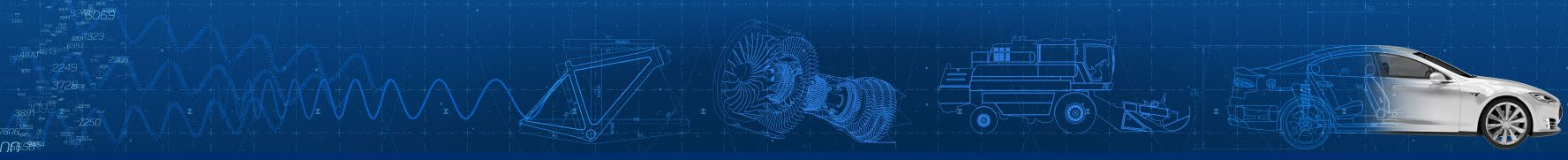


2019 Prencia User Group Meeting | April 30th – May 1st | Novi,MI (USA)



Additive Damage Analysis of the Frequency Damage Spectrum

Presented by Phil Korth



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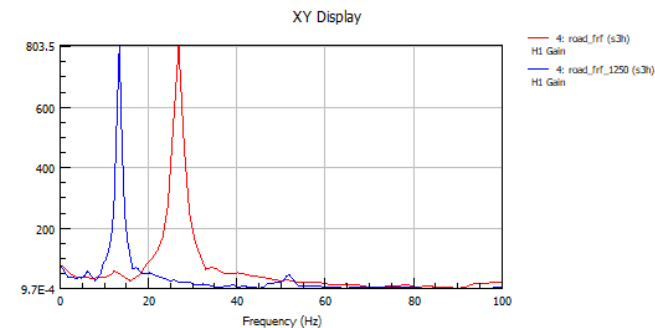
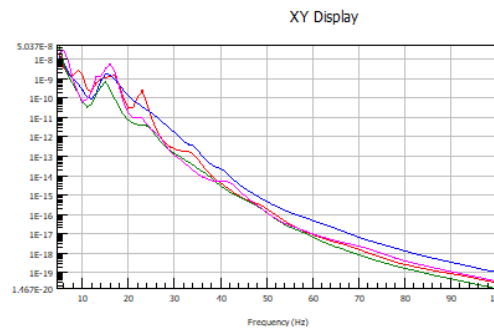
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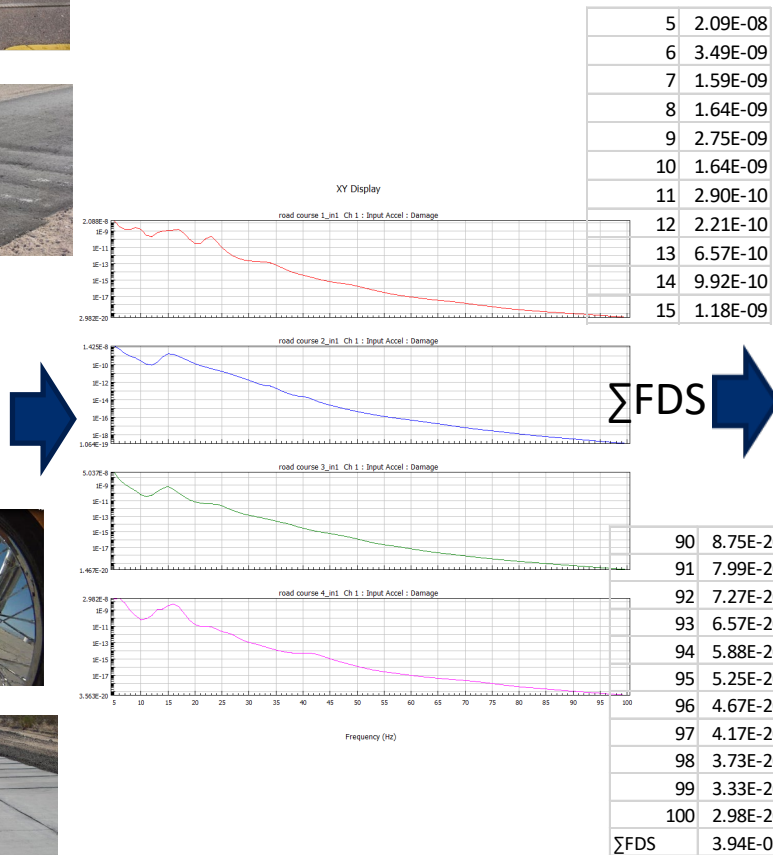
- The FDS (Frequency Damage Spectrum) provides relative damage with damage values across the spectrum at frequency intervals
- The \sum FDS is the arithmetic sum of all points on the FDS spectrum
- Is it possible to sum the damage values of an FDS to provide a relative damage comparison of different events?
 - Utilize multiple duty cycle events
 - Calculate the FDS for each event
 - \sum FDS for each event
 - Measure strain response of 2 different component variations for each duty cycle event
 - Use strain response to calculate a relative damage
 - Compare relative strain damage vs \sum FDS



Use GlyphWorks Accelerated Test for Frequency Damage Spectrum Calculation



- Calculate FDS for 4 different road courses
- Sum the FDS of each across the full spectrum

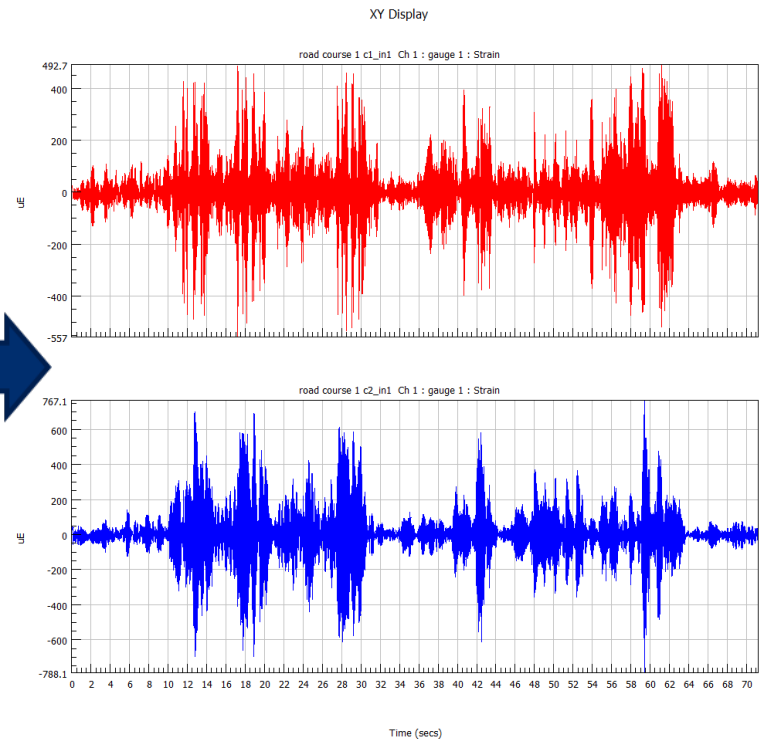
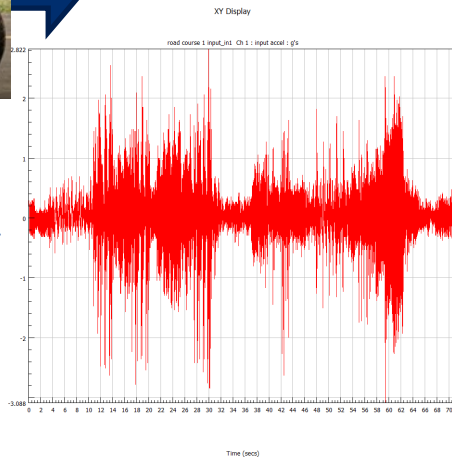
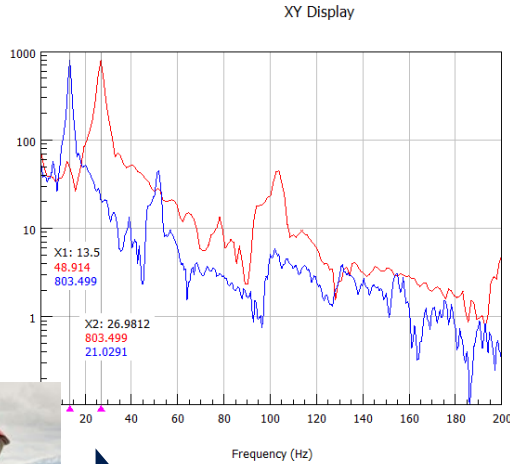


Course	ΣFDS	Damage Rank	% Damage
Road Course 1	3.9373E-08	3	19.12%
Road Course 2	3.0817E-08	4	14.97%
Road Course 3	5.9659E-08	2	28.97%
Road Course 4	7.6075E-08	1	36.94%

Use GlyphWorks Custom Fourier Filter to Convolve Input Acceleration With H1 Gain to Generate Strain Response

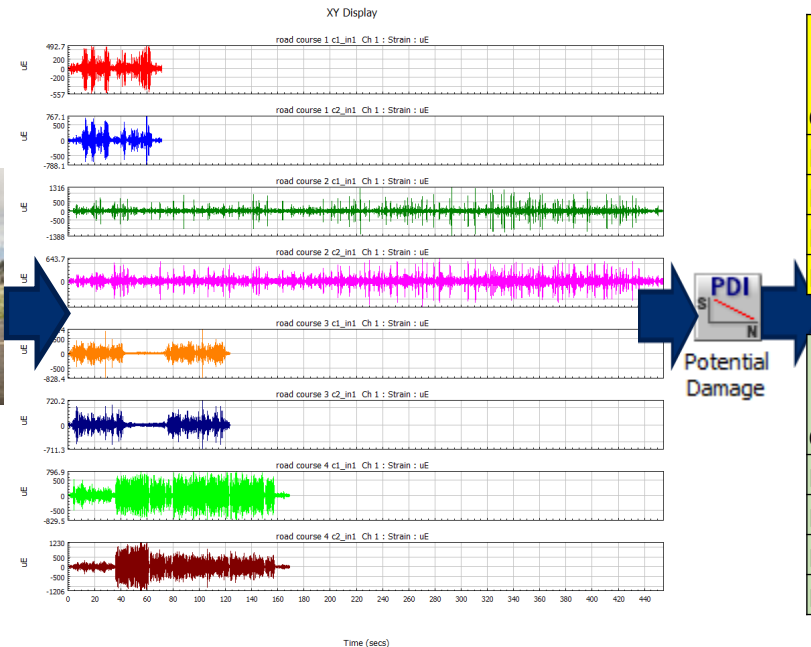


- Use H1 gain variation to create 2 different specimen responses from the same input acceleration (representation of change to mass/stiffness)





- Calculate Relative Strain Damage of 2 different components for 4 different road courses



Course	Relative Damage Component 1	Damage Rank	% Damage
Road Course 1	40.6851	4	4.90%
Road Course 2	652.9135	1	78.61%
Road Course 3	45.7268	3	5.51%
Road Course 4	91.2558	2	10.99%

Course	Relative Damage Component 2	Damage Rank	% Damage
Road Course 1	118.1831	2	23.85%
Road Course 2	41.8587	4	8.45%
Road Course 3	42.7693	3	8.63%
Road Course 4	292.7666	1	59.08%



- ΣFDS damage shows poor correlation to relative strain damage results

Course	ΣFDS	Damage Rank	% Damage
Road Course 1	3.9373E-08	3	19.12%
Road Course 2	3.0817E-08	4	14.97%
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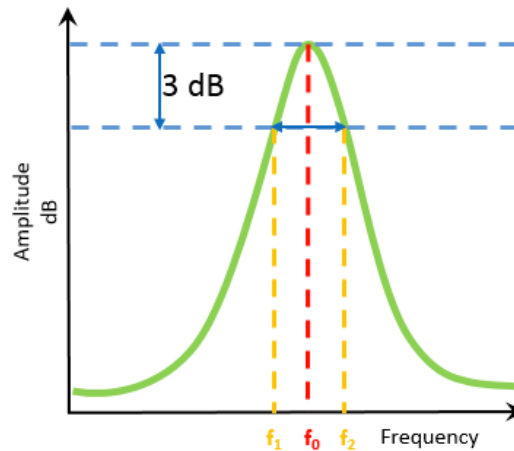
Course	Relative Damage Component 1	Damage Rank	% Damage
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- Determine Resonant Frequency from FRF
- Determine Q Bandwidth
- Sum FDS at f1 to f2

In a FRF, the damping is proportional to the width of the **resonant peak** about the peak's center frequency. By looking at the **three dB** down from the peak level, one can determine the associated damping.



$$Q = \frac{f_0}{f_2 - f_1}$$

The "quality factor" (also known as "damping factor") or "Q" is found by the equation $Q = f_0/(f_2-f_1)$, where:

- f_0 = frequency of resonant peak in Hertz
- f_2 = frequency value, in Hertz, 3 dB down from peak value, higher than f_0
- f_1 = frequency value, in Hertz, 3 dB down from peak value, lower than f_0

ΣFDS f1 to f2 vs Relative Damage



- ΣFDS f1 to f2 shows better correlation to relative strain damage results

Course	Relative Damage Component 1	Damage Rank	% Damage
Road Course 1	40.6851	4	4.90%
Road Course 2	652.9135	1	78.61%
Road Course 3	45.7268	3	5.51%
Road Course 4	91.2558	2	10.99%

Course	ΣFDS f1 to f2 Component 1	Damage Rank	% Damage
Road Course 1	3.6286E-12	2	13.63%
Road Course 2	1.8719E-11	1	70.31%
Road Course 3	1.7059E-12	4	6.41%
Road Course 4	2.5699E-12	3	9.65%

Course	Relative Damage Component 2	Damage Rank	% Damage
Road Course 1	118.1831	2	23.85%
Road Course 2	41.8587	4	8.45%
Road Course 3	42.7693	3	8.63%
Road Course 4	292.7666	1	59.08%

Course	ΣFDS f1 to f2 Component 2	Damage Rank	% Damage
Road Course 1	1.6487E-09	2	28.35%
Road Course 2	1.0236E-09	3	17.60%
Road Course 3	5.573E-10	4	9.58%
Road Course 4	2.585E-09	1	44.46%

Course	ΣFDS	Damage Rank	% Damage
Road Course 1	3.9373E-08	3	19.12%
Road Course 2	3.0817E-08	4	14.97%
Road Course 3	5.9659E-08	2	28.97%
Road Course 4	7.6075E-08	1	36.94%



Challenge

- The FDS (Frequency Damage Spectrum) provides relative damage with damage values across the spectrum at frequency intervals
- The Σ FDS is the arithmetic sum of all points on the FDS spectrum
- Is it possible to sum the damage values of an FDS to provide a relative damage comparison of different events?

Solution

If you are utilizing the FDS to compare damage of different spectrums an understanding of the resonant frequencies and Q is recommended. These measurements can be obtained from virtual measurements (DesignLife) or physical measurements of the component on a vehicle or test rig. Using GlyphWorks to analyze the data, the resonant frequencies can be obtained.

Results

Analysis showed that utilizing Σ FDS across the entire spectrum doesn't produce good correlation. Better results were obtained by utilizing the resonant frequency and summing f1 to f2 of the Q value.

Thank You!



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XR-750 Racing Motorcycle



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