AFGROW Workshop 2019

AFGROW Unknown Features

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Outline

- Motivation
- Advanced Corner Crack(s) at Hole Model
- Effective Width for Bearing Loaded Holes
- Online Data
- Material Data on AFMAT

Motivation

Highlight AFGROW underused features and capabilities that can provide an immediate benefit to the user

Selection

- Readily available in AFROW
- All necessary data are data
- Can have significantly impact the prediction or provide new capabilities

Advance Corner Crack(s) at Hole

Small differences in K Solutions yield large cumulative differences in fatigue life [1]

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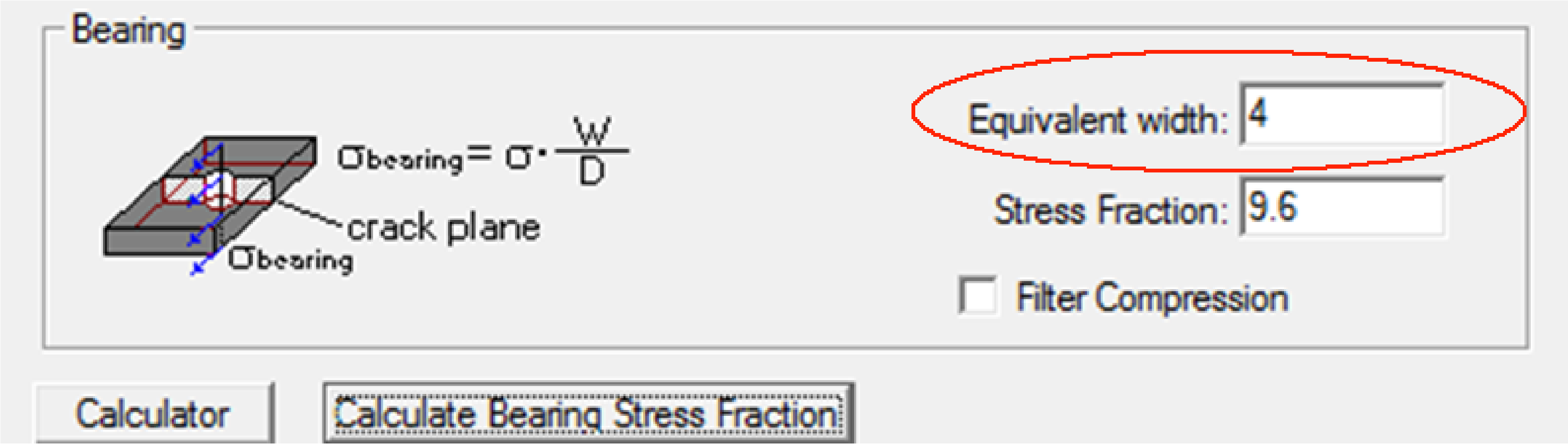
Advanced Corner Crack(s) at a Hole

Effect on Fatigue Life (1)

- Small cracks in thin sheets: 20-50%
- Small cracks in thick sheets: 25-45%
- Large cracks in thin sheets: 90-300%
- Continuing damage scenario: 125-350%

Equivalent Width



The "equivalent width" is currently only used to calculate the bearing stress fraction

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Issues

- The AFGROW K-Solutions for bearing load were all developed assuming an “infinite” plate height
- All FEM models used a total plate height = 5 x width
- For wide plates, the bearing solution drops off very quickly and can indicate much longer life for the “infinite” height model compared to a finite height case *

* Disscussions with Kaylon Anderson, A-10 ASIP. White paper “Modeling Bearing Load in Wide Panels Using AFGROW” available on the AFGROW Web Page.

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FEM Boundary Conditions

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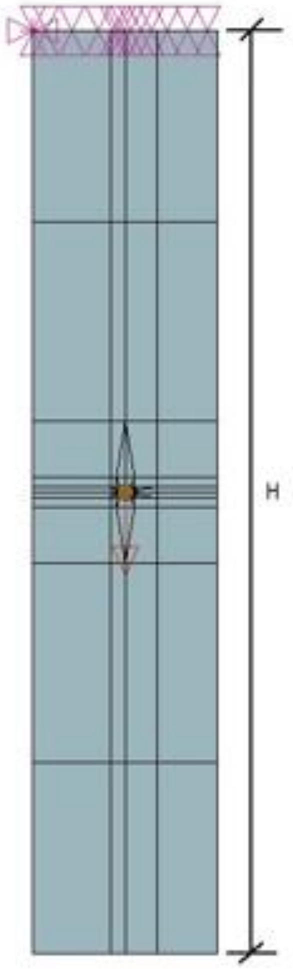
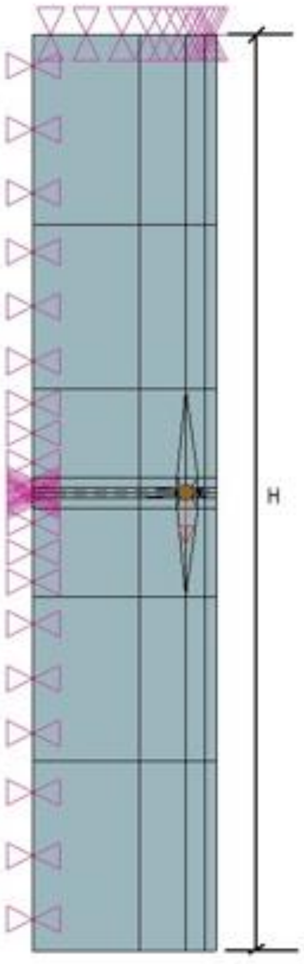
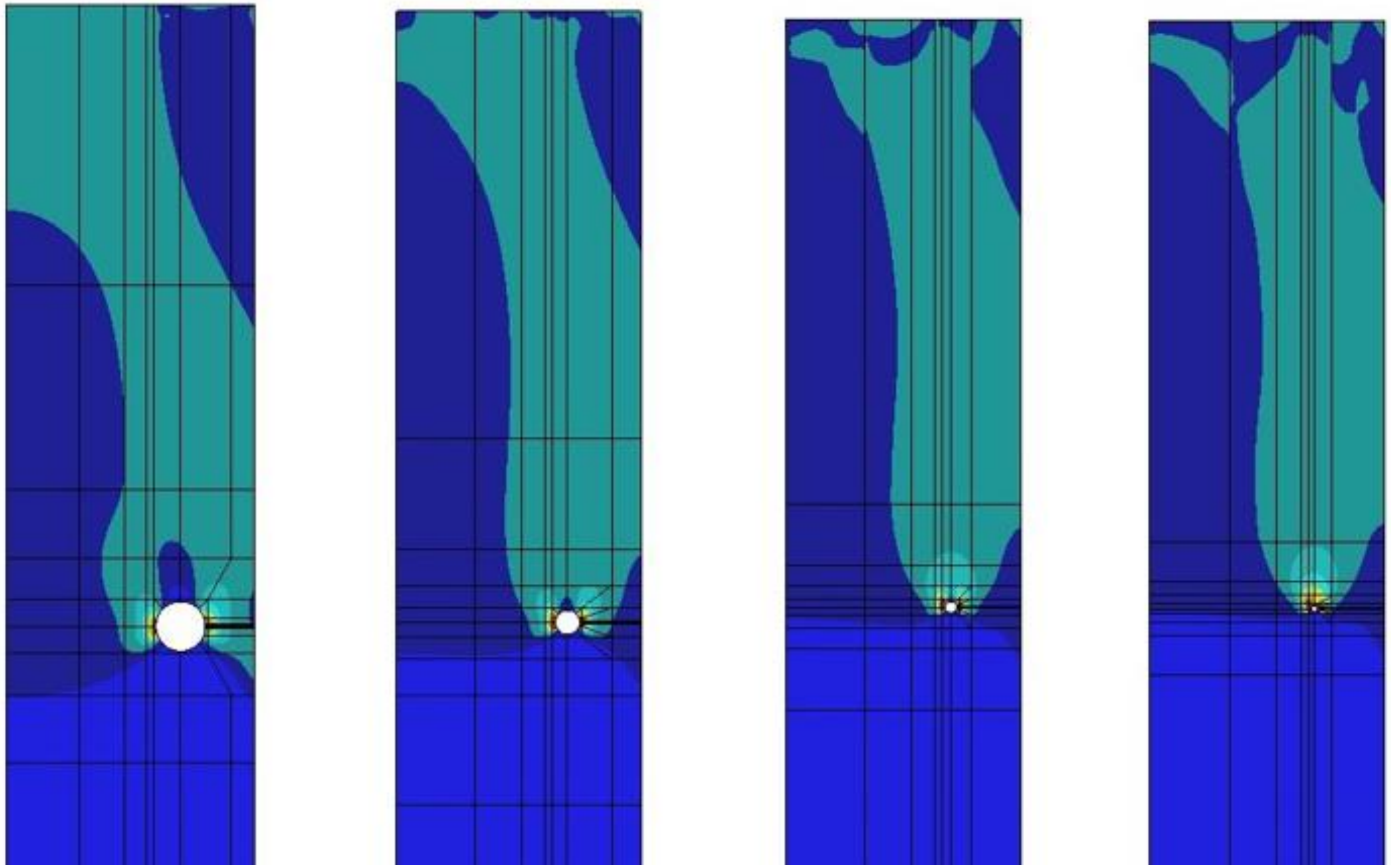




The offset hole was constrained since the curve fit solution was only possible for the constrained case

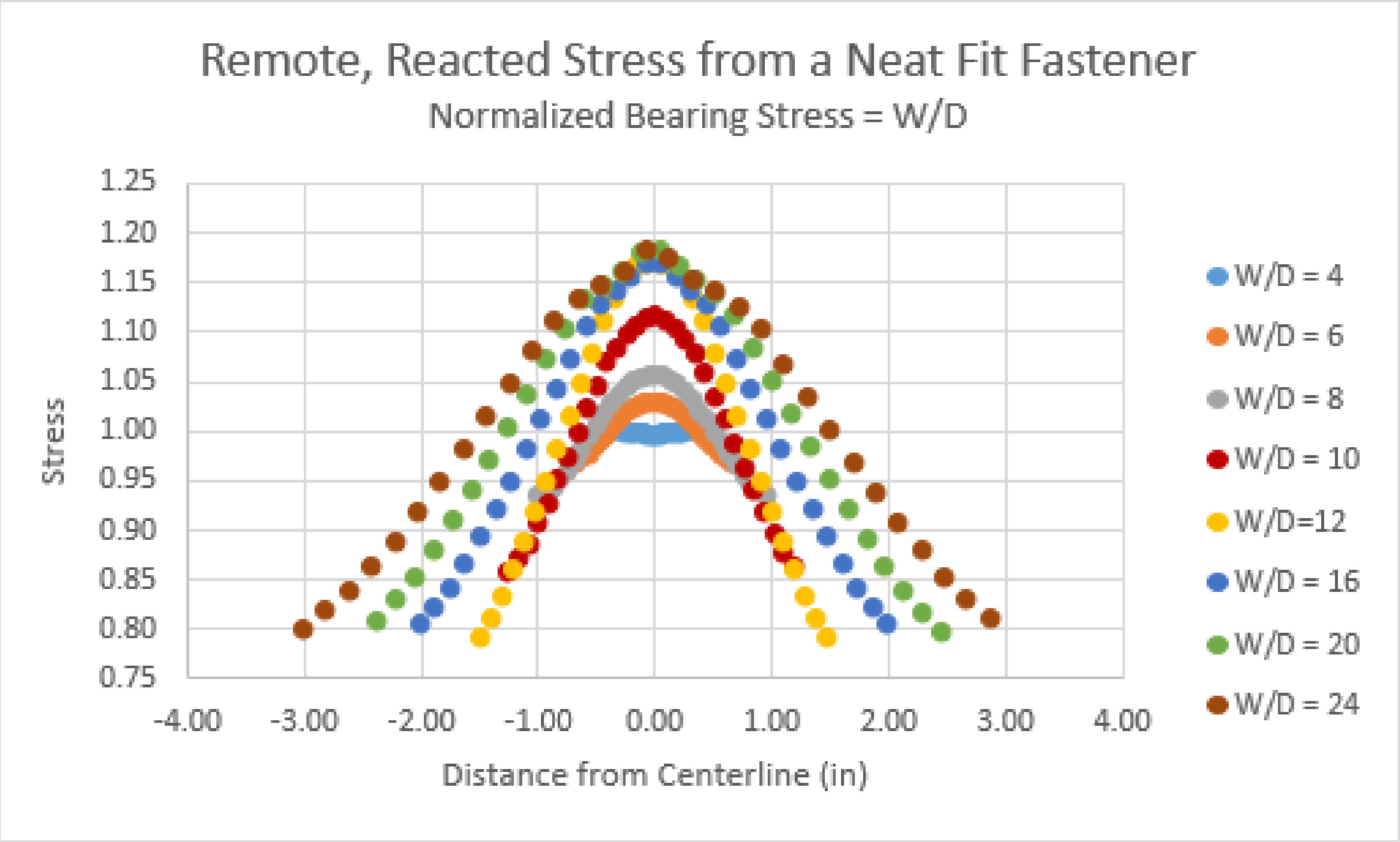
FEM Results for W/D



Teal fringe shows

$\sigma_y = P/(w\ t)$

Stress Distribution 8D Above a Loaded Hole



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Effect of Plate Height for Centered Holes

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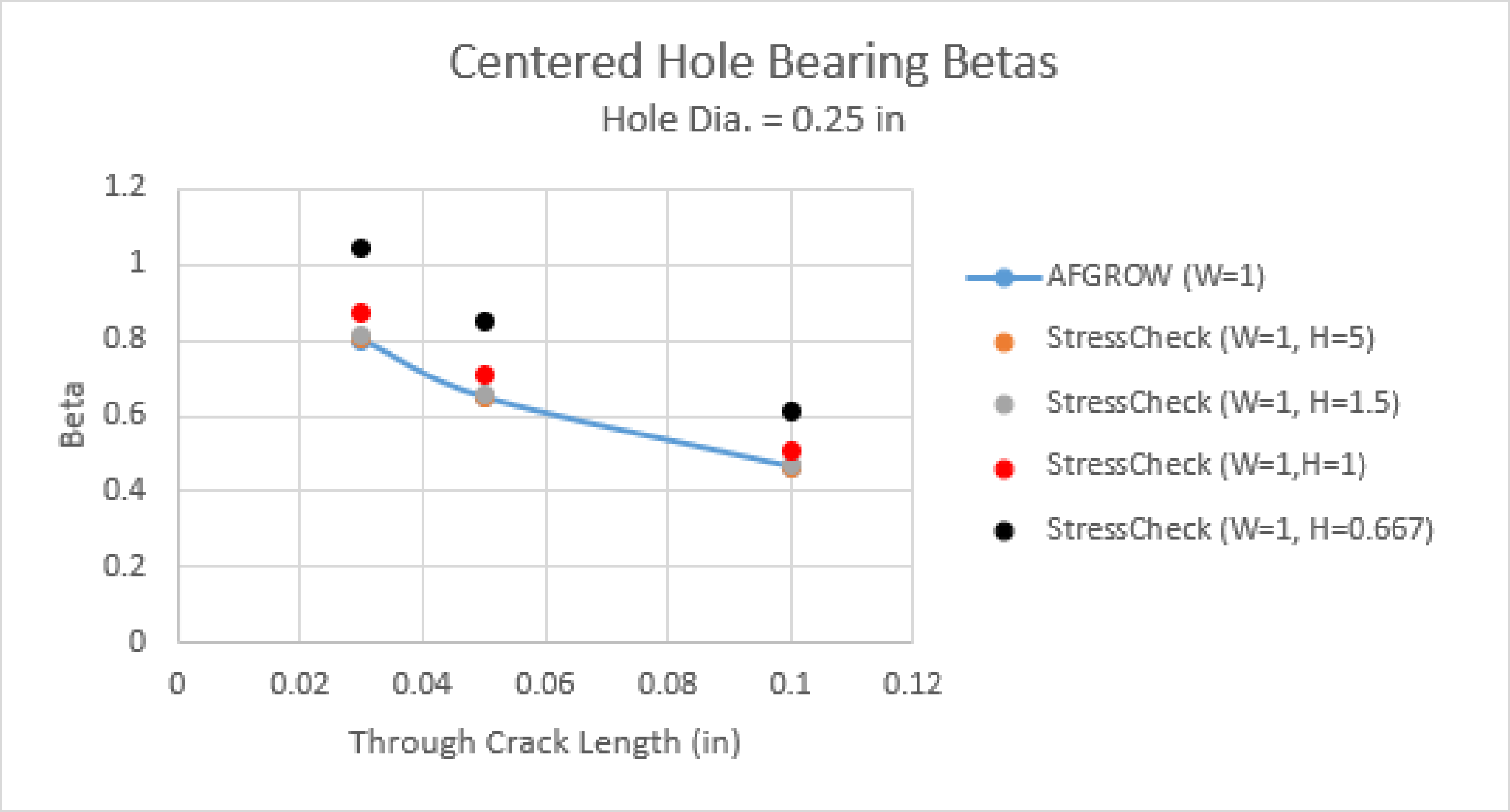

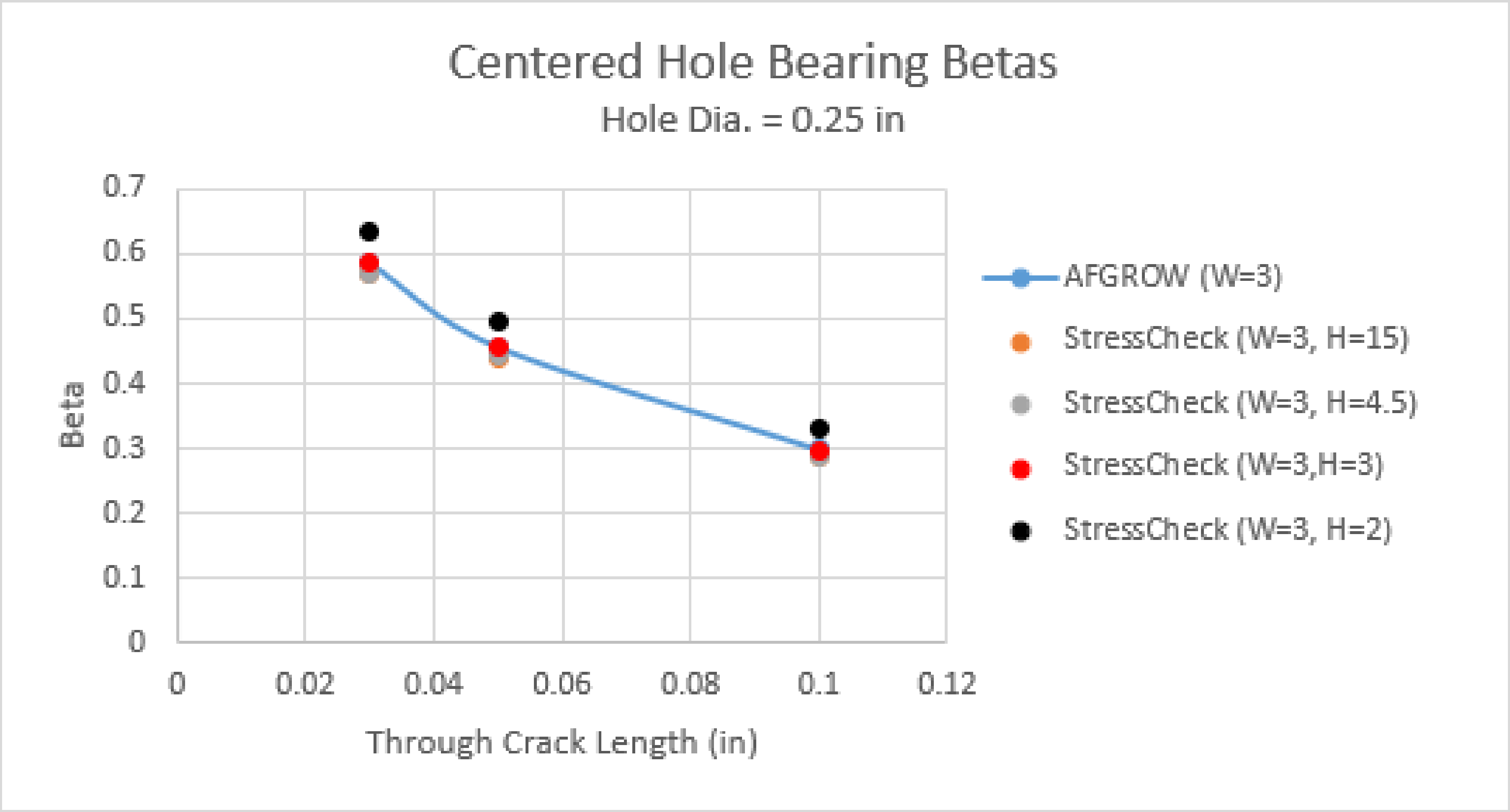
Centered Hole Bearing Betas
Hole Dia. = 0.25 in
Beta
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.02
0.04
0.06
0.08
0.1
0.12
Through Crack Length (in)
AFGROW (W=3)
StressCheck (W=3, H=15)
StressCheck (W=3, H=4.5)
StressCheck (W=3,H=3)
StressCheck (W=3, H=2)

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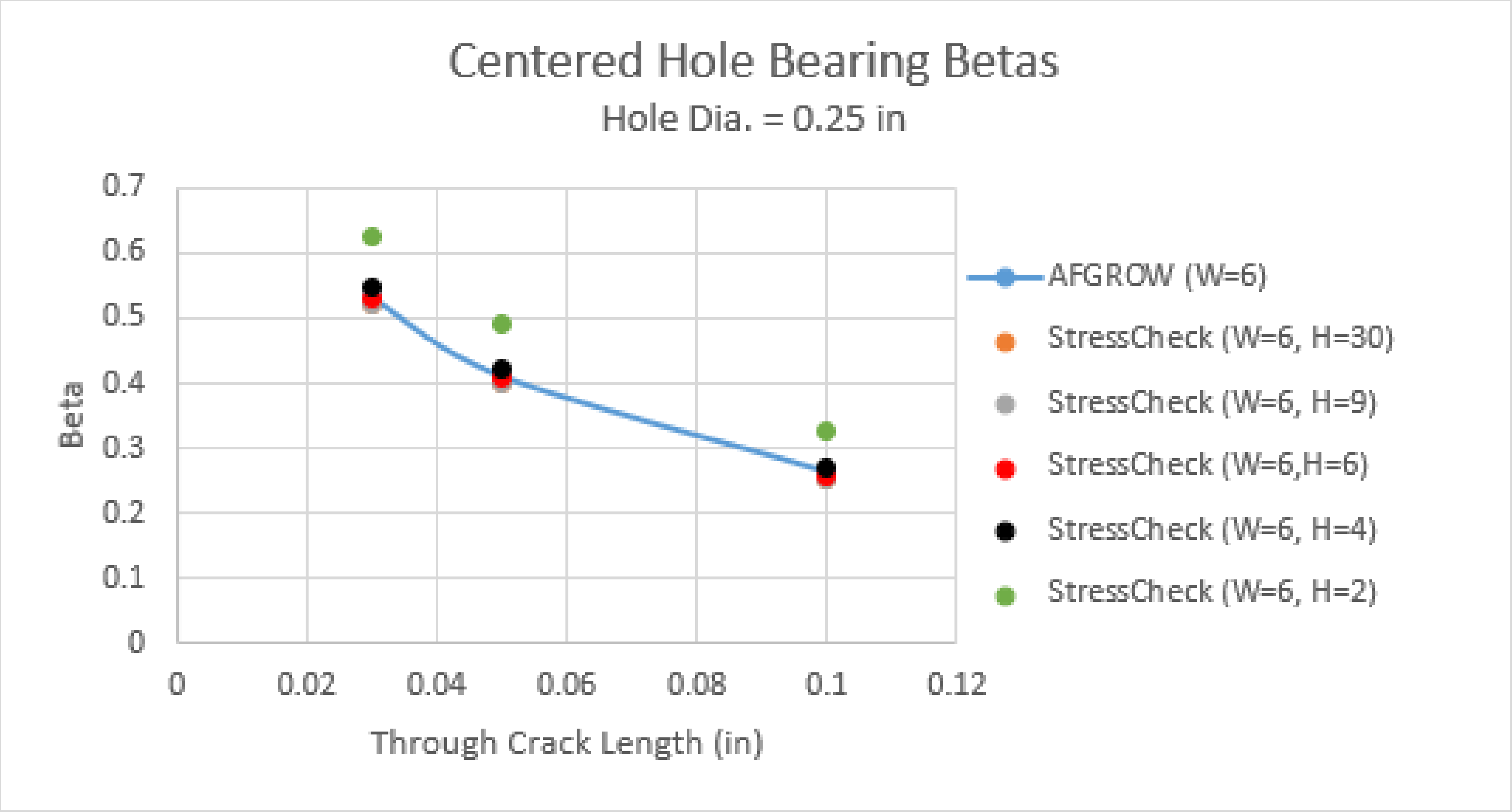

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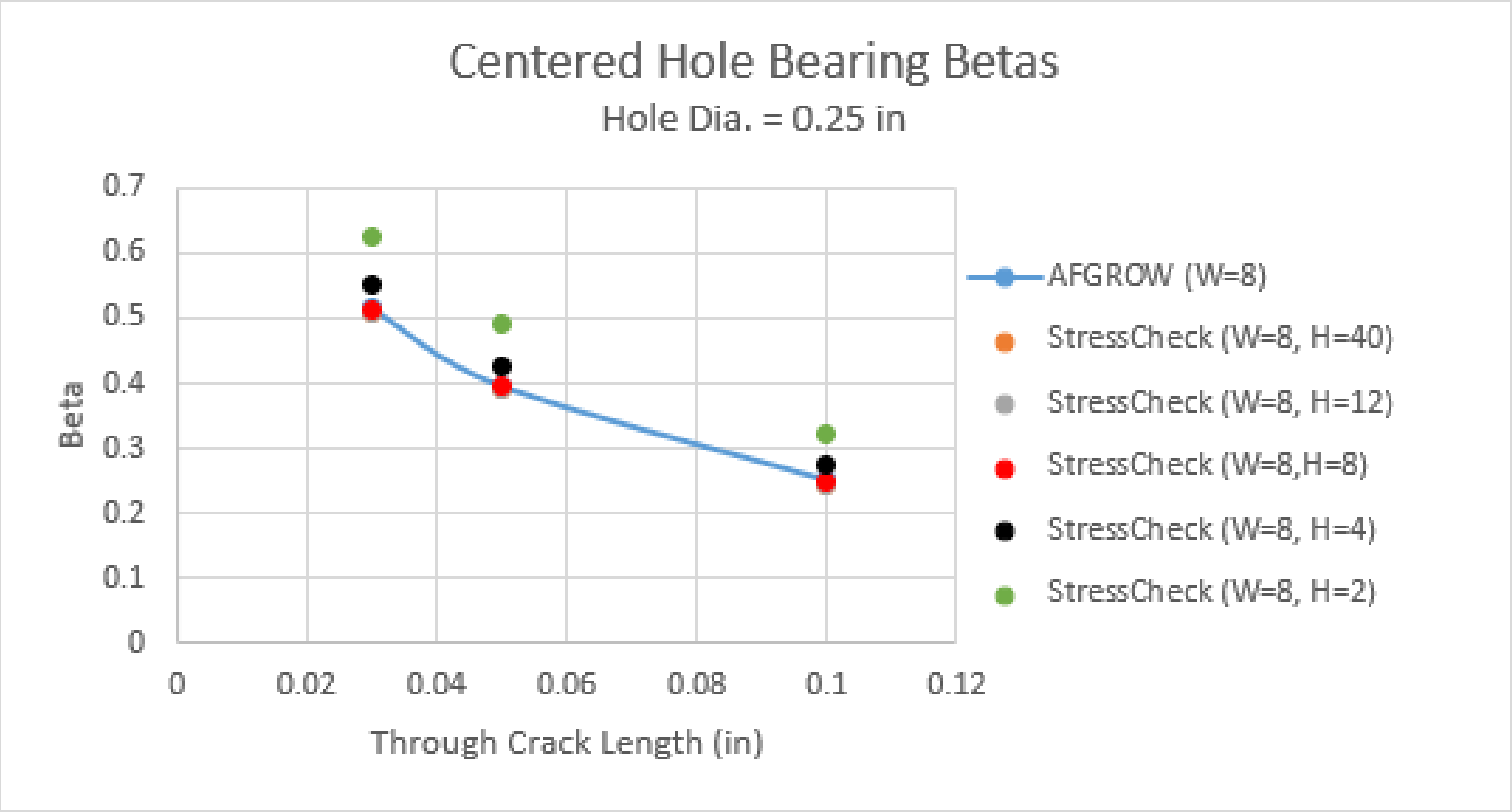

Using an “Equivalent Width” = 12D for Different Finite Heights

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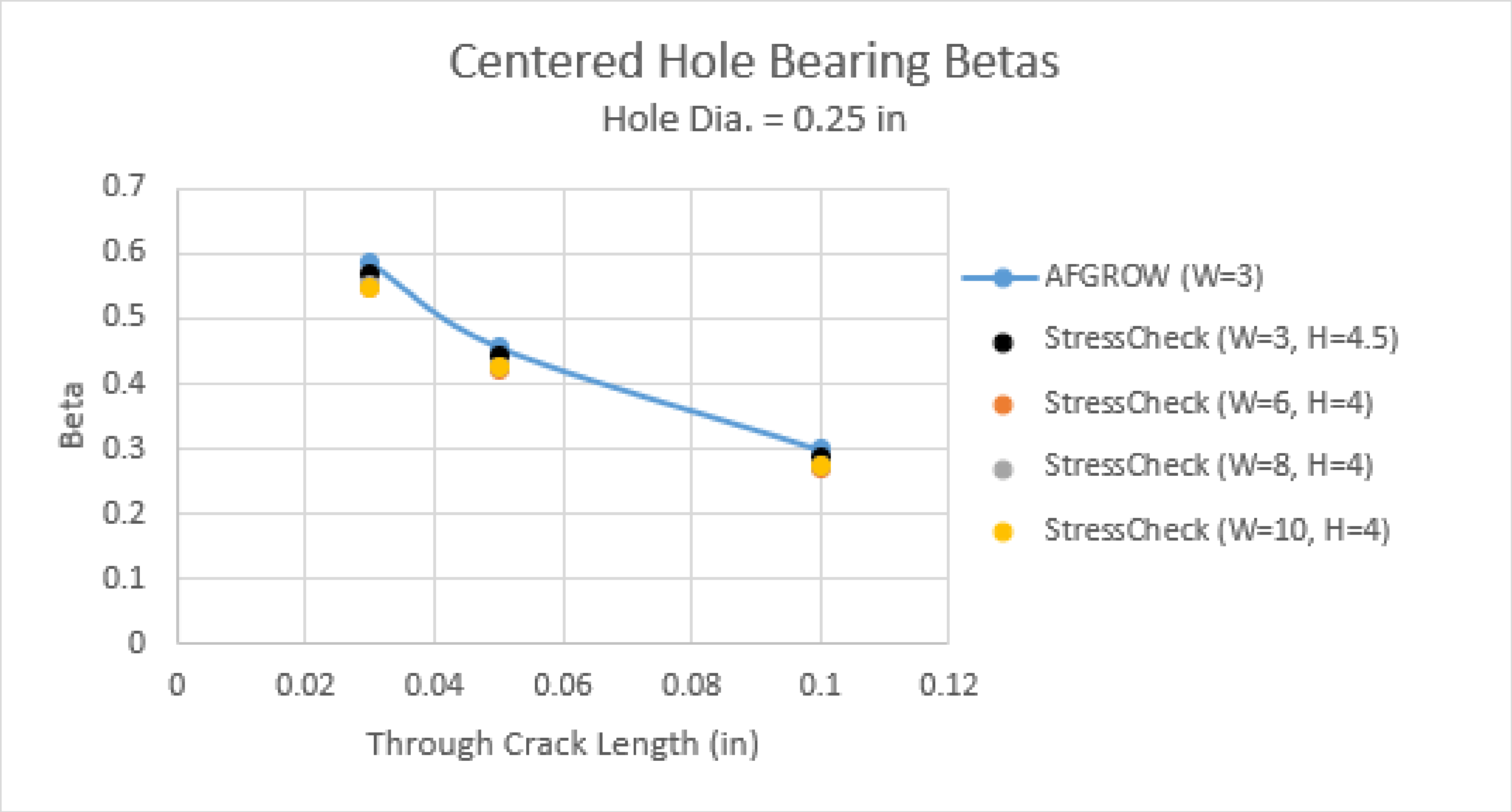

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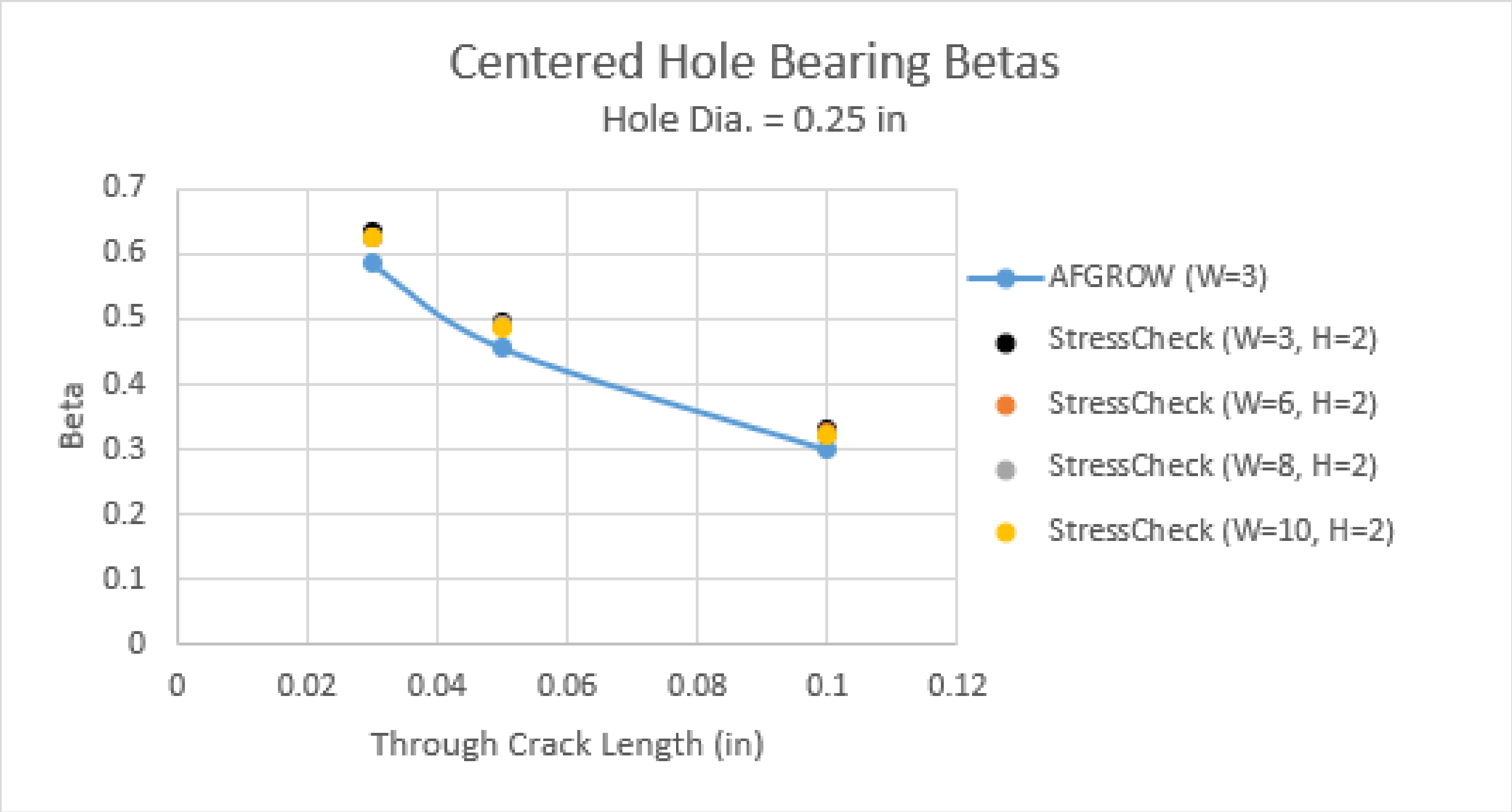

Offset Hole Comparisons

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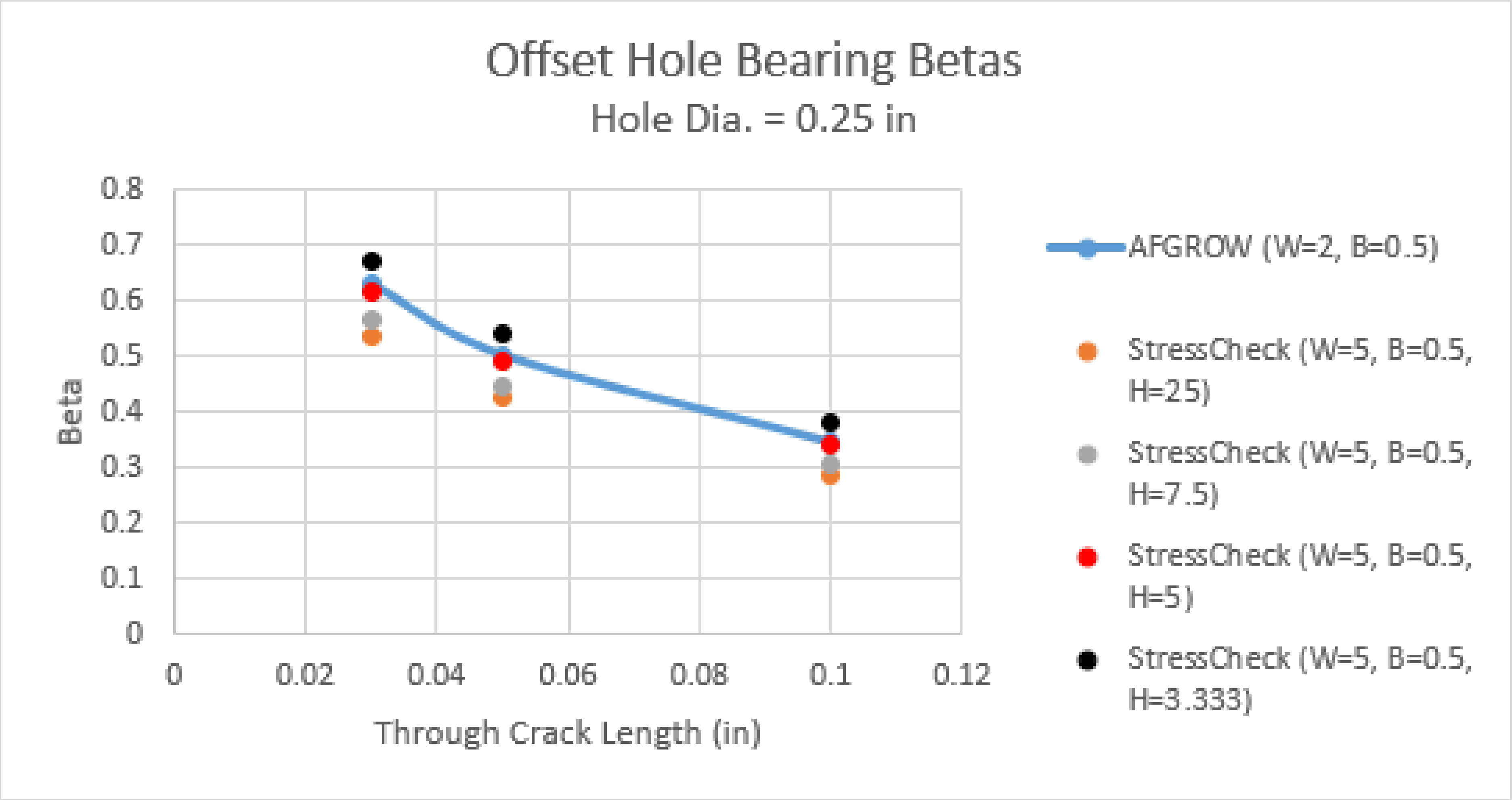

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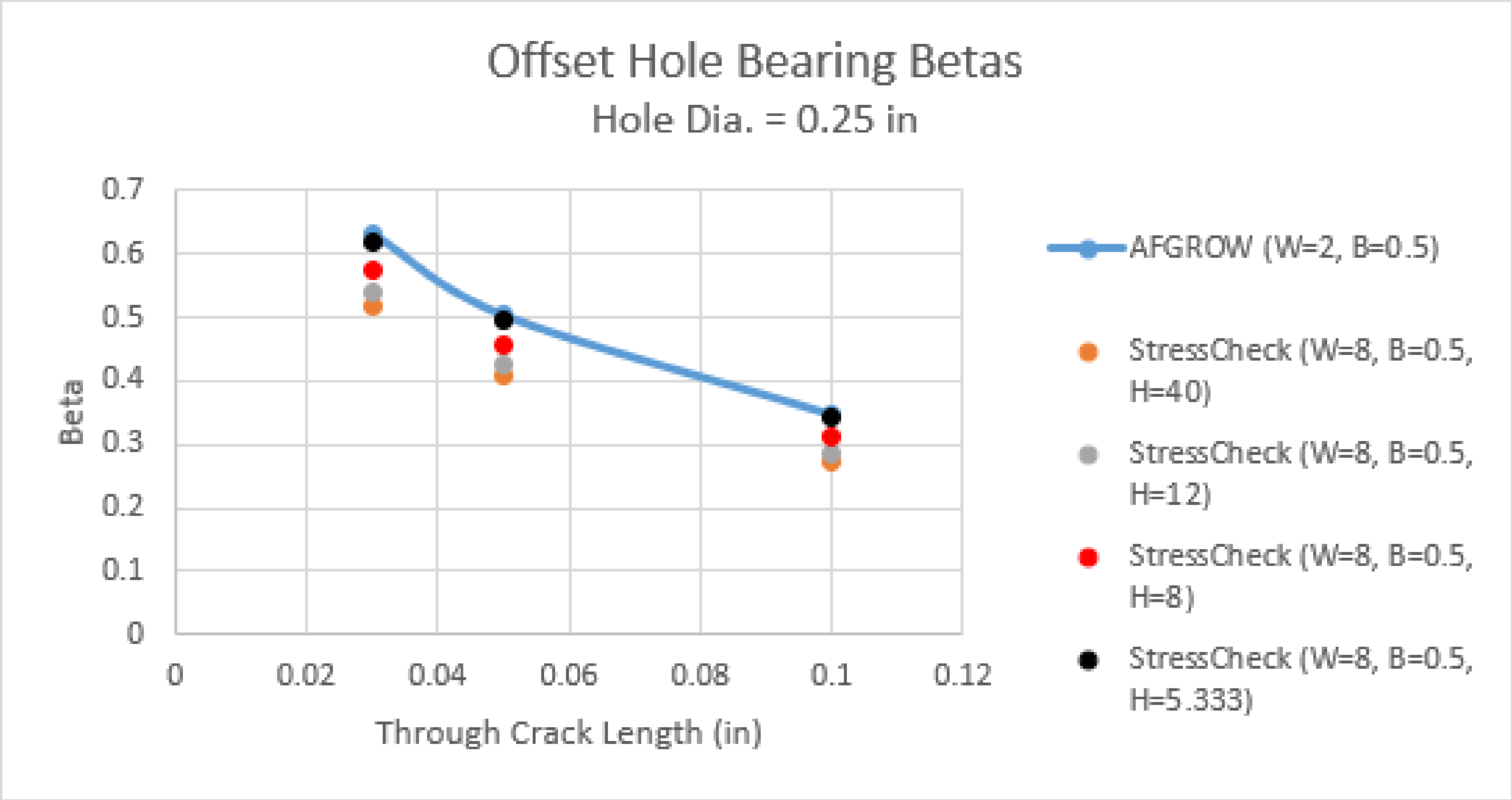

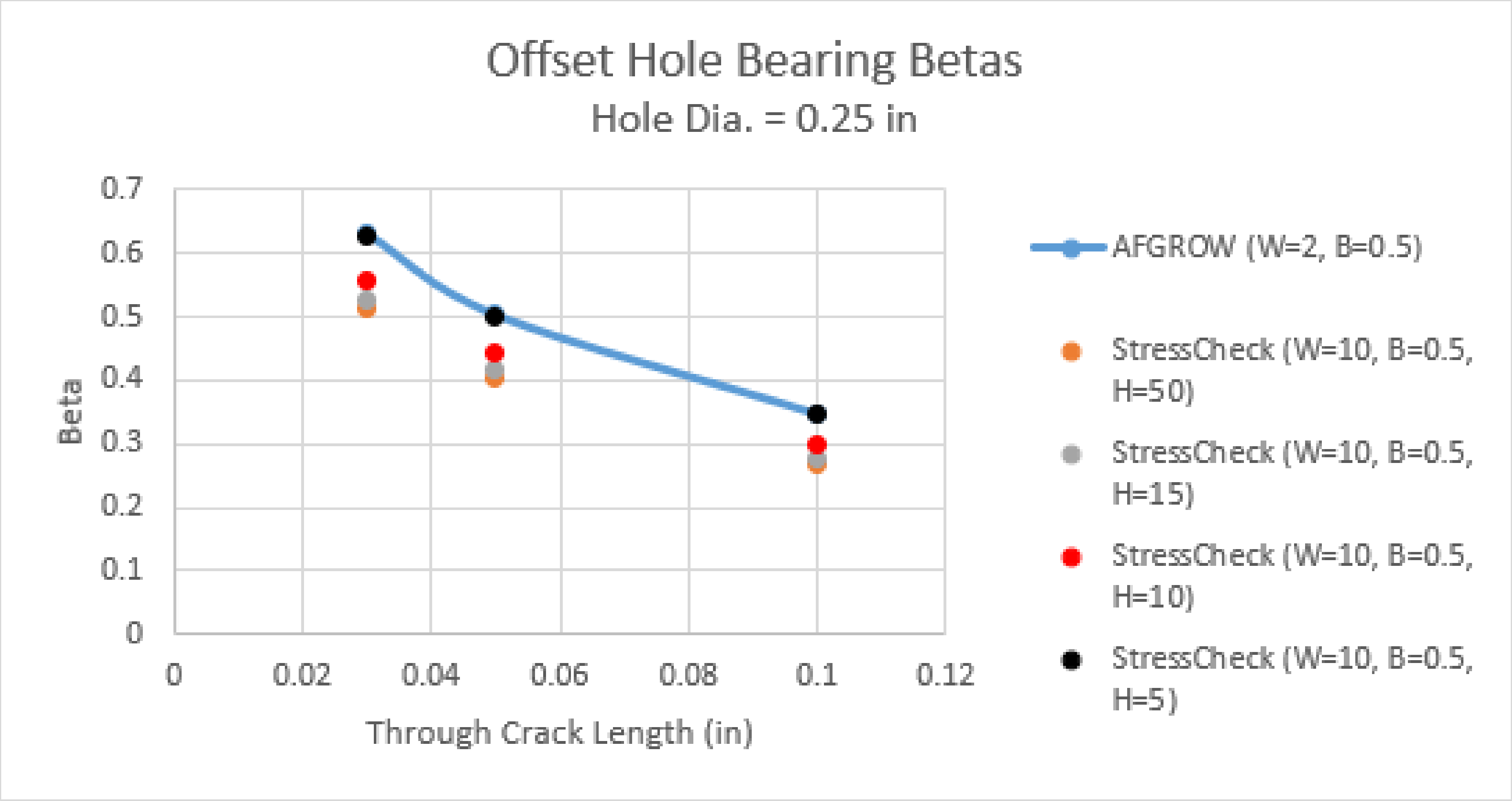

Offset Hole Bearing Betas
Hole Dia. = 0.25 in
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Beta
0
0.02
0.04
0.06
0.08
0.1
0.12
Through Crack Length (in)
AFGROW (W=2, B=0.5)
StressCheck (W=10, B=0.5, H=50)
StressCheck (W=10, B=0.5, H=15)
StressCheck (W=10, B=0.5, H=10)
StressCheck (W=10, B=0.5, H=5)

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Analysis Results

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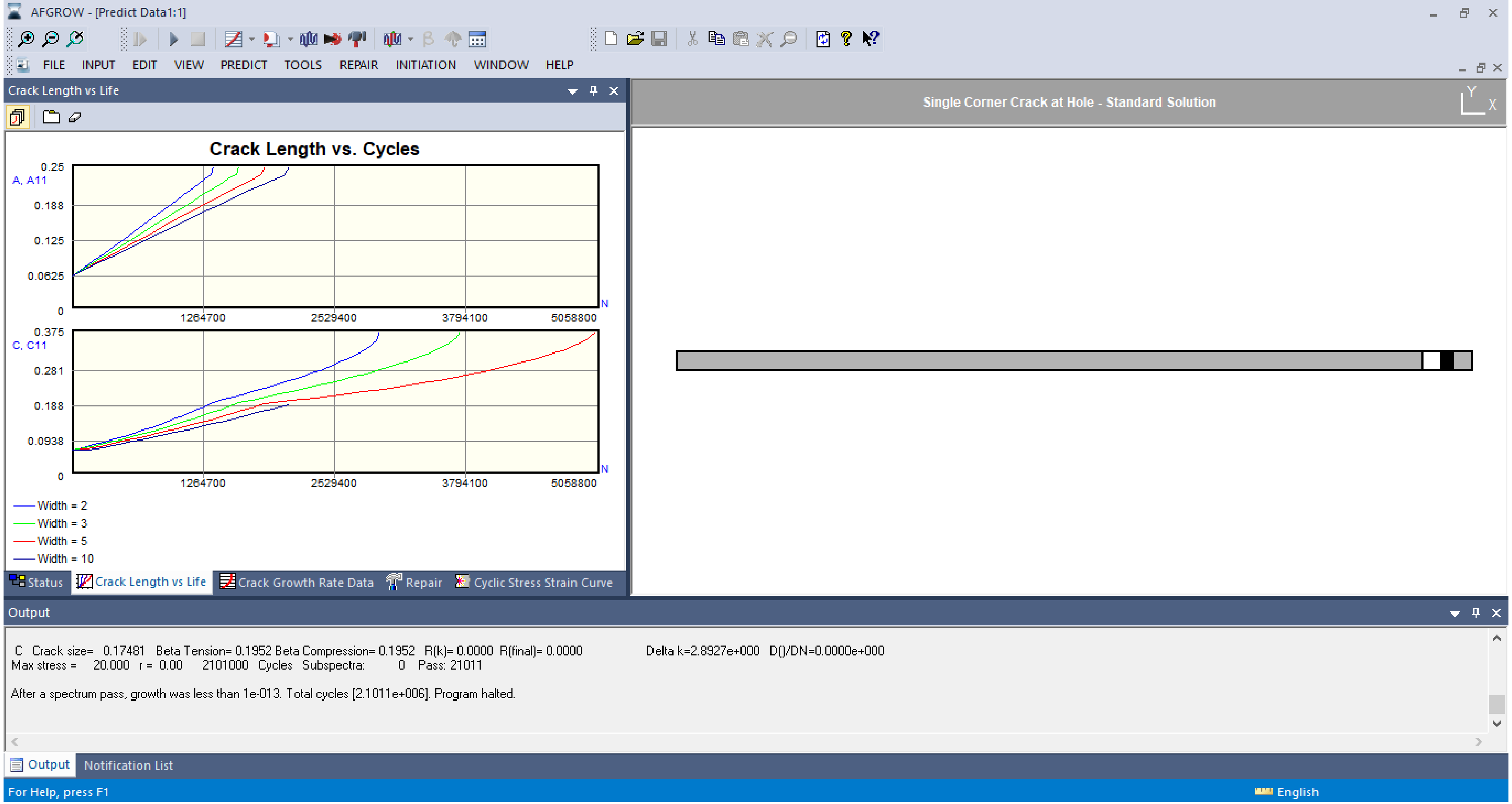

We are considering an option to use the “Equivalent Width” for the Bearing K-Solution Calculations

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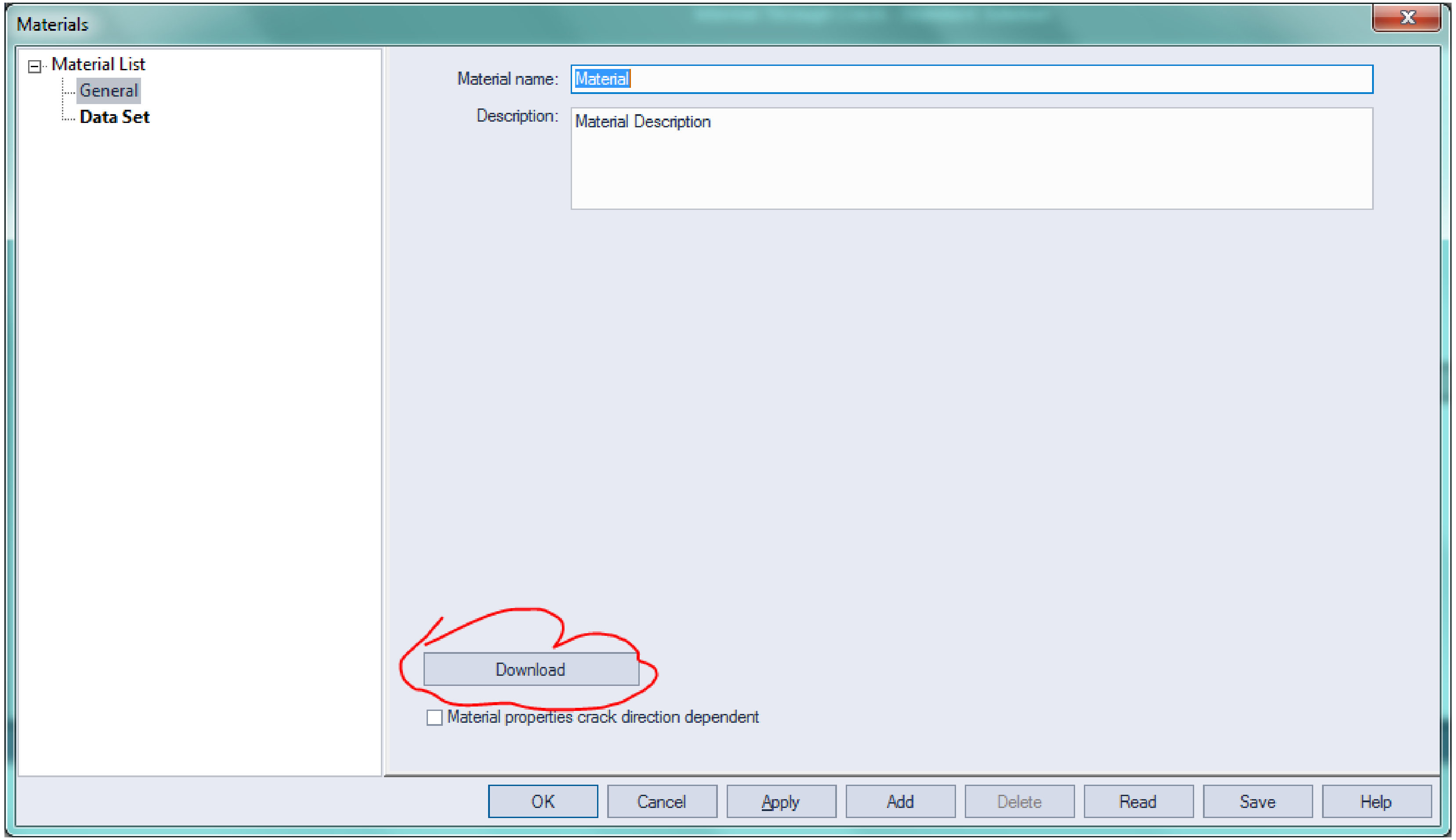
Network or Online Access to Material Data

- Only tabular lookup format right now
- Require modification to the AFGROW configuration file and can be done only by administrator
- Require a data configuration file that points to all material data files
- Material files need to be in the lkpx (XML based format)

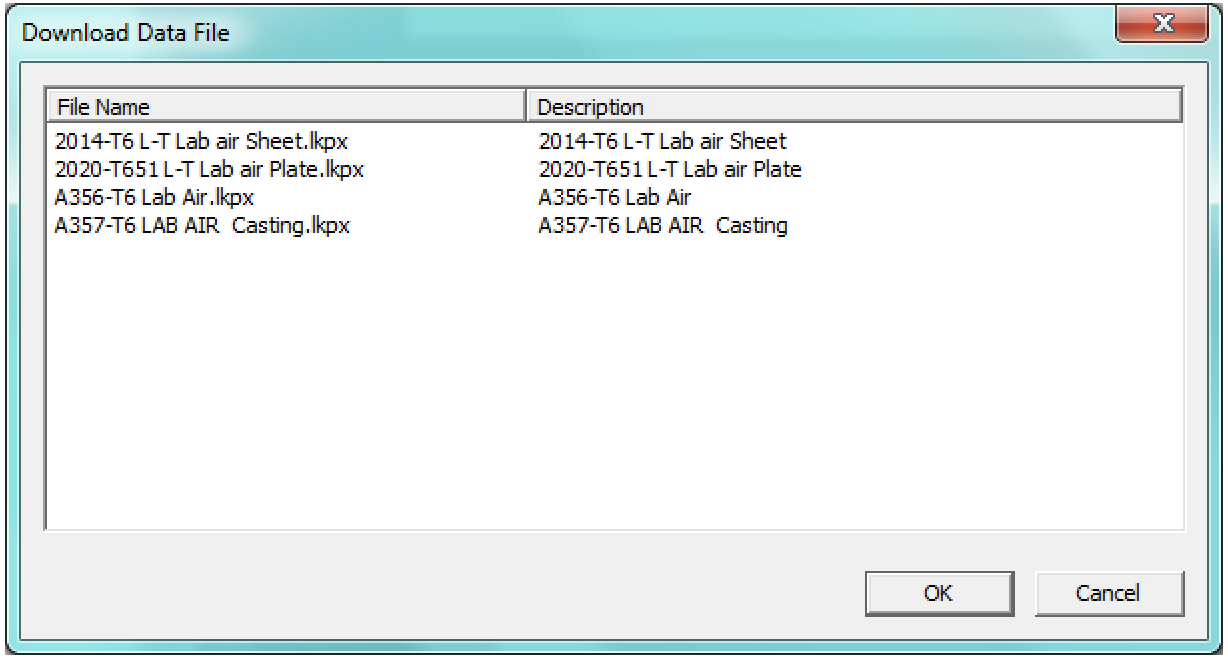
Network or Online Access to Material Data - Advantages

- Provides the same set of material data for all users
- Can not be modified by users
- Easy to implement and manage
- User access can be modified per file or per group of files

Network or Online Access to Material Data



Network or Online Access to Material Data – Download Data Dialog



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AFGROW Configuration File

```
<?xml version="1.0" encoding="utf-8" ?>
<configuration>
  <appSettings>
    <add key="MaterialLookupList Url"
value="http://www.afgrow.net/mate value = "Z:\ServerFolders\Material-Data_load\MaterialLookupList.xml“ />
</appSettings>
<custom.settings>
        <plugins>
                <plugin> Counter_Sunk_Hole_In_Plate.Counter_Sunk_Hole_In_Plate_Plugin</plugin>
                <plugin>VZLUPlugin.VZLUPluginClass</plugin>
  </plugins>
</custom.settings>
</configuration>
```

Material Configuration File


```
<?xml version="1.0"?>

-<MaterialFileList>

	<MaterialFile location="http://www.afgrow.net/material/" name="2020-T651 L-T Lab air Plate.lkpx">2020-T651 L-T Lab air Plate</MaterialFile>

	<MaterialFile location="http://www.afgrow.net/material/" name="A356-T6 Lab Air.lkpx">A356-T6 Lab Air</MaterialFile>

	<MaterialFile location="http://www.afgrow.net/material/" name="A357-T6 LAB AIR Casting.lkpx">A357-T6 LAB AIR Casting</MaterialFile>

	<MaterialFile location="http://www.afgrow.net/material/" name="2014-T6 L-T Lab air Sheet.lkpx">2014-T6 L-T Lab air Sheet</MaterialFile>

</MaterialFileList>
```

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Material Data on AFMAT

AF Mat > Tabular Lookup da/dN Data

Tabular Lookup da/dN Data

AND

Apply

Materials
- ALLOY STEELS
- Aluminum
- STAINLESS STEELS
- TITANIUM ALLOYS

Material Name	Ultimate Strength	Young's Modulus	Coefficent of Thermal Expansion	Poisson's Ratio	Upper limit on da/dN	Lower limit on da/dN	Plane Stress Fracture Toughness	Yield Strength	Plane Strain Fracture Toughness	Lower limit on R shift	Delta K Threshold value	Upper limit on R shift	Units
2324-T39 lab air & HHA L-T	70	10600	1.24E-05	0.33	0.1	1E-09	78	55	39	-0.33	2.8488	0.7	English
2224-T3511 L-T Lab Air Extrusion	70	10600	1.25E-05	0.33	0.1	1E-09	65	52	30	-0.33	2.7865	0.75	English
PH13-8Mo-H1050 L-T Lab Air Forging	190	30000	7E-06	0.33	0.01	1E-09	201	180	115	-0.33	5.486	0.7	English
7010-T73651 L-T Plt Lab Air	73	10000	1.31E-05	0.33	0.1	1E-09	62	63	34	-0.33	2.5057	0.8	English
7150-T7751 L-T Lab air Plate	85	10400	1.31E-05	0.33	0.1	1E-09	62	79	30	-0.33	1.9589	0.75	English
Ti-6AL-4V L-T Lab Air	140	16000	4.9E-06	0.32	0.1	1E-09	95	130	57	-0.33	4.2051	0.7	English
7050-T7451 L-T HHA Plate	75	10400	1.34E-05	0.33	0.01	1E-09	72	65	36	-0.33	2.1351	0.75	English
TI-6AL-4V C-R LAB AIR DISC	160	16000	4.9E-06	0.31	0.01	1E-09	95	150	45	-0.33	3.1208	0.7	English
7475-T7351 L-T HHA Plate	72	10400	1.31E-05	0.33	0.1	1E-09	100	62	45	-0.33	2.5926	0.75	English
4340 L-T 160-180 UTS Plt+Frg Lab air Temp 650	150	30000	7E-06	0.33	0.01	1E-09	185	120	120	-0.333	4.3829	0.75	English
7178-T6 L-T Lab Air Sheet	89	10400	1.31E-05	0.33	0.1	1E-09	48	80	25	-0.33	2.2306	0.72	English
2024-T3 Lab Air L-T	67	10600	1.29E-05	0.33	0.1	1E-09	80	49	35	-0.33	2.475	0.75	English
2618-T851 T-L HHA PLATE	53	10600	1.24E-05	0.33	0.1	1E-09	52	42	30	-0.33	2.7	0.75	English
2024-T3511 Lab Air L-T	70	10600	1.29E-05	0.33	0.1	1E-09	55	52	25	-0.33	2.794	0.75	English
2020-T651 L-T Lab air Plate	82	10600	1.28E-05	0.33	0.1	1E-09	45	77	22.5	-0.4	2.3	0.75	English

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AF Mat > Tabular Lookup da/dN Data > View Tabular_Lookup da/dN Data

Tabular Lookup da/dN Data - 2324-T39 lab air & HHA L-T

Materials

- ALLOY STEELS
- Aluminum
  - ALUMINUM 2000/6000 ALLOYS
    - 2014
    - 2020
    - 2024
    - 2090
    - 2091
    - 2124
    - 2219
    - 2224
    - 2324
      - 2324-T39 lab air & HHA L-T
    - 2618
  - ALUMINUM 7000/8000 ALLOYS
  - ALUMINUM CASTING ALLOYS
- STAINLESS STEELS
- TITANIUM ALLOYS

Download Tabular Lookup file

General | Plot

Res ID	R	Orientation	Condition Heat Treatment
nsM2JA11AB01D1	0.1	L-T	T39
nsM2JA11AB01E1	0.1	L-T	T39
nsM2JA11AB01A1	0.1	L-T	T39
nsM2JA11AB01C1	0.1	L-T	T39
nsM2JA11AB01B1	0.1	L-T	T39
a2dn_4664	0.33	L-T	T39
a2dn_4665	0.33	L-T	T39
a2dn_4666	0.33	L-T	T39

Tabular Lookup Parameter Data

Name:	2324-T39 lab air & HHA L-T	Units:	English
Ultimate Strength:	70	Young's Modulus:	10600
Coefficent of Thermal Expansion:	1.24E-05	Poisson's Ratio:	0.33
Upper limit on da/dN:	0.1	Lower limit on da/dN:	1E-09
Plane Stress Fracture Toughness:	78	Yield Strength:	55
Plane Strain Fracture Toughness:	39	Lower limit on R shift:	-0.33

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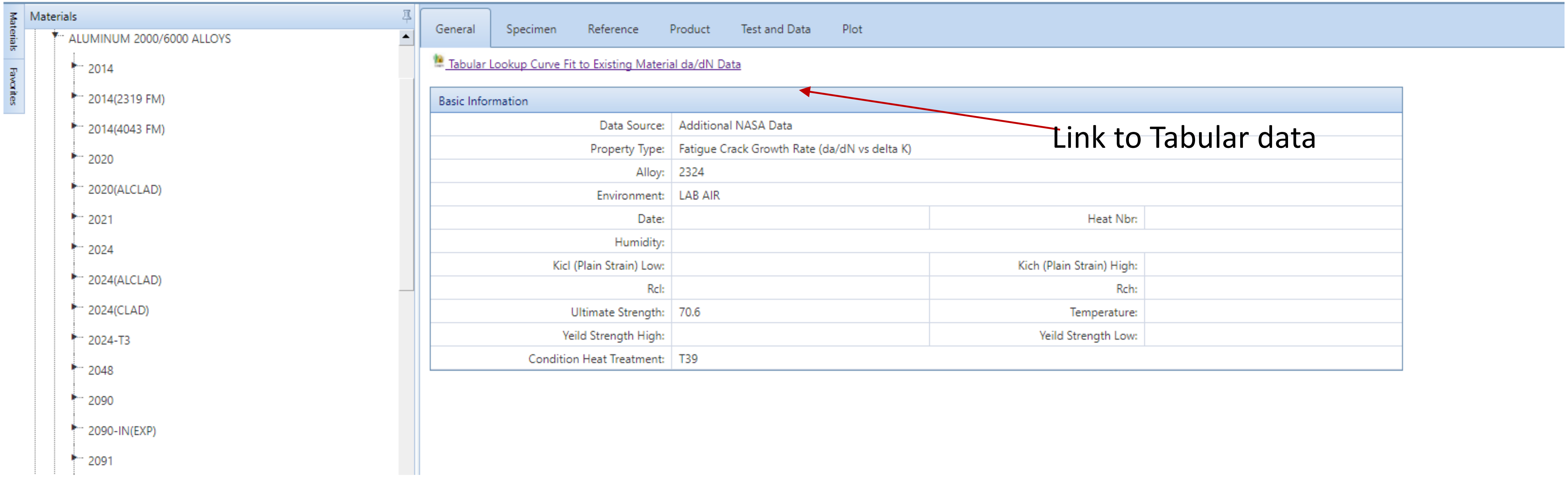
AF Mat > Test Profile > View Test Profile

Test Profile



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Tabular Lookup da/dN Data - 2091-T8 T-L HHA PLT&SHT

Materials

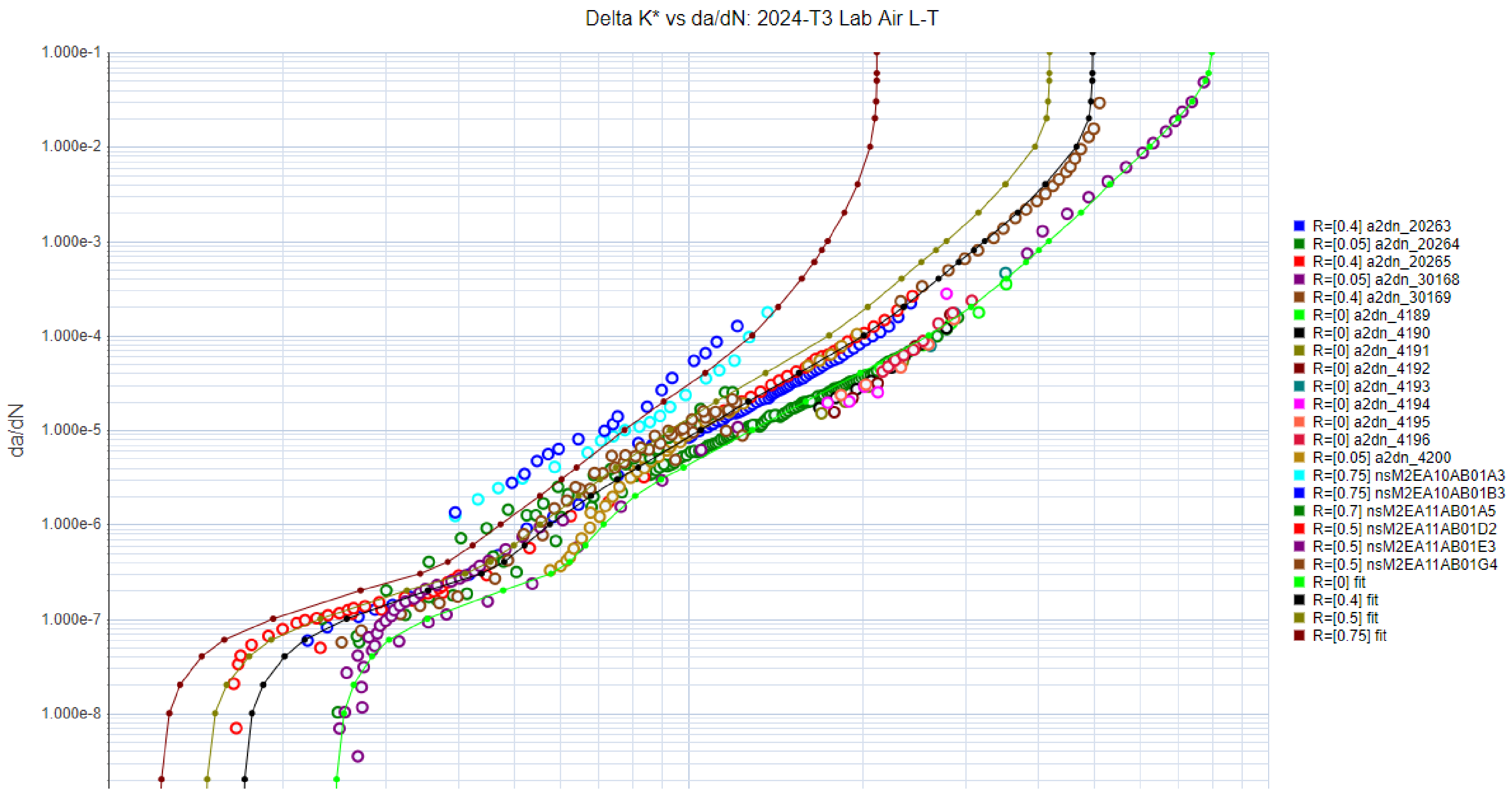
- ALLOY STEELS
- Aluminum
  - ALUMINUM 2000/6000 ALLOYS
    - 2014
    - 2020
    - 2024
    - 2090
    - 2091
      - 2091-T8 T-L HHA PLT&SHT
    - 2124
    - 2219
    - 2224
    - 2324
    - 2618
  - ALUMINUM 7000/8000 ALLOYS
  - ALUMINUM CASTING ALLOYS
- STAINLESS STEELS
- TITANIUM ALLOYS

a2dn 20016	0.5	T-L	T8;HT/275F/12HR

Tabular Lookup Parameter Data			
Name:	2091-T8 T-L HHA PLT&SHT	Units:	English
Ultimate Strength:	85	Young's Modulus:	10600
Coefficent of Thermal Expansion:	1.24E-05	Poisson's Ratio:	0.33
Upper limit on da/dN:	0.1	Lower limit on da/dN:	1E-09
Plane Stress Fracture Toughness:	66	Yield Strength:	75
Plane Strain Fracture Toughness:	33	Lower limit on R shift:	-0.33
Delta K threshold value:	3.55	Upper limit on R shift:	0.7

Tabular Lookup da/dN* data	R1 = 0	R2 = 0.5
1E-09	3.55	2.07
2E-09	3.551	2.075
1E-08	3.56	2.095
2E-08	3.6	2.17
4E-08	3.75	2.48
6E-08	3.98	2.8
1E-07	4.41	3.275
2E-07	5.28	4

Tabular look-up data



References

1. "The Effect of Stress The Effect of Stress Intensity Factor Models on Inspection Intervals", Lt Col Scott Fawaz, Center for Aircraft Structural Life Extension United States Air Force Academy
2. “The Redesigned AFMAT, Crack Growth Rate Database - AFGROW Workshop 2017”, Cordell E. Smith, James A. Harter, Alexander V. Litvinov, LexTech, Inc.
3. “AFGROW Release 5.3 - AFGROW Workshop 2018”, James A. Harter, Alexander V. Litvinov, LexTech, Inc.

Questions