Multiparameter approach for damage propagation analysis in Fiber Reinforced Polymer Composites

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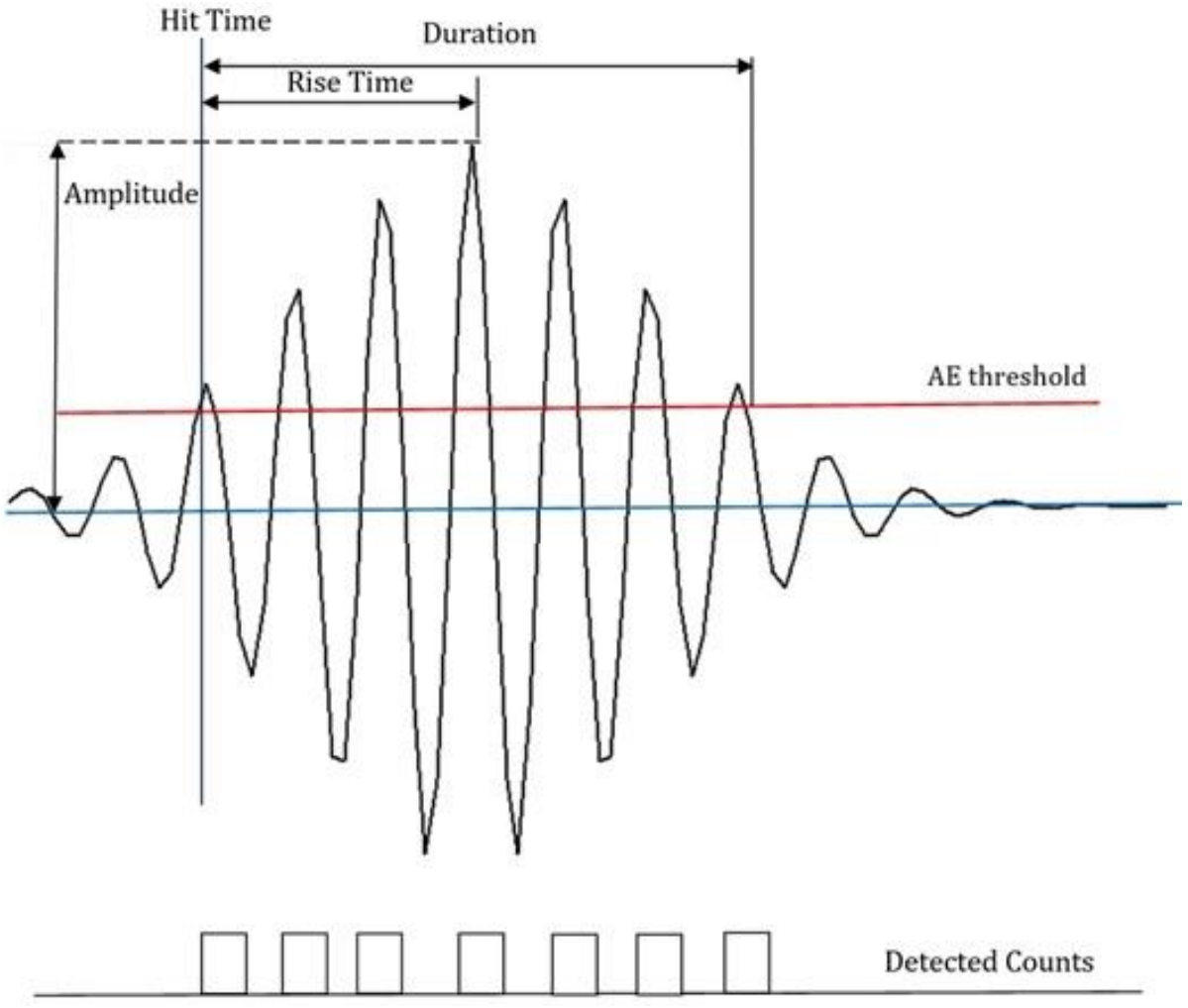
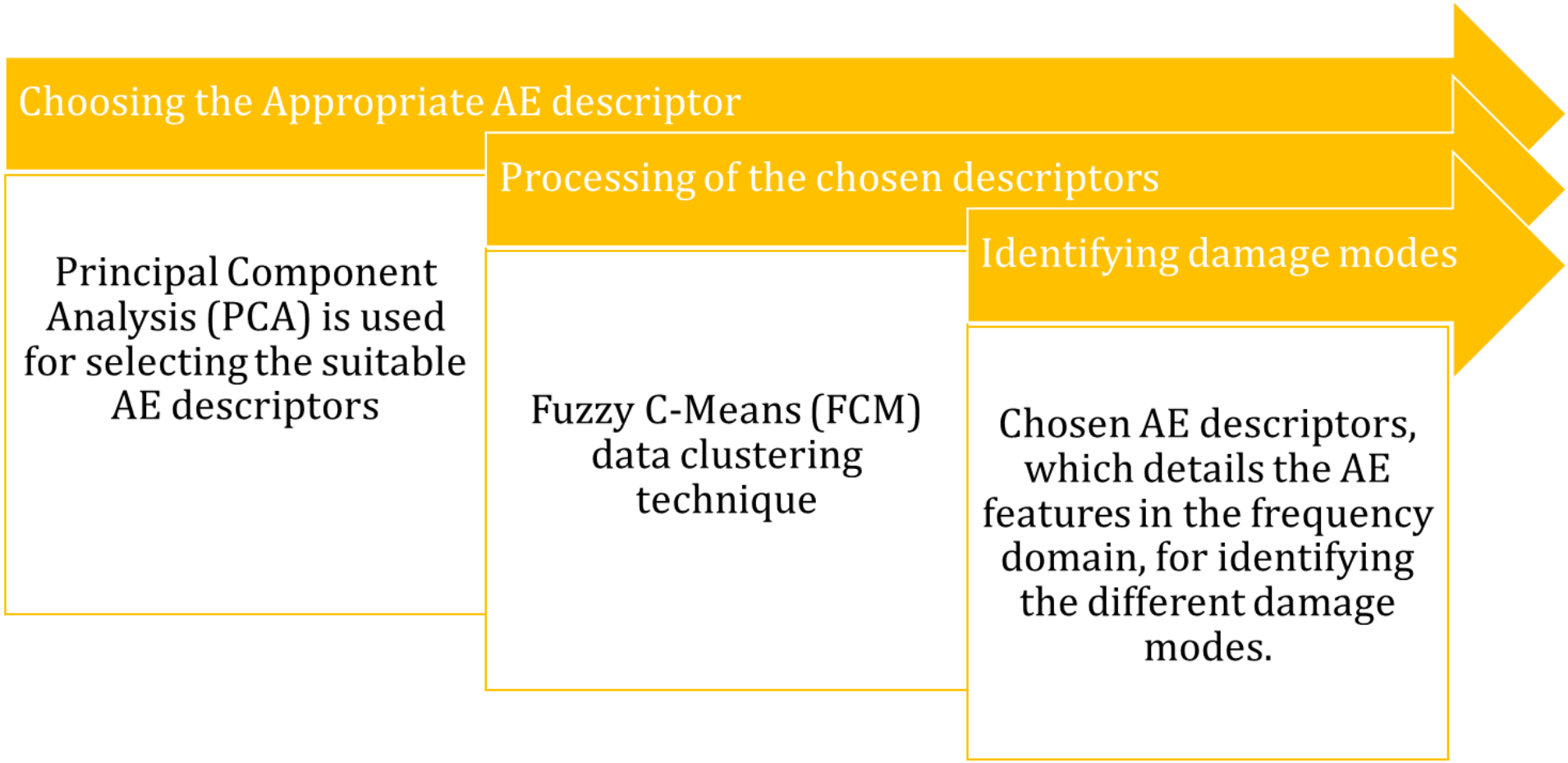
Introduction

- Acoustic Emission (AE) Technique records transient elastic waves generated by a material under loading.
- The generated waves are recorded by Piezoelectric Sensors.
- Longstanding debate on which parameters can be used for this technique.
- Most commonly used AE descriptors: Peak Amplitude, Energy, Counts, Duration and Risetime.

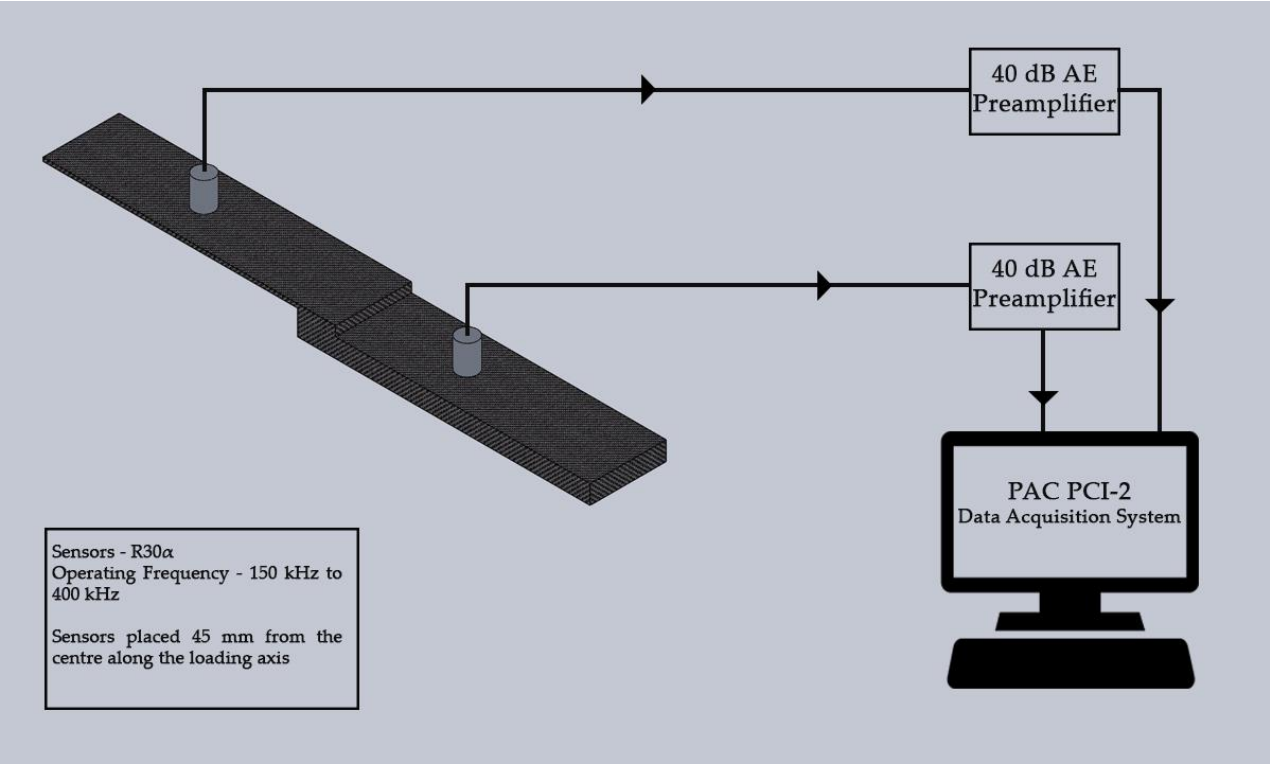




Objectives and Methodology

- Choosing the appropriate AE descriptors for analysis.
- Using the chosen descriptor for identifying damage modes in Fiber Reinforced Polymer Composites.

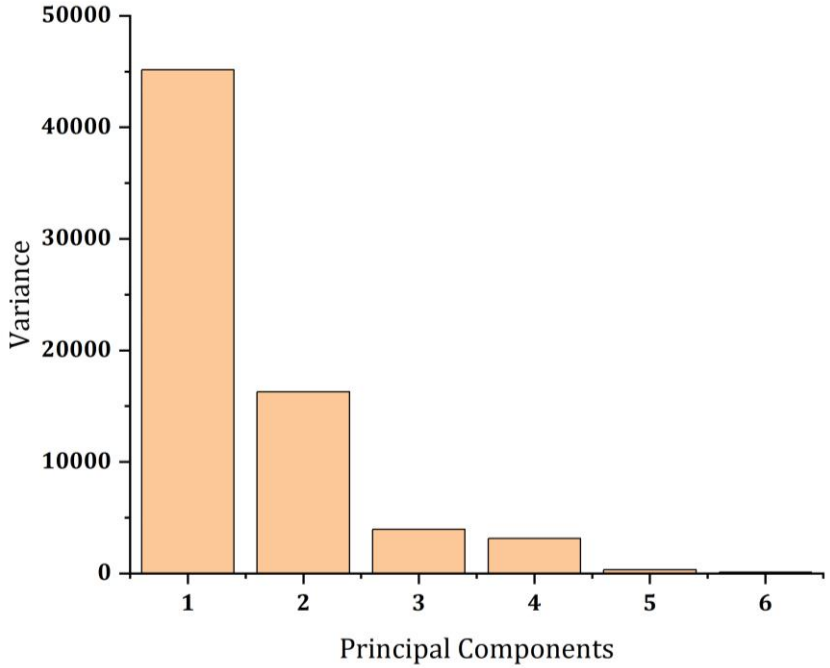
Experimental Procedure

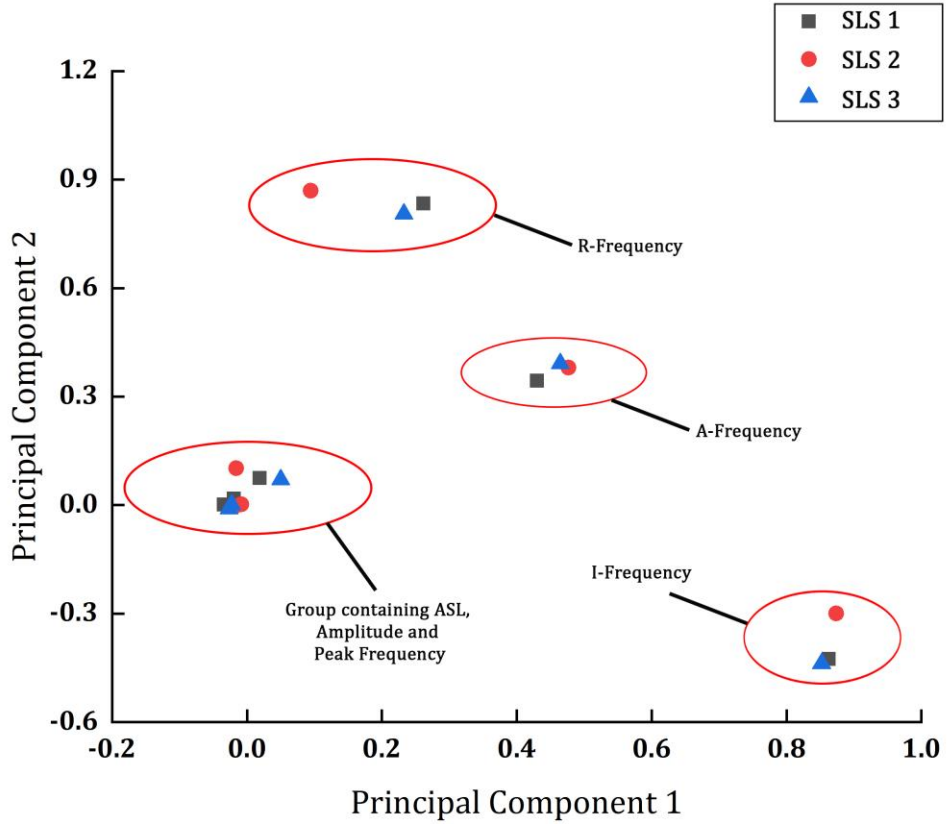


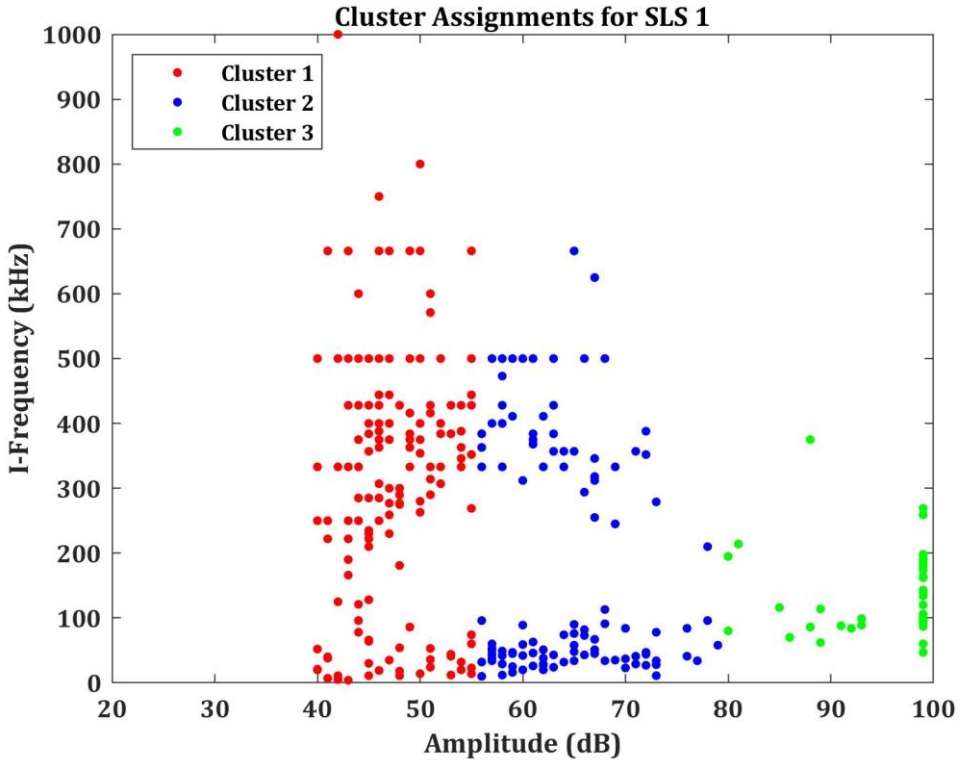
- CFRP Specimens, configured in Single Lap Shear (SLS) configuration was used for the analysis.
- Static Tensile load was applied to the specimens and the AE signals were recorded.
- Two piezoelectric sensors with an operating frequency of 150 kHz to 400 kHz is selected for this analysis.
- Signal attenuation due to the propagating distance is calibrated by Pencil Lead Break Test.
- The AE signals are recorded at a sampling rate of 1 MSps.

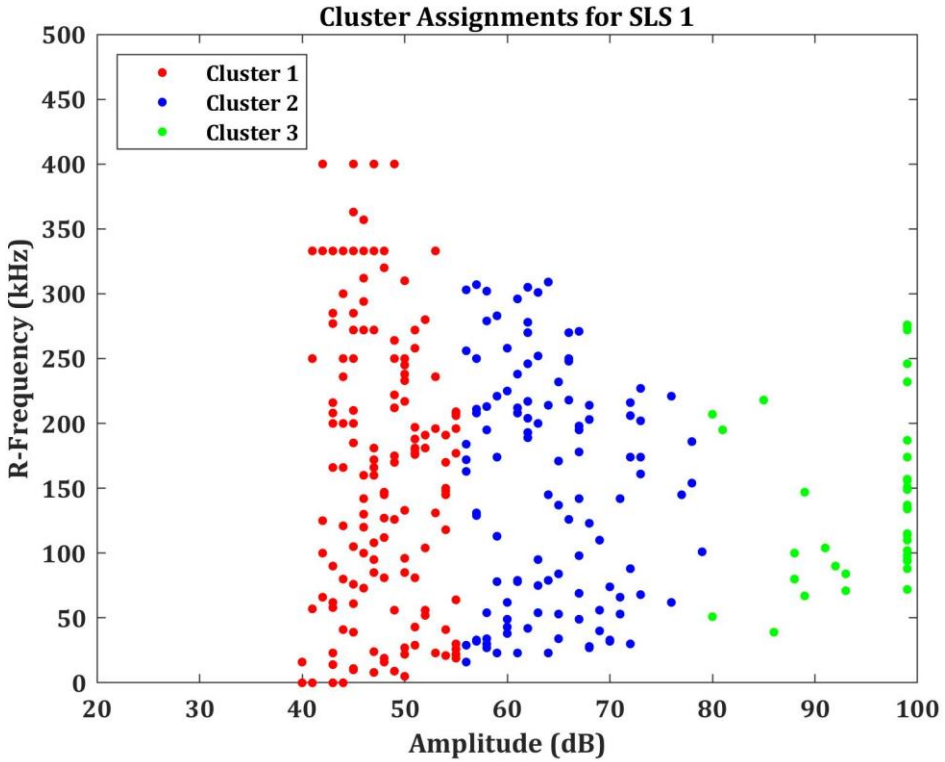
Selecting Appropriate Parameters using Principal Component Analysis

- The parameters considered for this study are Peak Amplitude, Peak Frequency, ASL, I-Frequency, R-Frequency and Average Frequency.





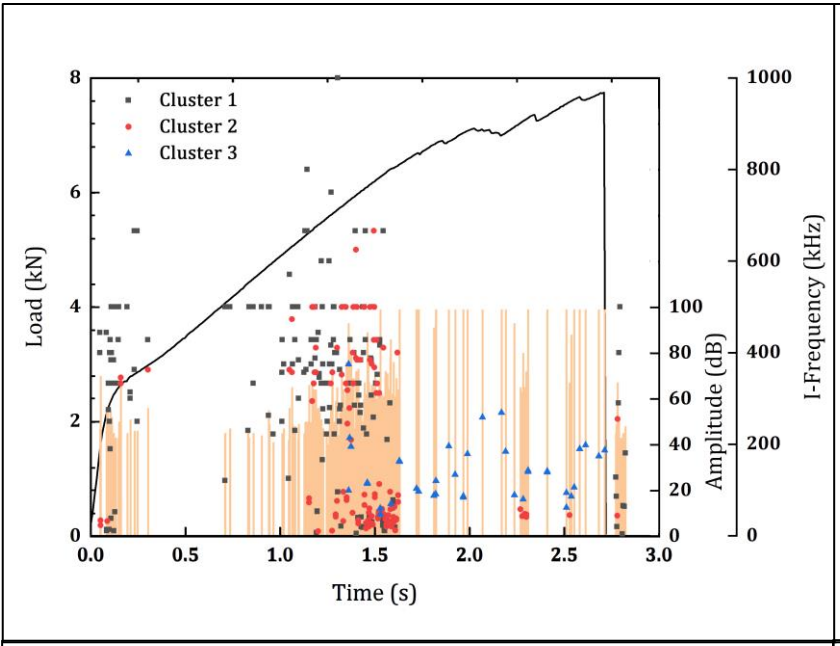




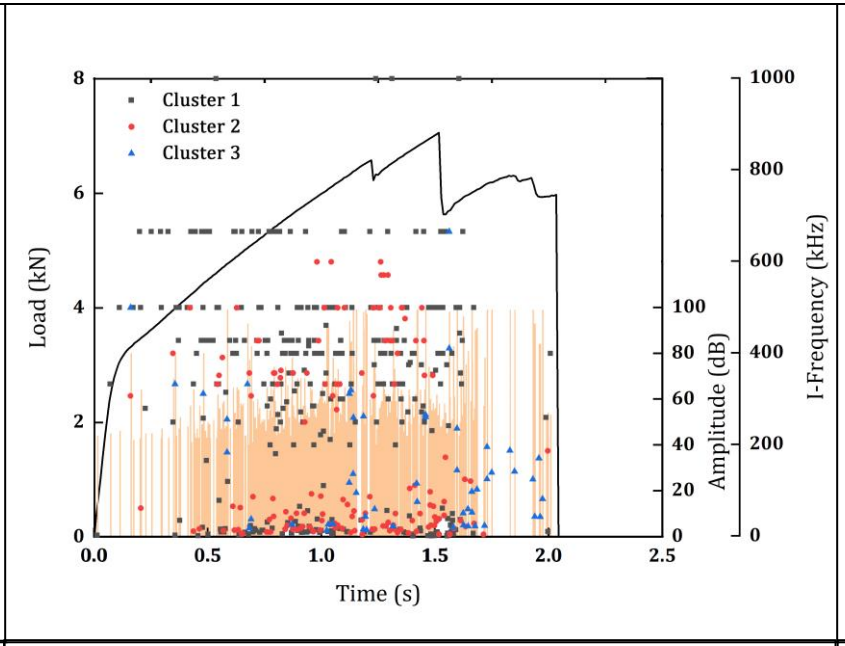
Data Clustering using Fuzzy C-Means

Results and Discussions

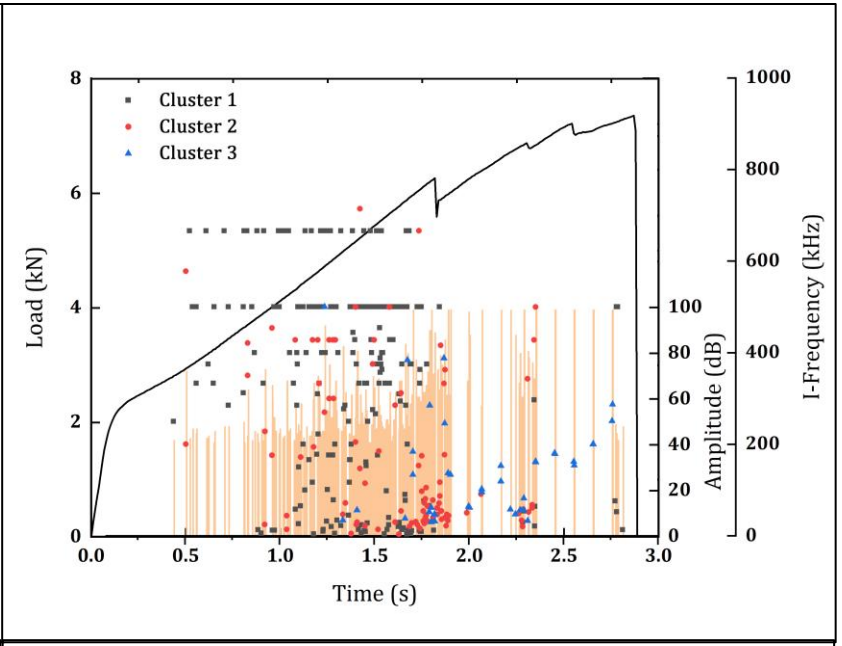
- During the Final Rupture stage of SLS 1 and SLS 3, more signals with I-Frequency in Cluster 3 are observed.
- Signals with high amplitude and low I-Frequency can be associated with AE signals having Interlaminar Crack Growth as their source.
- Cluster 3 signals are observed more during the initial stages of SLS 2.



SLS 1



SLS 2

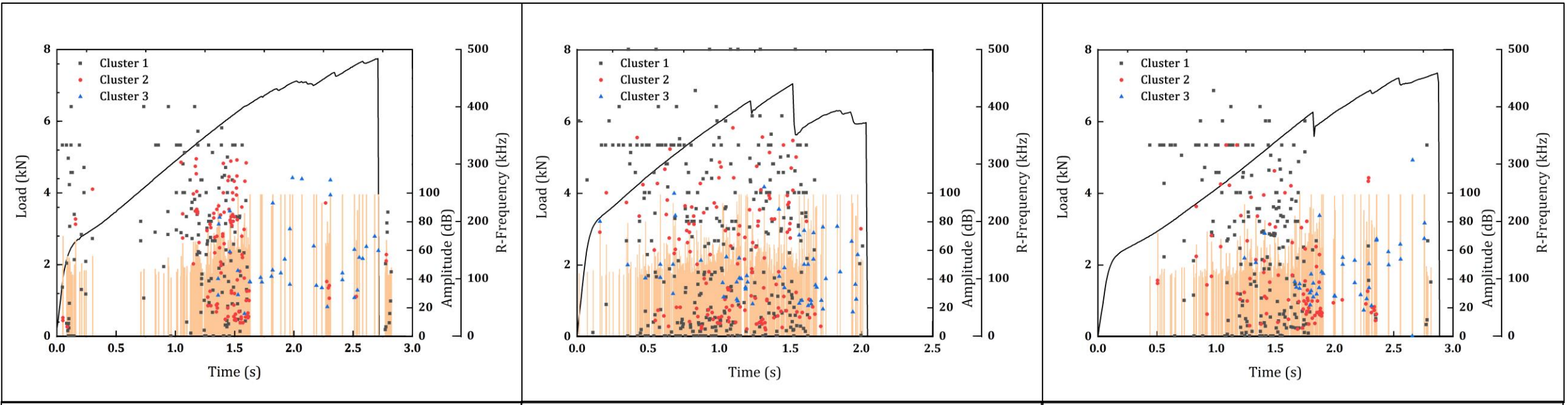


SLS 3

Initiation Frequency

Results and Discussions

- R-Frequency pattern is more similar to the I-Frequency results in SLS 1 and SLS 2.
- Frequency in Cluster 3 is almost the same, which indicates the signals are highly symmetrical in terms of frequency.
- These signals represents interlaminar crack growth.



SLS 1	SLS 2	SLS 3

Reverberation Frequency

Conclusions

- The I-Frequency and R-Frequency clustered data can provide information about the damage modes.
- Future works involves counting the number of signals that corresponds to different damage modes in each loading stage.
- Comparing them with in situ fractographic analysis will be an added advantage.

Thank you!!
Any questions?

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