensions
- The new solution data exhibits more consistent behavior when plotted across its parameters.

Symmetric Oblique Cracks - Vertex Calculation

- The C vertex was calculated by finding the local maximum near the surface of the crack in the C direction
- The A vertex was calculated with an analytic formula provided by BARE that provides a K value at 1% of the thickness of the specimen
- The analytic solution allows for consistent Ks even when the crack front Ks go to infinity when reaching the surface of the specimen.

Symmetric Oblique Valid Ranges

- New Symmetric Oblique Solution Limits
  - 0.1 <= r/t <= 10.0
  - 1.05 <= a/t <= 10.0
  - 0.1 <= a/c <= 10.0
- Old Symmetric Oblique Solution Limits
  - 0.2 <= a/c <= 2.0
  - 1.05 <= a/t <= 10.0
  - 0.5 <= r/t <= 2.0

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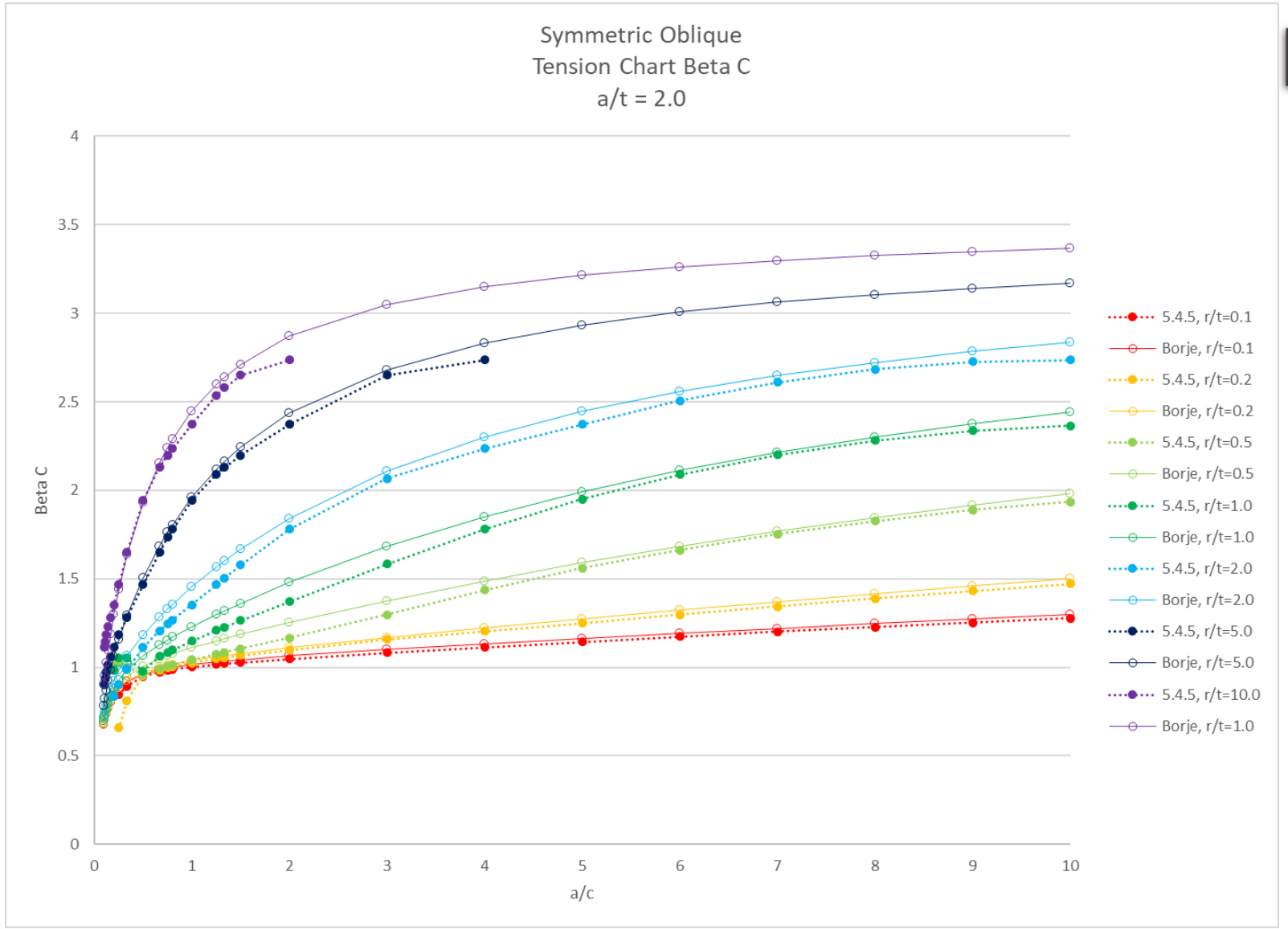

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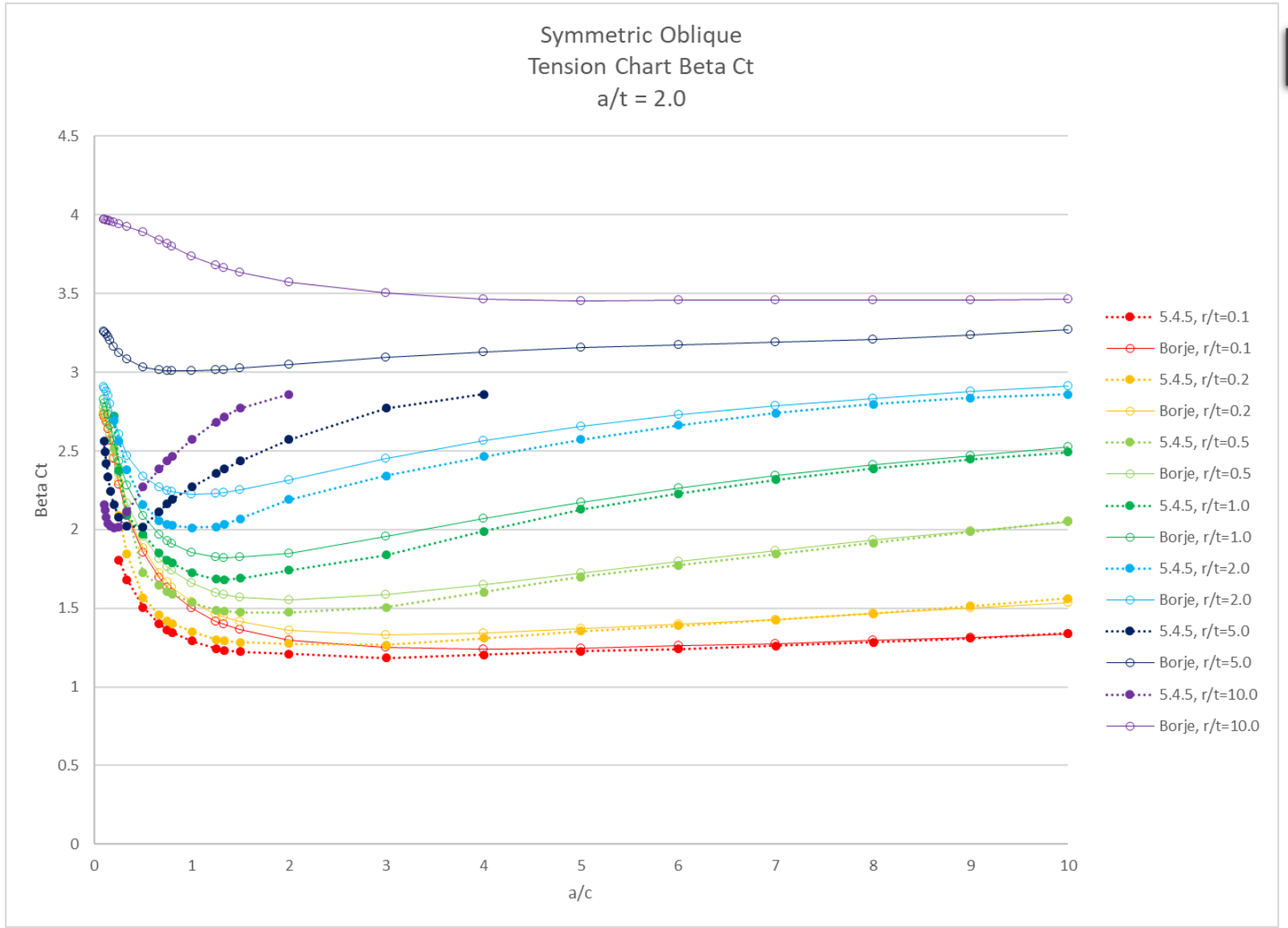

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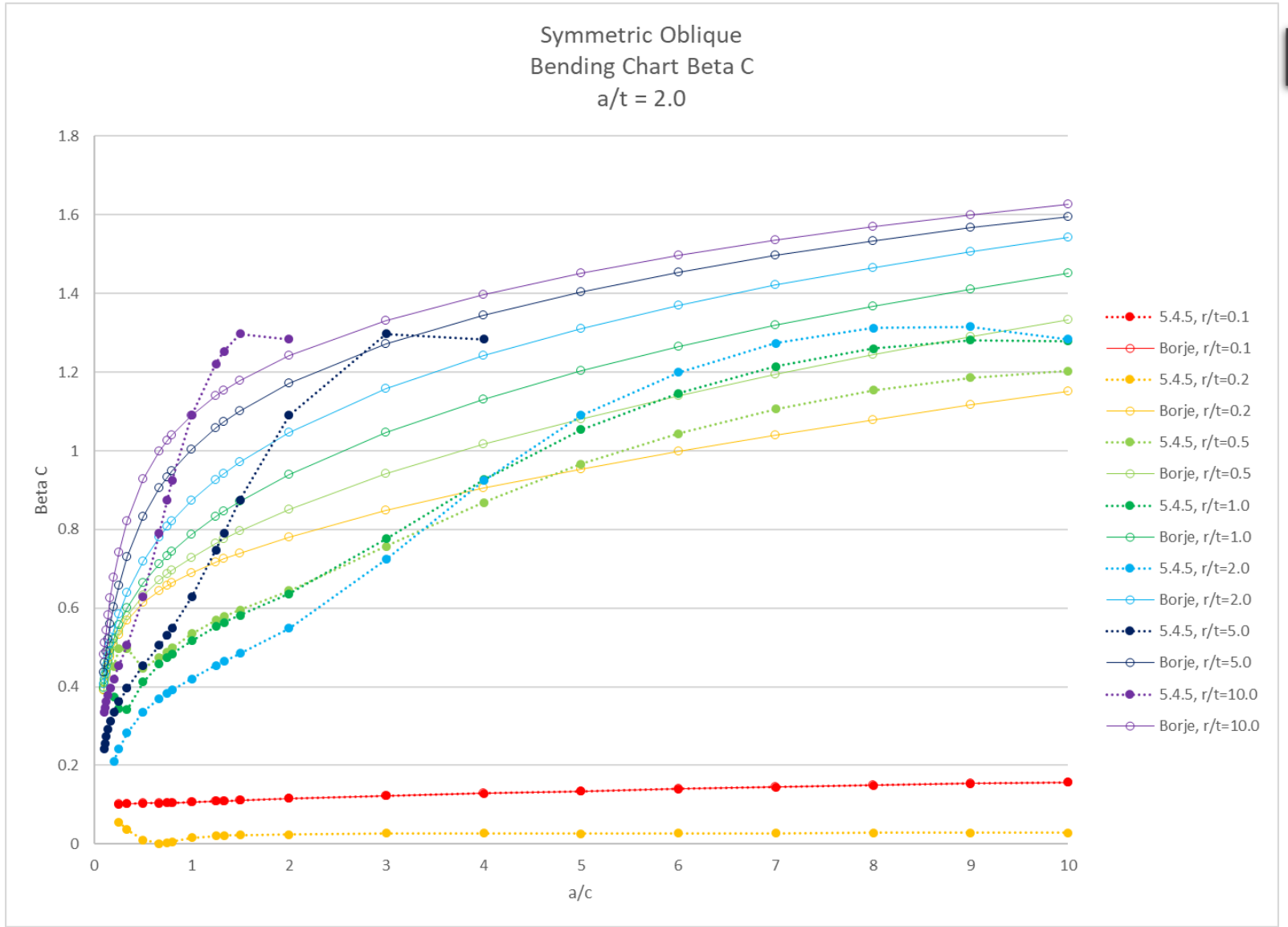

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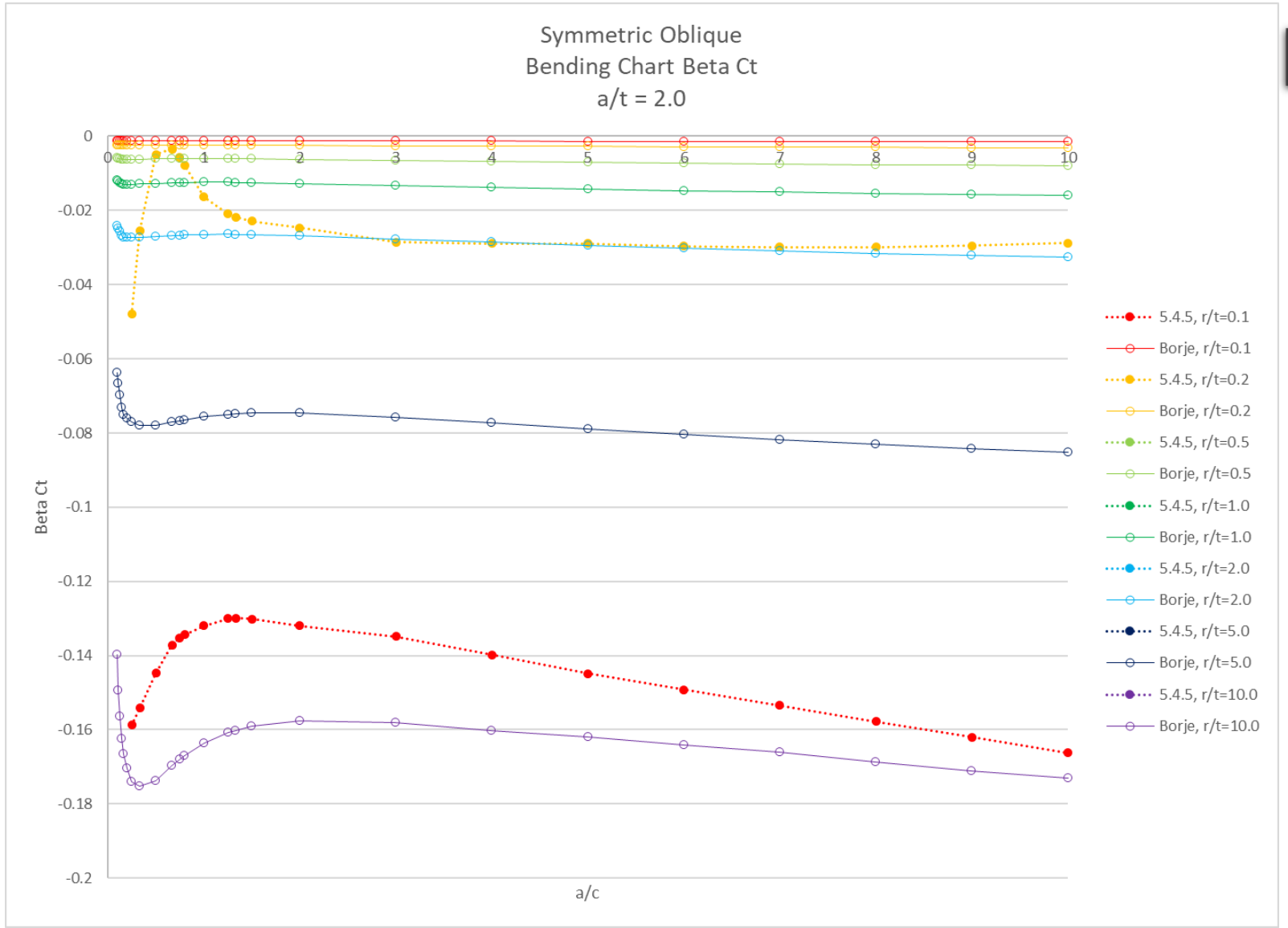

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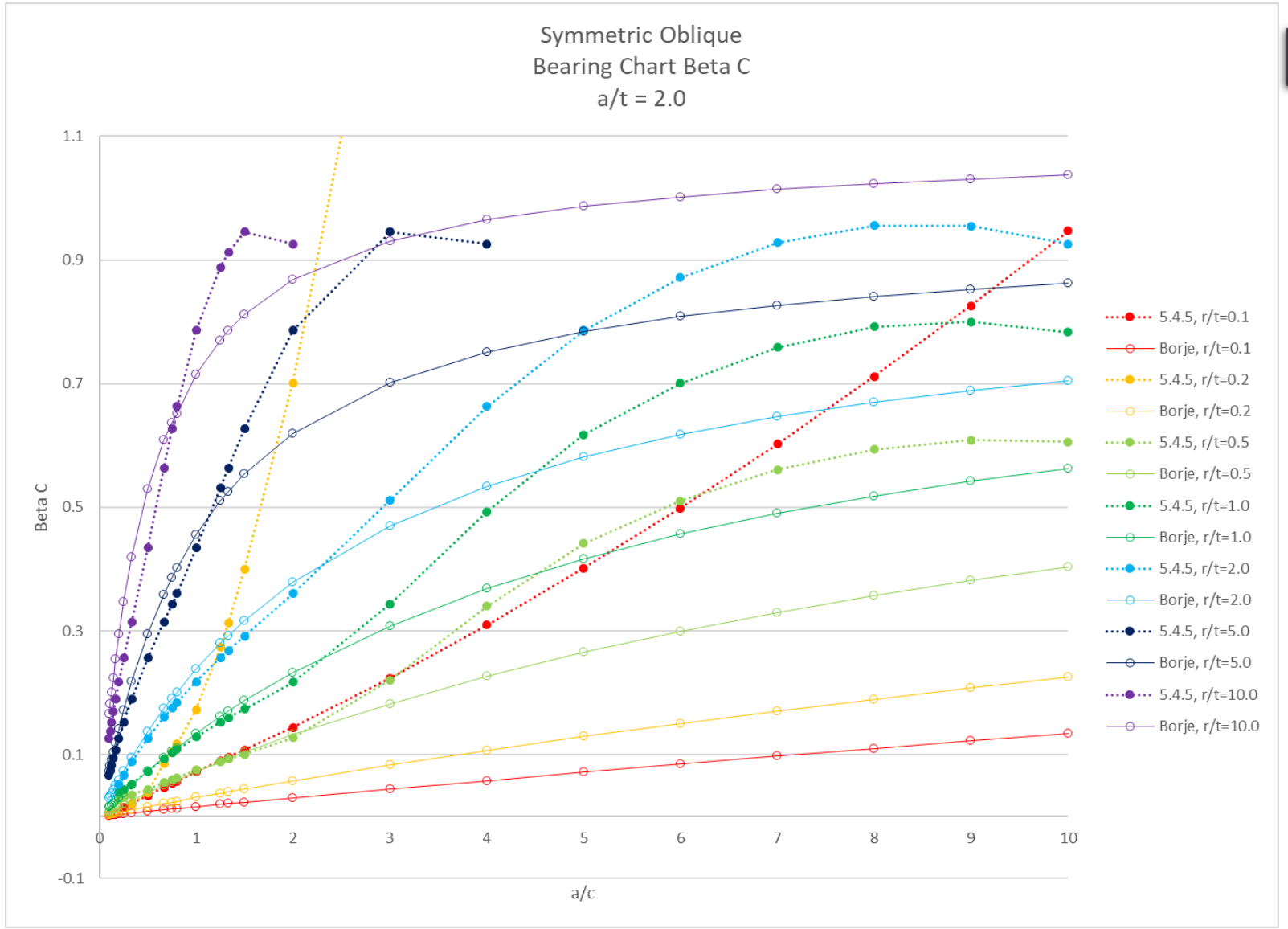

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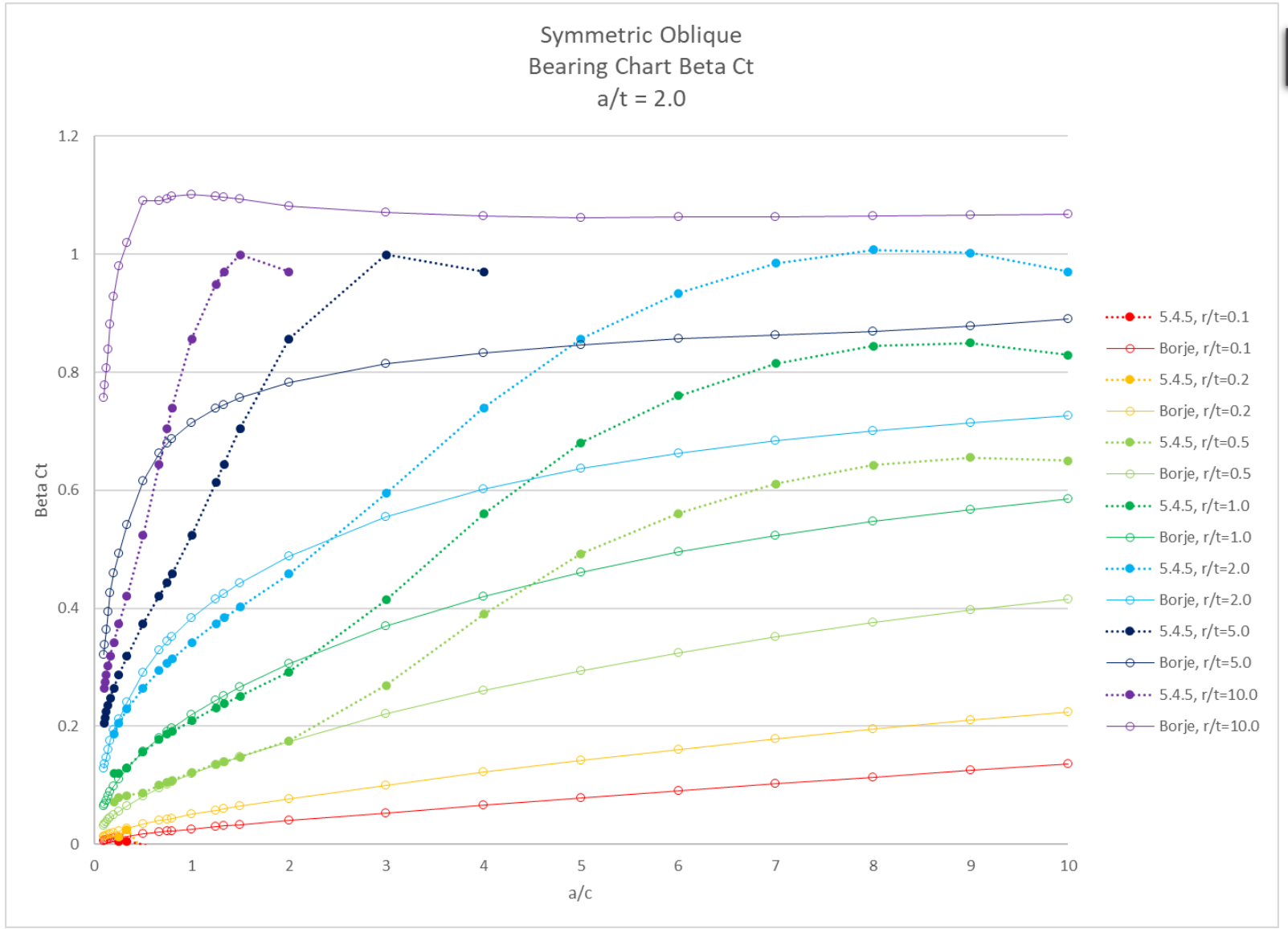

Updated Corner Crack at Hole Solution

- An updated symmetric oblique solution will be included with AFGROW 5.5
- This solution was generated using a subset of BARE's Corner and Oblique crack data set
- This model has been extended to a/t=0.0001 using the classic single corner crack at hole as a guide.
- This extension allows for much smaller cracks, a dimension range 0.0001 <= a/t <= 0.95
- This extension also reduces spline curve oscillation near the edge of the solution.

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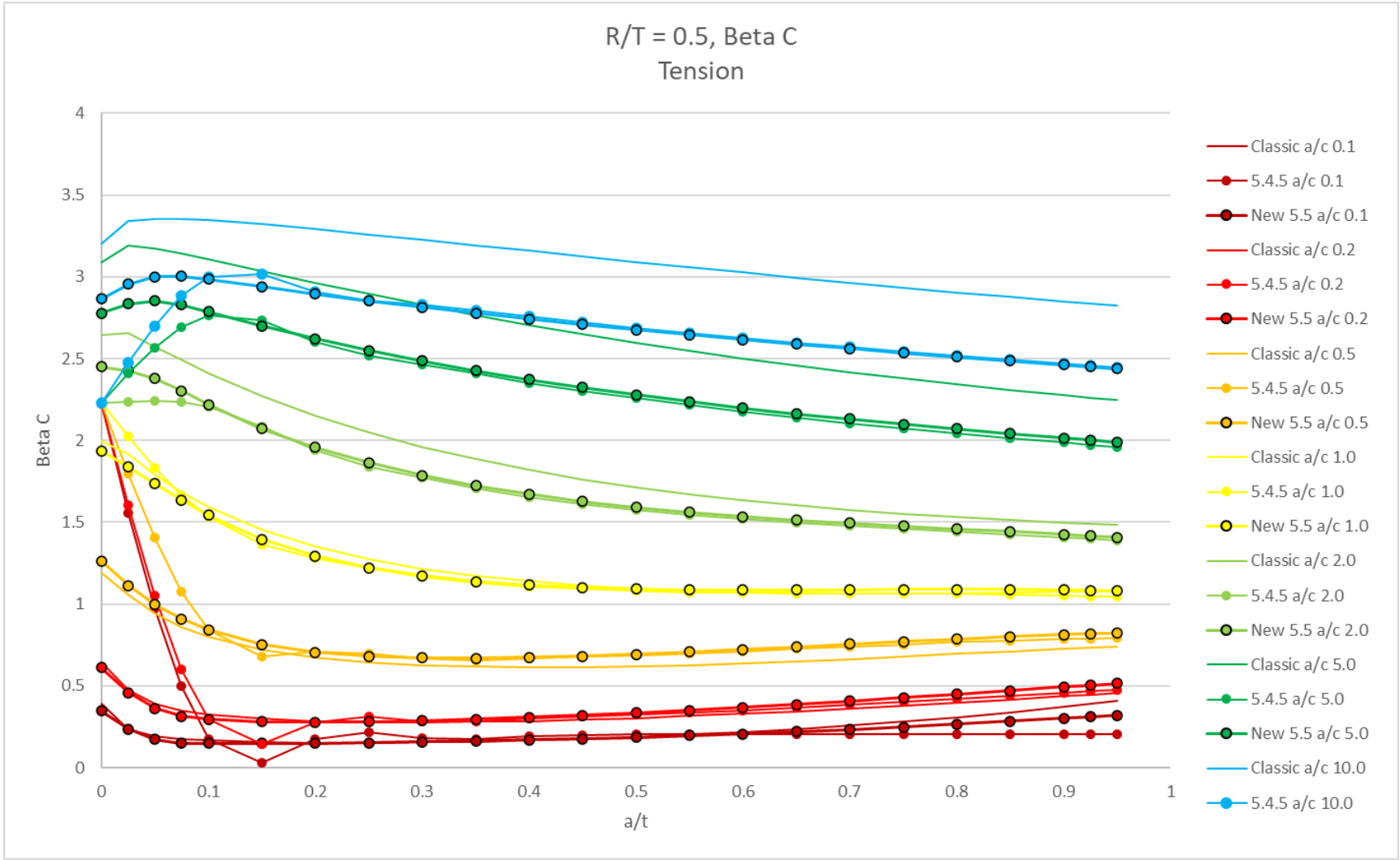

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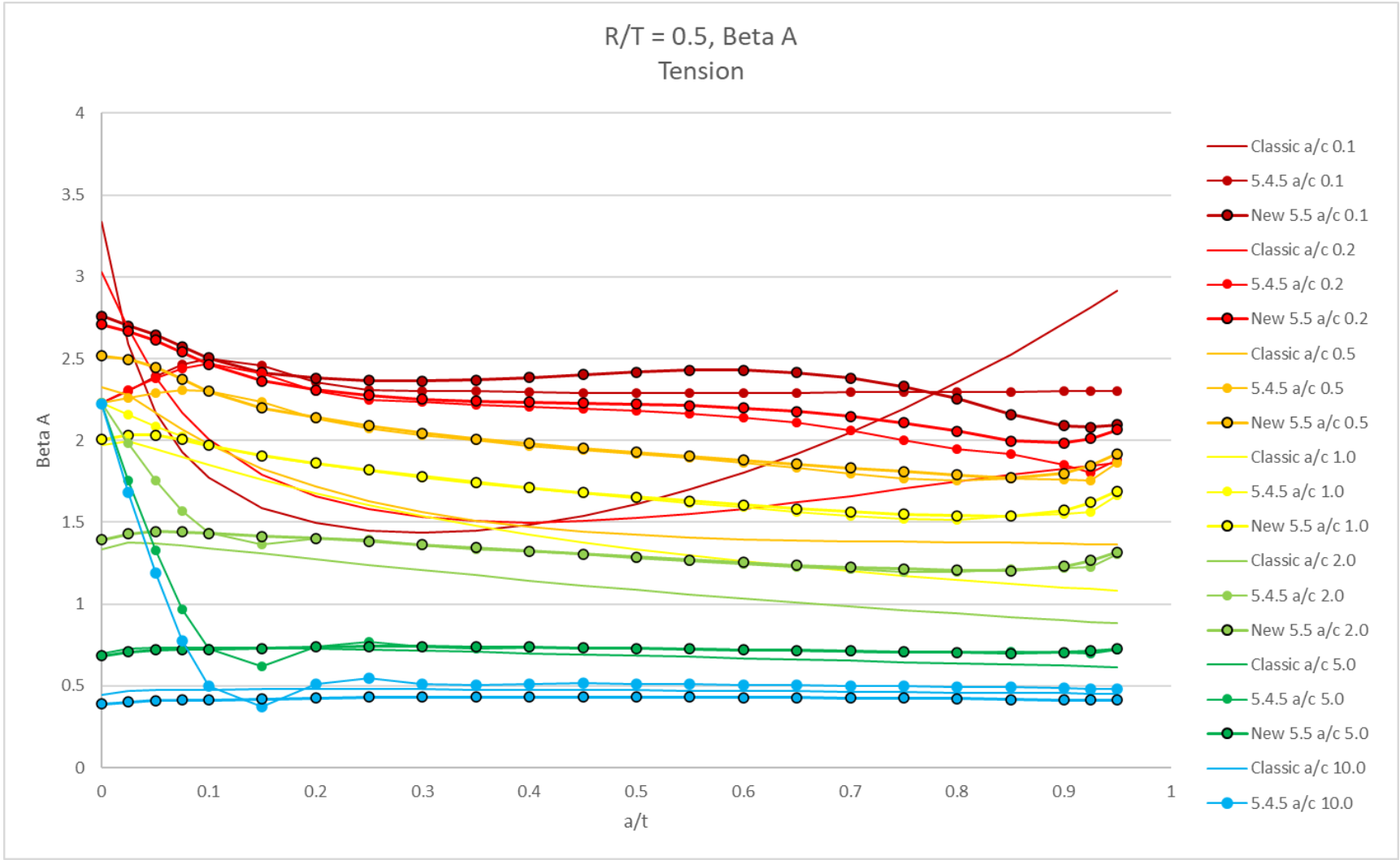

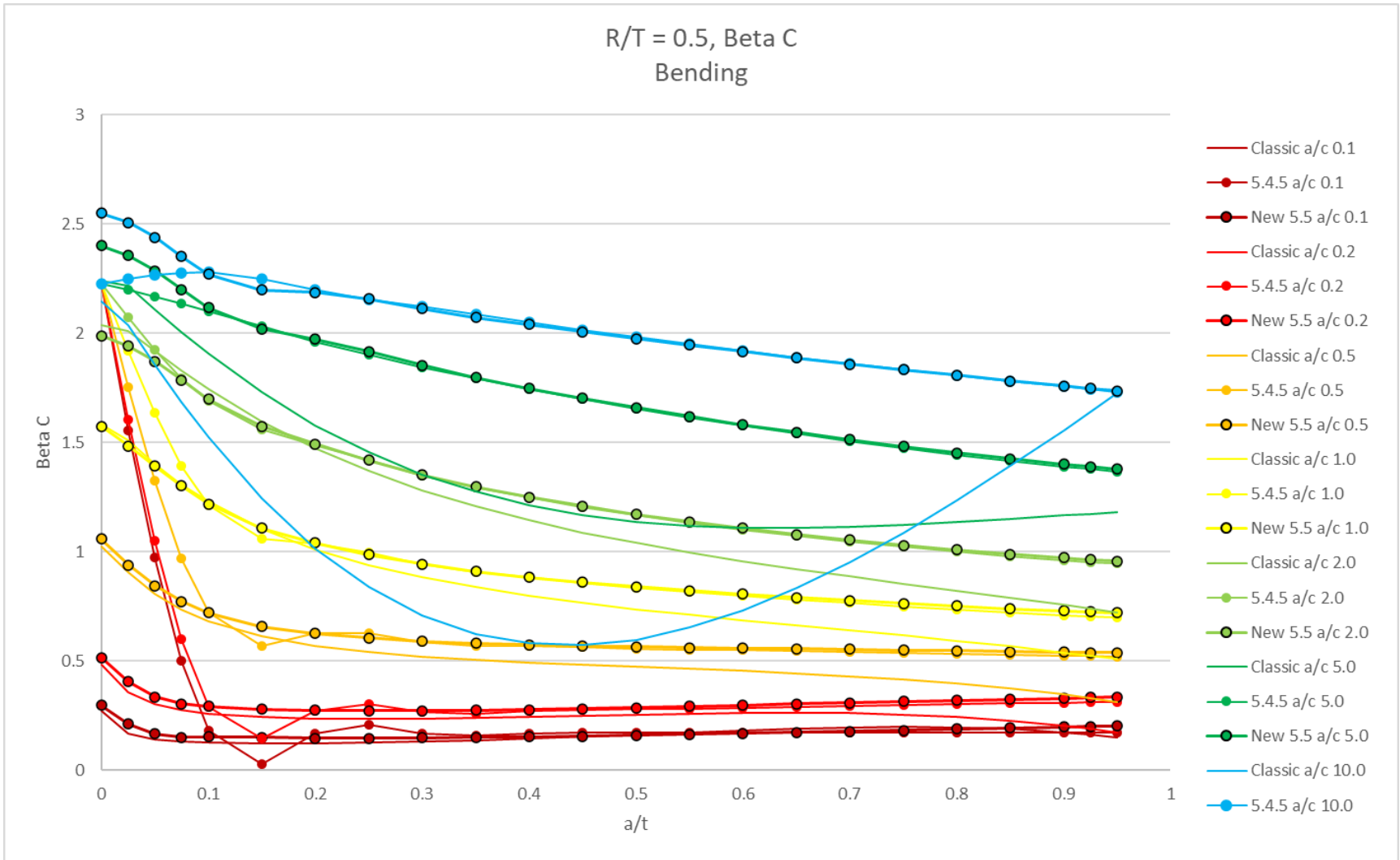
R/T = 0.5, Beta C
Bending
Beta C
a/t
0
0.5
1
1.5
2
2.5
3
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Classic a/c 0.1
5.4.5 a/c 0.1
New 5.5 a/c 0.1
Classic a/c 0.2
5.4.5 a/c 0.2
New 5.5 a/c 0.2
Classic a/c 0.5
5.4.5 a/c 0.5
New 5.5 a/c 0.5
Classic a/c 1.0
5.4.5 a/c 1.0
New 5.5 a/c 1.0
Classic a/c 2.0
5.4.5 a/c 2.0
New 5.5 a/c 2.0
Classic a/c 5.0
5.4.5 a/c 5.0
New 5.5 a/c 5.0
Classic a/c 10.0
5.4.5 a/c 10.0

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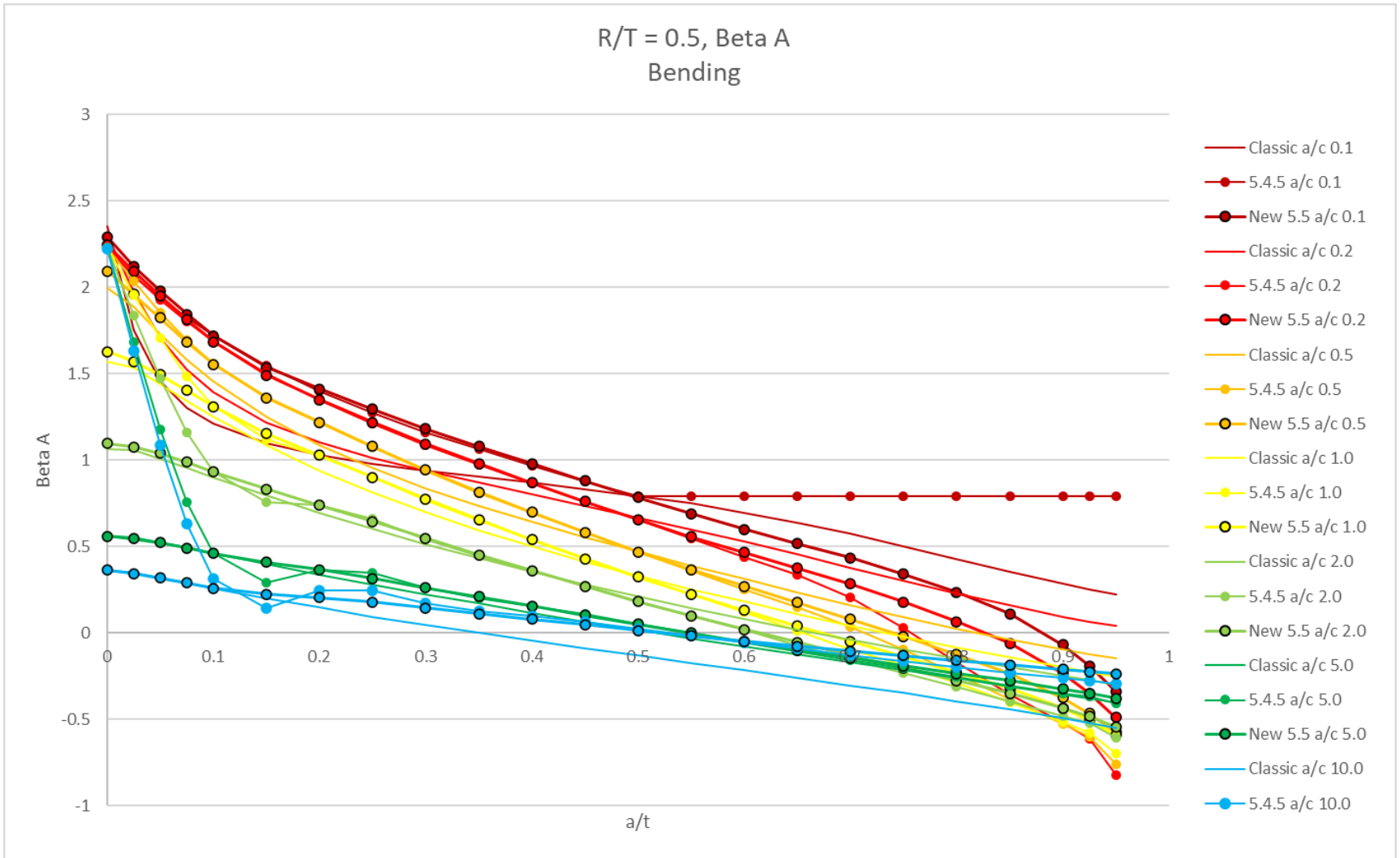

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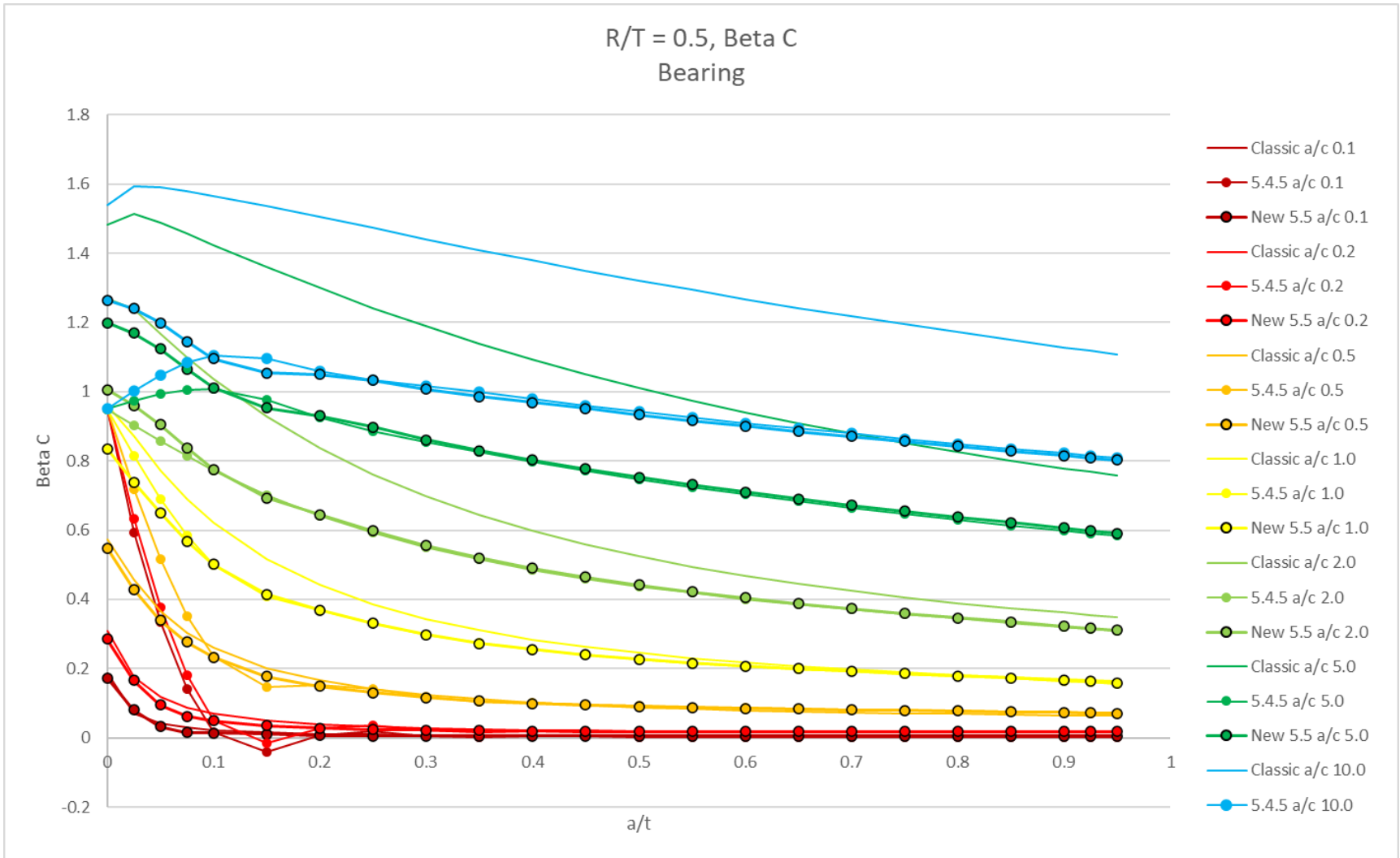

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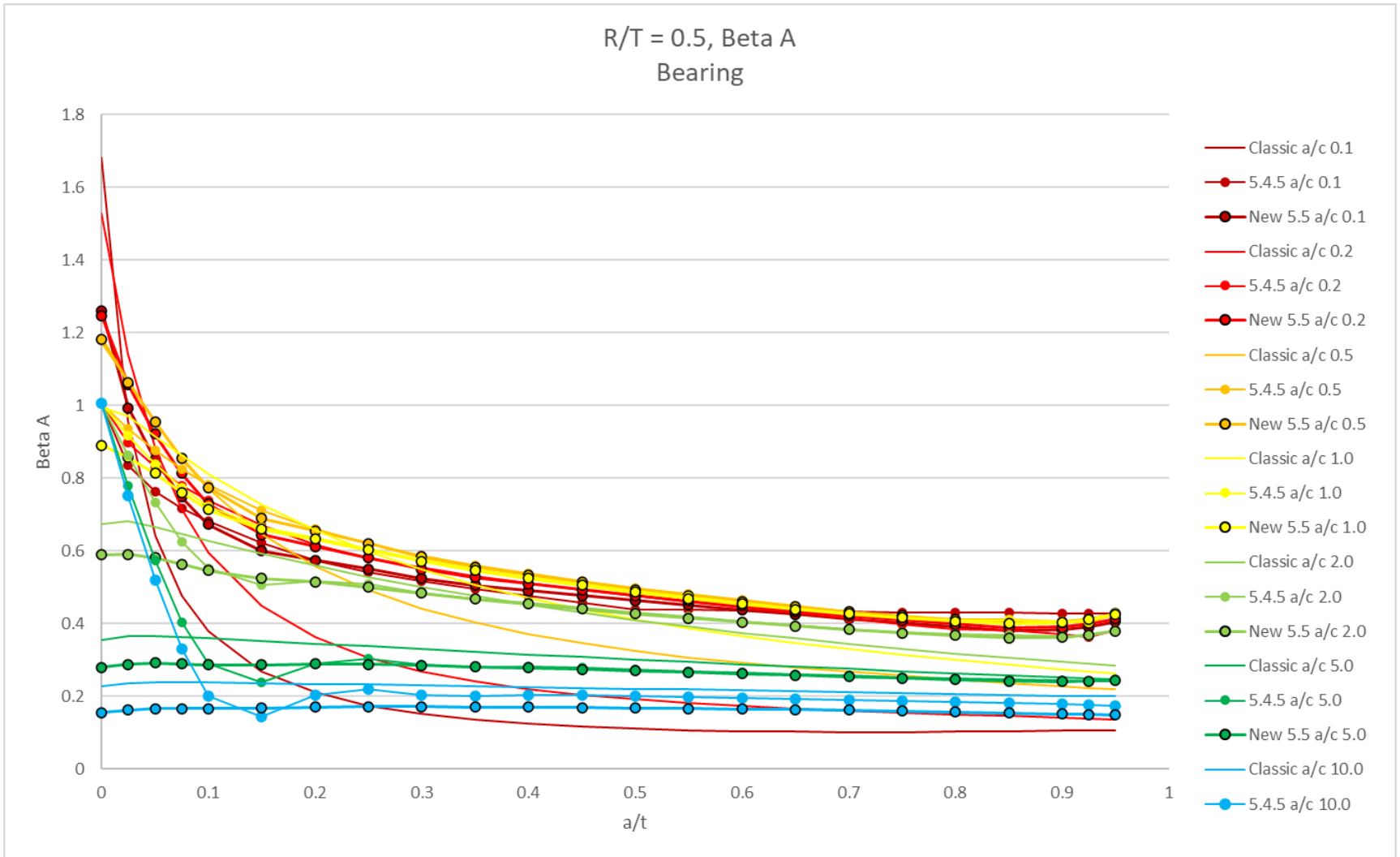


Updated Crack at Countersunk Hole Solution

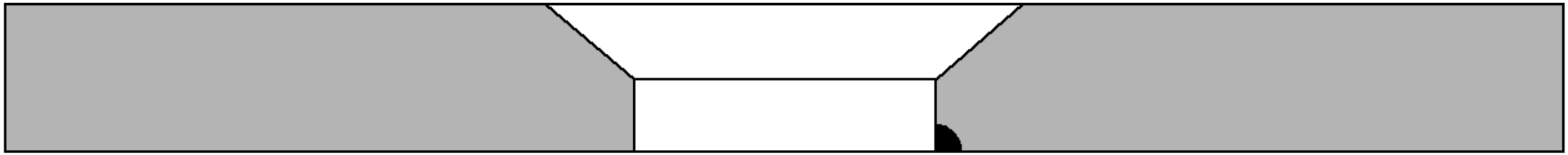
- We are in the preliminary stages of extracting vertices from FEA data prepared by BARE to produce a improved corner-crack at countersunk hole solution within our advanced model interface.
- For this presentation, sample vertices have been produced by extracting table values at a subjectively consistent index from the crack front data.
- The extracted vertices have not been finalized and do not represent the final solution that will be implemented in AFGROW

Updated Crack at Countersunk Hole – Valid Ranges

- AFGROW 5.4.5
  - 0.5 <= a/c <= 5.0
  - 0.025 <= a/t <= 60
  - 0.1 <= r/t <= 2.4
- Current Database Limits
  - 0.1 <= a/c <= 10.0
  - 0.1 <= a/t <= 15
  - 0.2 <= r/t <= 5.0

b/t=0.5 Geometry

- Ratio Values
  - b/t = 0.5
  - r/t = 1.0
  - w/r = 5.2
- Unitless Dimensions
  - Diameter = 20
  - Thickness = 10
  - Countersunk Depth = 5
  - Width = 104



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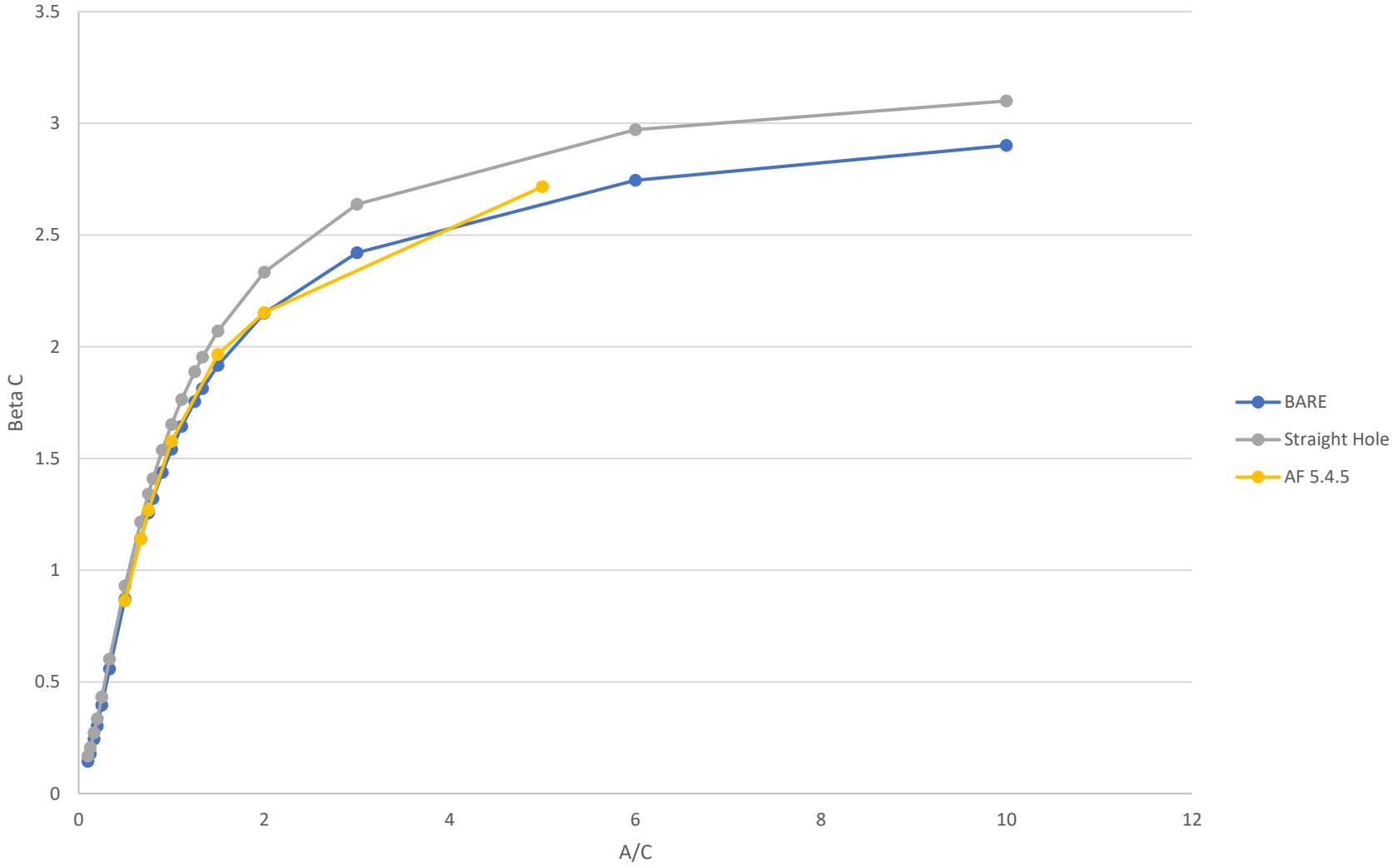
BARE Countersunk Vs Current AFGROW 5.4.5
r/t=1, w/r=5.2, a/t=0.2
Tension - Beta C



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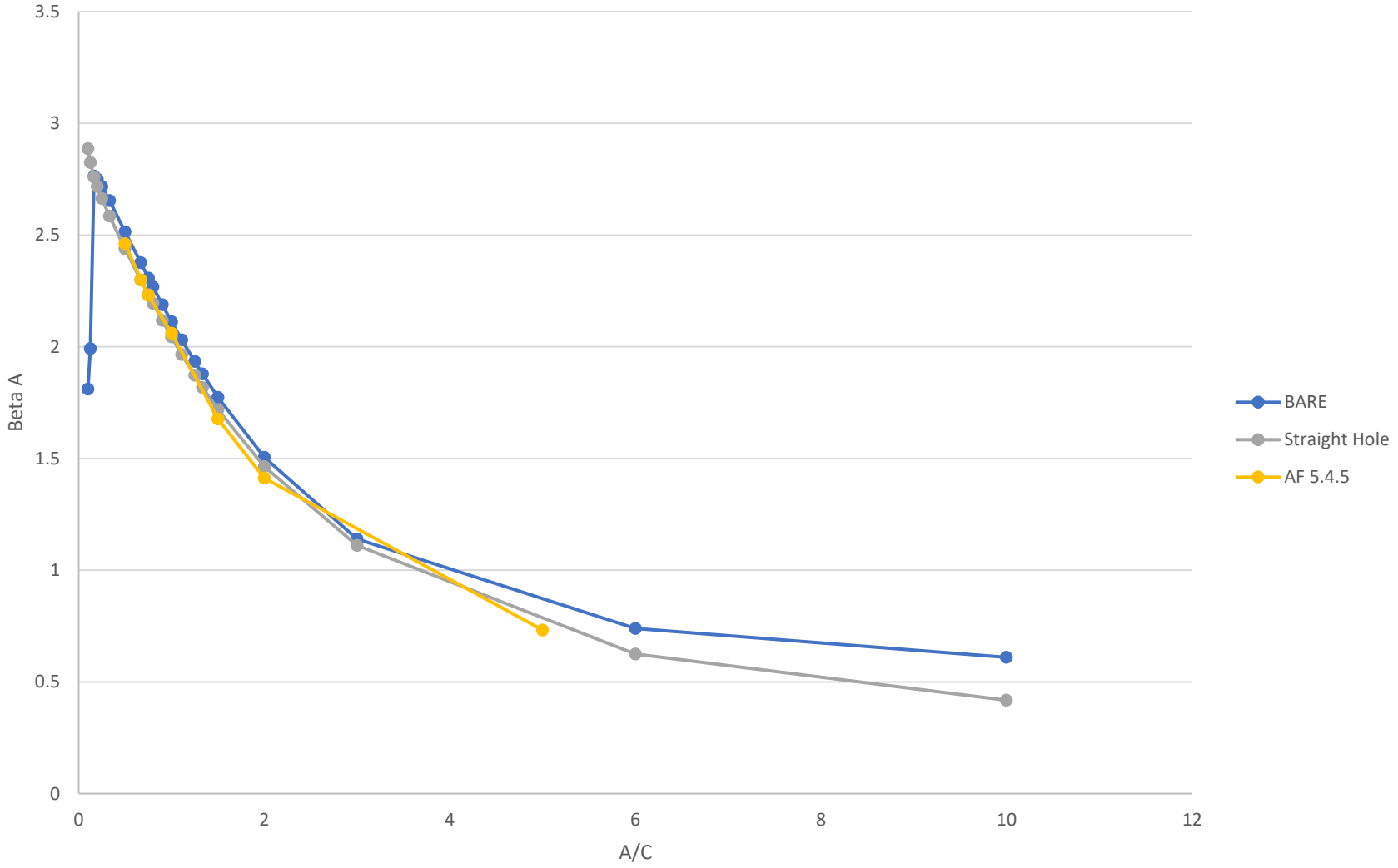
BARE Countersunk Vs AFGROW 5.4.5 (Reinier)
r/t=1, w/r=5.2, a/t=0.2
Tension - Beta A



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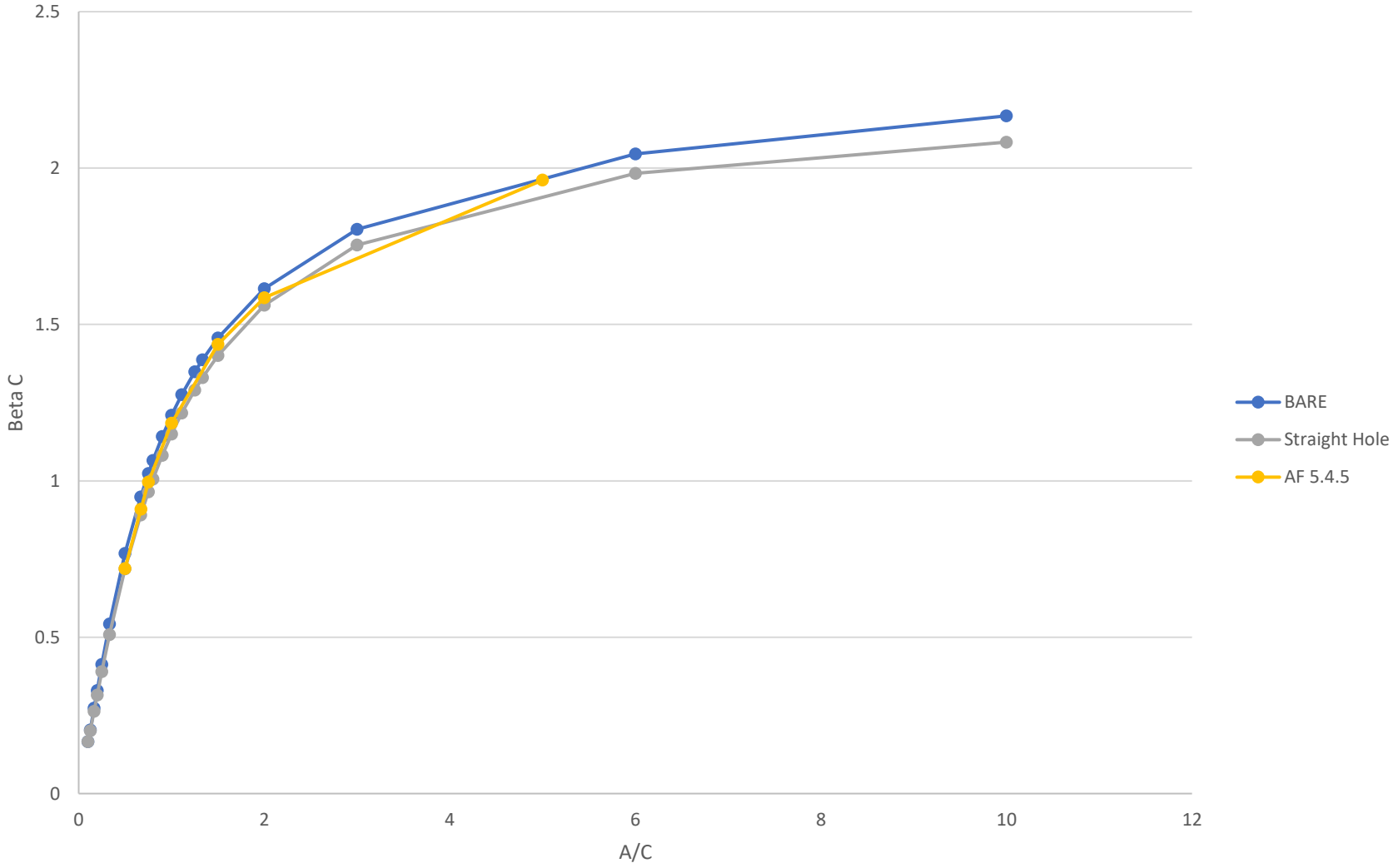
BARE Countersunk Vs AFGROW 5.4.5 (Reinier)
r/t=1, w/r=5.2, a/t=0.2
Bending - Beta C



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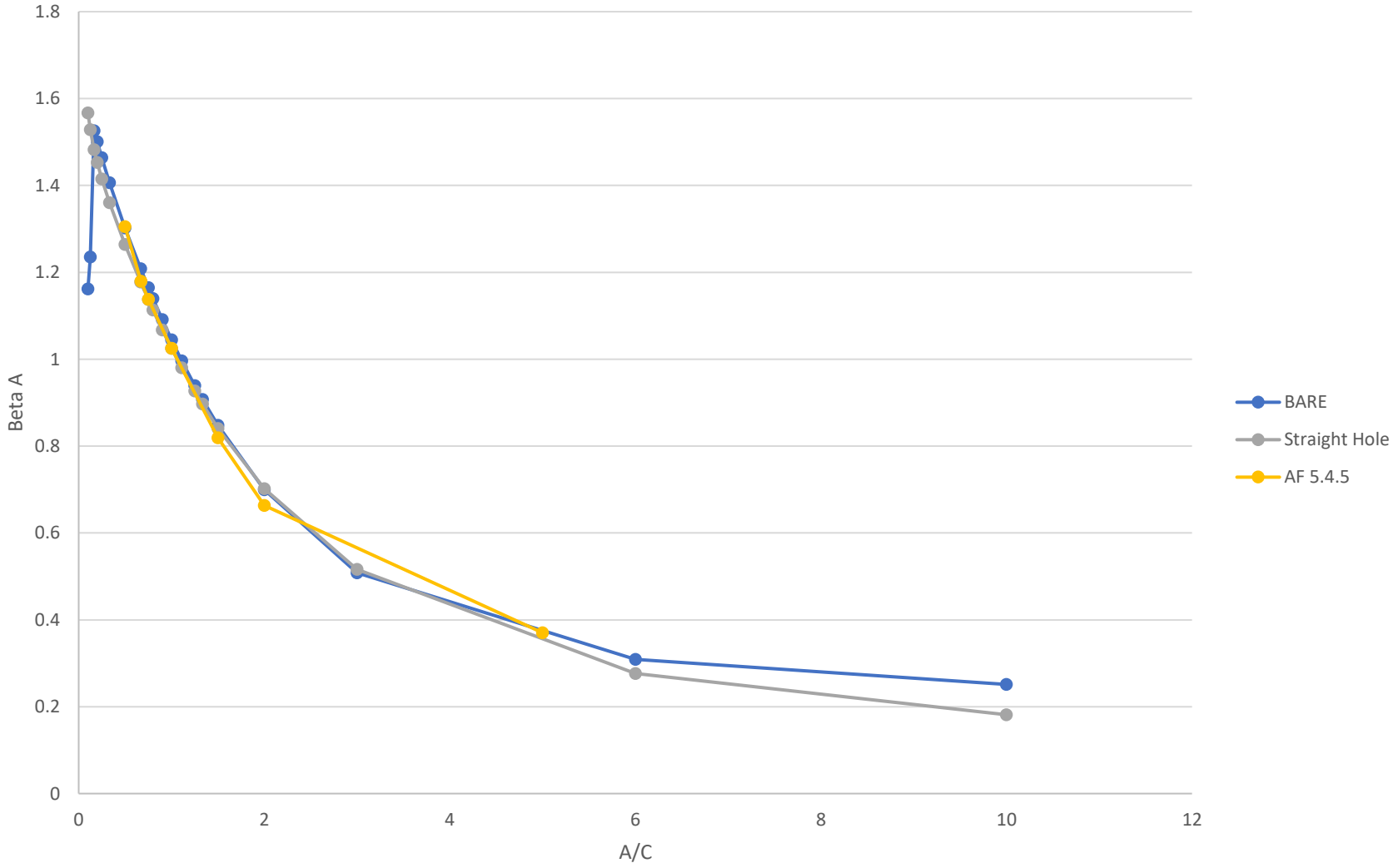
BARE Countersunk Vs AFGROW 5.4.5 (Reinier)
r/t=1, w/r=5.2, a/t=0.2
Bending - Beta A



b/t=0.05 Geometry

- Ratio Values
  - b/t = 0.05
  - r/t = 1.0
  - w/r = 5.132
- Unitless Dimensions
  - Diameter = 20
  - Thickness = 10
  - Countersunk Depth = 9.5
  - Width = 102.64

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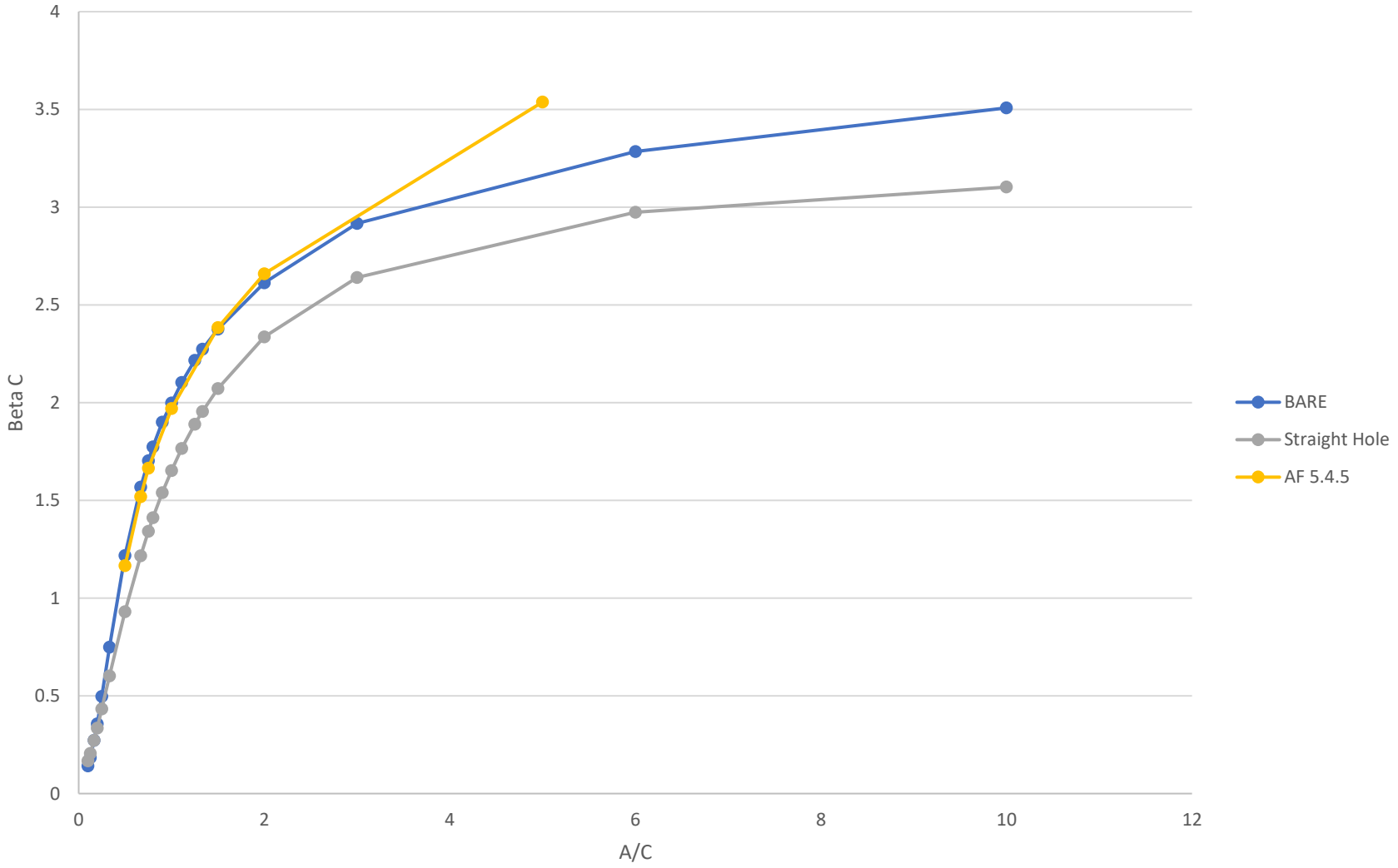
BARE Countersunk Vs AFGROW 5.4.5
r/t=1, w/r=5.132, a/t=0.2
Tension - Beta C



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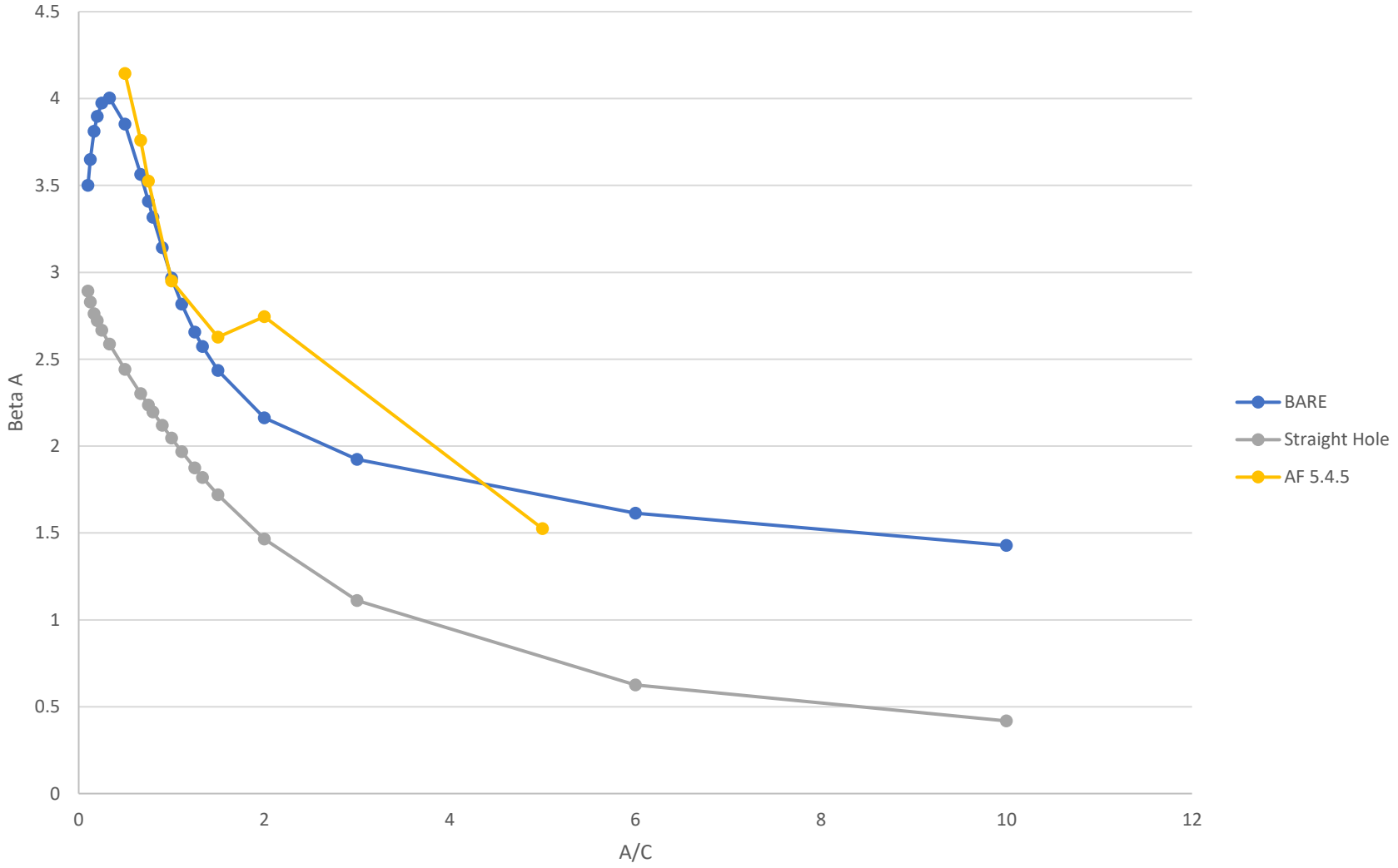
BARE Countersunk Vs AFGROW 5.4.5
r/t=1, w/r=5.2, a/t=0.2
Tension - Beta A



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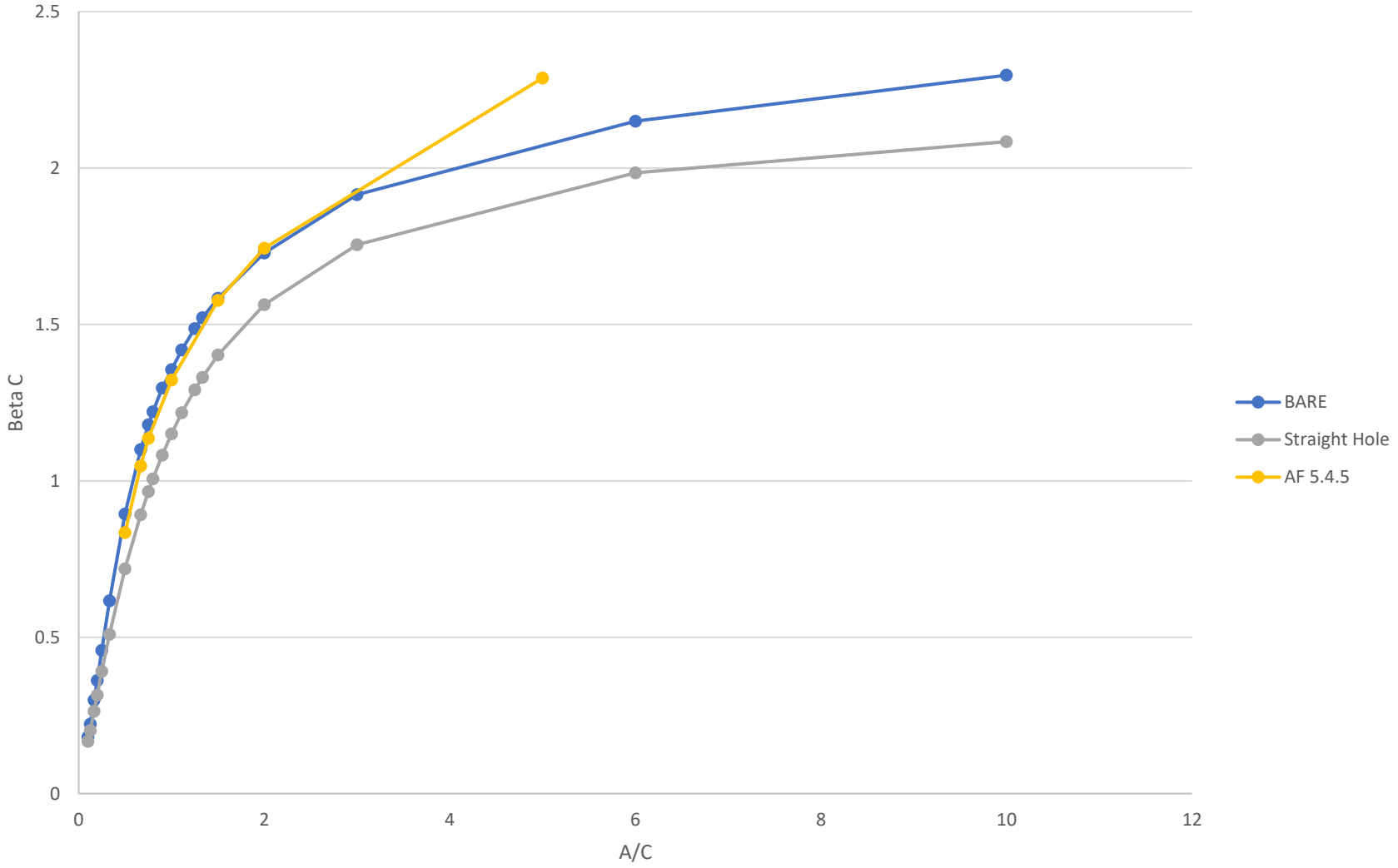
BARE Countersunk Vs AFGROW 5.4.5
r/t=1, w/r=5.2, a/t=0.2
Bending - Beta C



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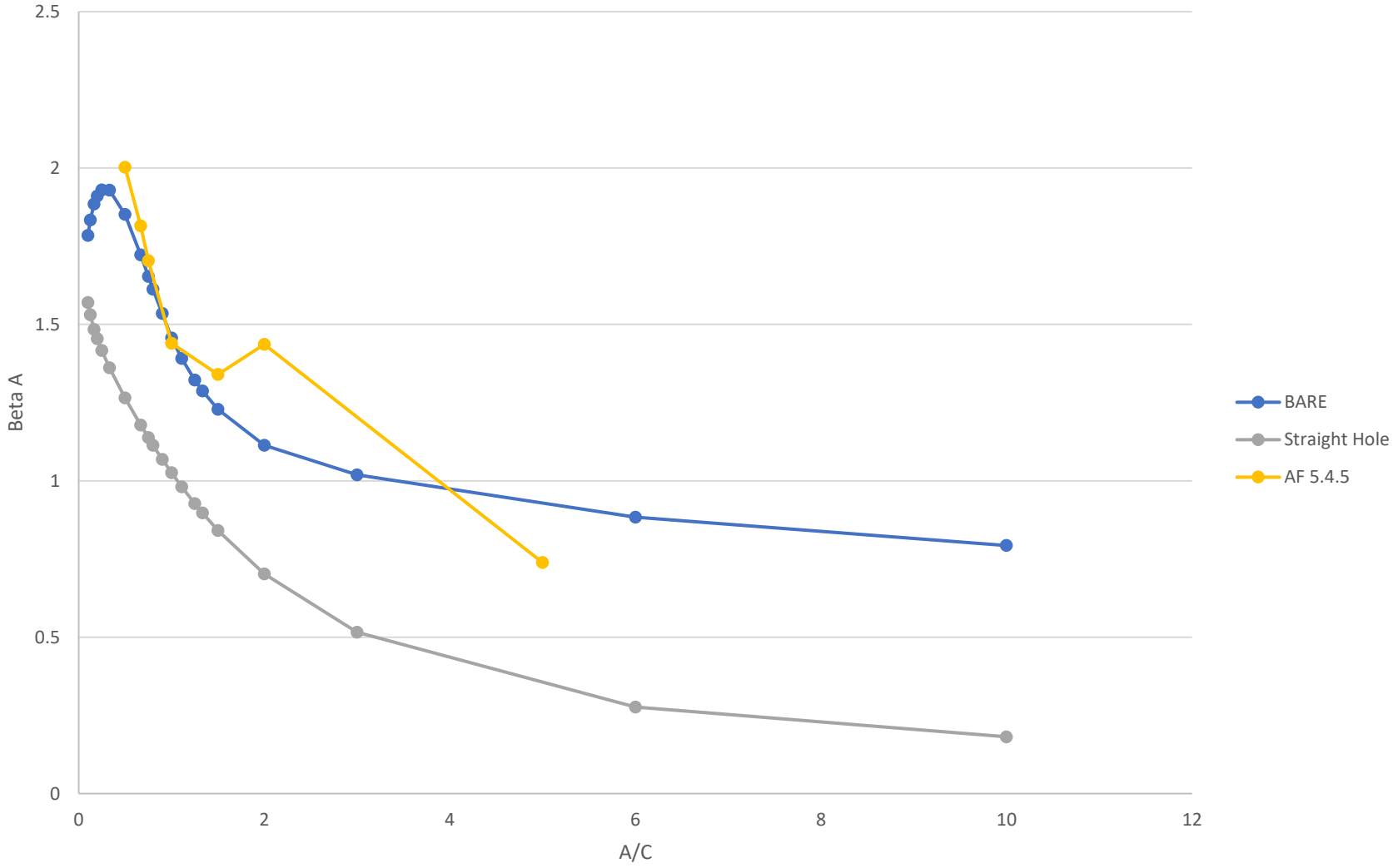
BARE Countersunk Vs AFGROW 5.4.5
r/t=1, w/r=5.2, a/t=0.2
Bending - Beta A



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Thank You