LexTech

AFGROW.NET

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Using the New Multi-Channel Spectrum Format

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Current AFGROW Spectrum

To date, AFGROW has used a single channel load spectrum. Because of this limitation, K-solutions for combined loading (axial, bending, and bearing) are limited by the assumption that fractional components of each load case are constant.

Why Change?

- Several AFGROW Users have expressed an interest in the ability to input independent loading spectra for axial, bending, and bearing loads

- As we move toward a 3-D capability, it will be important to be able to manage applied loading in more than one direction

Current K Calculation

$$\textbf{Alpha}_{tension} = \text{Alpha}_{axial} * \text{AxialTensionModifier} + \text{Alpha}_{bending} * \text{BendingTensionModifier} + \text{Alpha}_{bearing} * \text{BearingTensionModifier}$$

$$\textbf{Alpha}_{compression} = \text{Alpha}_{axial} * \text{AxialCompressionModifier} + \text{Alpha}_{bending} * \text{BendingCompressionModifier} + \text{Alpha}_{bearing} * \text{BearingCompressionModifier}$$

$$\textbf{Beta}_{tension} = (\textbf{Alpha}_{tension} * \text{Beta}_{Correction}) / \text{sqrt}(\text{Pi} * \text{Crack Length})$$

$$\textbf{Beta}_{compression} = (\textbf{Alpha}_{compression} * \text{Beta}_{Correction}) / \text{sqrt}(\text{Pi} * \text{Crack Length})$$

$$\textbf{K}_{max} = \text{Stress}_{Max} * \text{sqrt}(\text{Pi} * \text{Crack Length}) * ((\text{Stress}_{Max} >= 0)? \textbf{Beta}_{tension} : \textbf{Beta}_{compression})$$

$$\textbf{K}_{min} = \text{Stress}_{Min} * \text{sqrt}(\text{Pi} * \text{Crack Length}) * ((\text{Stress}_{Min} >= 0)? \textbf{Beta}_{tension} : \textbf{Beta}_{compression})$$

$$\textbf{K}_{max} = \textbf{K}_{max} + \textbf{K}_{res}$$

$$\textbf{K}_{min} = \textbf{K}_{min} + \textbf{K}_{res}$$

Proposed K Calculation - Alpha

Alpha $_{\text{axial-tension}}$ = Alpha $_{\text{axial}}$ * AxialTensionModifier
Alpha $_{\text{bending-tension}}$ = Alpha$_{\text{bending}}$ * BendingTensionModifier
Alpha $_{\text{bearing-tension}}$ = Alpha$_{\text{bearing}}$ * BearingTensionModifier
Alpha $_{\text{axial-compression}}$ = Alpha $_{\text{axial}}$ * AxialCompressionModifier
Alpha $_{\text{bending-compression}}$ = Alpha$_{\text{bending}}$ * BendingCompressionModifier
Alpha $_{\text{axial-compression}}$ = Alpha$_{\text{bearing}}$ * BearingCompressionModifier

Beta $_{\text{axial-tension}}$ = (**Alpha** $_{\text{axial-tension}}$ * Beta$_{\text{Correction}}$) / sqrt (Pi*Crack Length)
Beta $_{\text{bending-tension}}$ = (**Alpha** $_{\text{bending-tension}}$ * Beta$_{\text{Correction}}$) / sqrt (Pi*Crack Length)
Beta $_{\text{bearing-tension}}$ = (**Alpha** $_{\text{bearing-tension}}$ * Beta$_{\text{Correction}}$) / sqrt (Pi*Crack Length)
Beta $_{\text{axial-compression}}$ = (**Alpha** $_{\text{axial-compression}}$ * Beta$_{\text{Correction}}$) / sqrt (Pi*Crack Length)
Beta $_{\text{bending-compression}}$ = (**Alpha** $_{\text{bending-compression}}$ * Beta$_{\text{Correction}}$) / sqrt (Pi*Crack Length)
Beta $_{\text{bearing-compression}}$ = (**Alpha** $_{\text{bearing-compression}}$ * Beta$_{\text{Correction}}$) / sqrt (Pi*Crack Length)

Proposed K Calculation - Beta

$$K_{max\text{-}axial} = Stress_{Max\text{-}axial} * \sqrt{(\pi * Crack\ Length)} * ((Stress_{Max\text{-}axial} >= 0)? \mathbf{Beta}_{axial\text{-}tension} : \mathbf{Beta}_{axial\text{-}compression})$$

$$K_{min\text{-}axial} = Stress_{Min\text{-}axial} * \sqrt{(\pi * Crack\ Length)} * ((Stress_{Min\text{-}axial} >= 0)? \mathbf{Beta}_{axial\text{-}tension} : \mathbf{Beta}_{axial\text{-}compression})$$

$$K_{max\text{-}bending} = Stress_{Max\text{-}bending} * \sqrt{(\pi * Crack\ Length)} * ((Stress_{Max\text{-}bending} >= 0)? \mathbf{Beta}_{bending\text{-}tension} : \mathbf{Beta}_{bending\text{-}compression})$$

$$K_{min\text{-}bending} = Stress_{Min\text{-}bending} * \sqrt{(\pi * Crack\ Length)} * ((Stress_{Min\text{-}bending} >= 0)? \mathbf{Beta}_{bending\text{-}tension} : \mathbf{Beta}_{bending\text{-}compression})$$

$$K_{max\text{-}bearing} = Stress_{Max\text{-}bearing} * \sqrt{(\pi * Crack\ Length)} * ((Stress_{Max\text{-}bearing} >= 0)? \mathbf{Beta}_{bearing\text{-}tension} : \mathbf{Beta}_{bearing\text{-}compression})$$

$$K_{min\text{-}bearing} = Stress_{Min\text{-}bearing} * \sqrt{(\pi * Crack\ Length)} * ((Stress_{Min\text{-}bearing} >= 0)? \mathbf{Beta}_{bearing\text{-}tension} : \mathbf{Beta}_{bearing\text{-}compression})$$

$$K_{max} = K_{max\text{-}axial} + K_{max\text{-}bending} + K_{max\text{-}bearing}$$

$$K_{min} = K_{max\text{-}bearing} + K_{min\text{-}bending} + K_{min\text{-}bearing}$$

$$K_{max} = K_{max} + K_{res}$$

$$K_{min} = K_{min} + K_{res}$$

New Spectrum Format Goals

- Forward Compatible – Can be added without breaking older versions
- Simple – Can be easily understood
- Can be created manually in notepad and similar text editors with relatively minor effort
- Can be easily created using programming tools
- Easy to post process by readily available data processing applications (i.e. Excel)
- Easy to edit - Modular

XML Based New Spectrum Format

- XML was designed to transport and store data with a focus on the data
- Is the basis for a majority document formats today: MS Office for example
- Available software libraries – easy and fast development
- Familiar to software developers
- Easy to read
- Not as easy to create manually
- Tools exists that assist with XML file creation
- Powerful transformation pre and post processor library

Current Spectrum Format

- Minimum of 2 files – **Information** and **SubSpectrum**
- Text base
- Very easy to create manually or programmatically

Information

```
AFGROW Tutorial Sample Spectrum
Block
BLOCKED
1
```

SubSpectrum

```
1 2
  16.000000 0.000000 1
  12.000000 8.000000 1000
```

Preliminary View of the New Spectrum Format

Header

```
1  <?xml version="1.0" encoding="utf-8"?>
2  <Spectrum xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:xsd="http://www.
   w3.org/2001/XMLSchema">
3    <Description />
4    <SubSpectrumLabel>Block</SubSpectrumLabel>
5    <Title>AFGROW Tutorial Sample Spectrum</Title>
6    <SubSpectra>
7      <SubSpectrum Name="1" Items="2">
8        <Block MinAxial="0" MaxAxial="16" MinBending="0" MaxBending="16" MinBearing="0"
   MaxBearing="16" Cycles="1" />
9        <Block MinAxial="8" MaxAxila="12" MinBending="8" MaxBending="12" MinBearing="8"
   MaxBearing="12" Cycles="1000" />
10     </SubSpectrum>
11   </SubSpectra>
12   <Sequences>
13     <Sequence Position="1" Name="1" />
14   </Sequences>
15 </Spectrum>
```

Sequence

Sub-Spectrum

Spectrum Header

- Title
- Description
- SubSpectrum Label
- Time Dependent or Not
- Hours Per Pass
- Multi Channel or Not ???

Sub Spectrum

- Name
- Description
- Multi Channel or Not ???
- Block 1
- Block 2
- …

Level

- MinAxial
- MaxAxial
- MinBearing
- MaxBearing
- MinBending
- MaxBending
- Cycles
- Time
- Cycle Shape

New Spectrum Format Sequence

List of sub spectra by name in the order to be applied in the spectrum

New Spectrum Format Application Support

- Afgrow: Open, View, Zoom, Exceedance curve
- New Spectrum Conversion Utility – Afgrow tool
- New Spectrum Design/Editing Application, – Separate, but still part of AFGROW in terms of licensing
- Old AFGROW spectrum creation Wizard will be removed

New Spectrum Design/Edit Application Capabilities

- Visual representation of spectrum, sub-spectra
- Editing spectrum in the spreadsheet like control
- Editing Sequence using Drag and Drop
- Clipping
- Truncation
- Spectrum generation – from Exceedance Data
- Randomization

Future Development

- Out of phase spectrum?
- Cycle counting - Jim’s Cycle counting app?,
- Any other suggestions?

Summary

- Afgrow will have Multi-channel spectrum support in the next release
- New spectrum format development has been completed
- A new spectrum tool will be created
- Afgrow will support old spectrum format initially, but we hope to transition everyone to the new format