Acoustic Emission in CFRP compression tests

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The dataset collects acoustic emission monitoring of a series of compression tests on Carbon Fiber Reinforced Composites (CFRP). The data can be used to perform signal analysis and recognise specific waveforms associable to specific damage modes (i.e. ***train classification algorithms***).
The used AE sensor was the AE1045SVS900 M, a broadband single-crystal piezoelectric transducer with operational frequency range of 100–900 kHz supplied by Vallen Systeme GmbH. The used material is Toray M30SC – Deltapreg DT120-200-36 UD.
The following compression tests were conducted:

- 90-test; rectangular specimen of dimensions 135x100x3.8 mm and layup $[90]_{24}$ was tested in order to isolate pure matrix cracking.
- 0-test; rectangular specimen of dimensions 110x85x1.8 mm and layup $[0]_{12}$ was tested to isolate fibre failure and fibre-matrix debonding.
- Teflon test; rectangular specimen of dimensions 120x90x2.5 mm and layup $[-45,0,45,90]_{2,s}$ was tested in compression. A circular Teflon insert of diameter 50mm was located in the centre of the 0//45 interface (second interface from the surface) in order to trigger sub-laminate buckling and delamination.
- Compression after impact test (CAI) on three specimens of dimensions 150x100x5.15 and layup $[-45,0,45,90]_{2,s}$

The dataset is divided in **acoustic emission data** (full waveforms and waveform descriptors) **force-displacement data** and **C-scan data**.
To help in the analysis of the data, python scripts are available on Github:
https://github.com/biaginidavide/AcousticEmissionAnalysis

This data is made public to allow other researchers to use this data in their own work

1. Methodological information

Materials and manufacturing

Toray M30SC – Deltapreg DT120-200-36 UD was manually laid-up in $[0]_{12}$, $[90]_{24}$ and $[-45,0,45,90]_{2,s}$ laminates for the preliminary tests to isolate damage modes and in a $[-45,0,45,90]_{4,s}$ laminate for the CAI tests. Curing was conducted in autoclave following the procedure suggested by the manufacturer. The curing temperature was 120 °C while the maximum pressure was 6 bar

Preliminary compression tests

The following preliminary tests were conducted to correlate acoustic waveforms to damage modes:

- *90-test*; rectangular specimen of dimensions 135x100x3.8 mm and layup $[90]_{24}$ was tested in order to isolate pure matrix cracking. Compression was applied at a loading rate of 1 mm/min, while reproducing the boundary conditions of ASTM D7137. Two AE sensors were positioned the surface of the specimen.

- *0-test*; rectangular specimen of dimensions 110x85x1.8 mm and layup $[0]_{12}$ was tested to isolate fibre failure and fibre-matrix debonding. Compression was applied reproducing the boundary conditions of ASTM D7137 at a loading rate of 1 mm/min. One AE sensor was positioned on the surface.

- *Teflon test*; rectangular specimen of dimensions 120x90x2.5 mm and layup $[-45,0,45,90]_{2.s}$ was tested in compression. A circular Teflon insert of diameter 50mm was located in the centre of the 0//45 interface (second interface from the surface) in order to trigger sub-laminate buckling and delamination. Two AE sensors were positioned. A compression loading rate of 1 mm/min was applied reproducing the boundary conditions of ASTM D7137.

Impact test

Impact testing was conducted using a drop-weight tower according to ASTM D7136. The test set up is shown in Fig 1a. The support fixture has a cut-out of 125 ± 1 mm in the length direction and 75 ± 1 mm in the width direction. To obtain single impacts, the impact tower was equipped with a catcher triggered by optical sensors. A hemi-spherical impactor with a diameter of 16 mm and a mass of 4.8 kg was used. A target impact energy of 34 J was used in all the impacts. This condition can be classified as low velocity impact (LVI) and produced a dent depth < 2 mm (BVID). After the impact, the size of delamination was checked with ultrasound inspection.

Compression after impact

CAI testing was conducted according to ASTM D7137. The test set up is shown in Fig.1b and Fig.1c. Specimens were loaded in compression, in a displacement-controlled mode, with a cross head displacement of 1 mm/min. The crosshead displacement and the applied force were recorded using a 250 kN load-cell MTS hydraulic testing machine. Two AE sensors were placed on the non-impacted surface.

Acoustic emission

The used AE sensor was the AE1045SVS900 M, a broadband single-crystal piezoelectric transducer with operational frequency range of 100–900 kHz supplied by Vallen Systeme GmbH. In addition, an external 34 dB pre-amplifier was used to amplify the recorded signals. To reduce noise, an acquisition threshold was set to 45 dB. The AE data was collected with a sampling frequency of 2 MHz by the AMSY-6 Vallen, 4-channel AE system. Ultrasound gel was applied to improve the coupling between the AE sensor and the specimen's surface. The two sensors were kept in position using plastic sensor holders glued to the non-impacted surface of the specimen. The performance of the AE system was validated before each test by conducting a standard pencil lead break procedure.

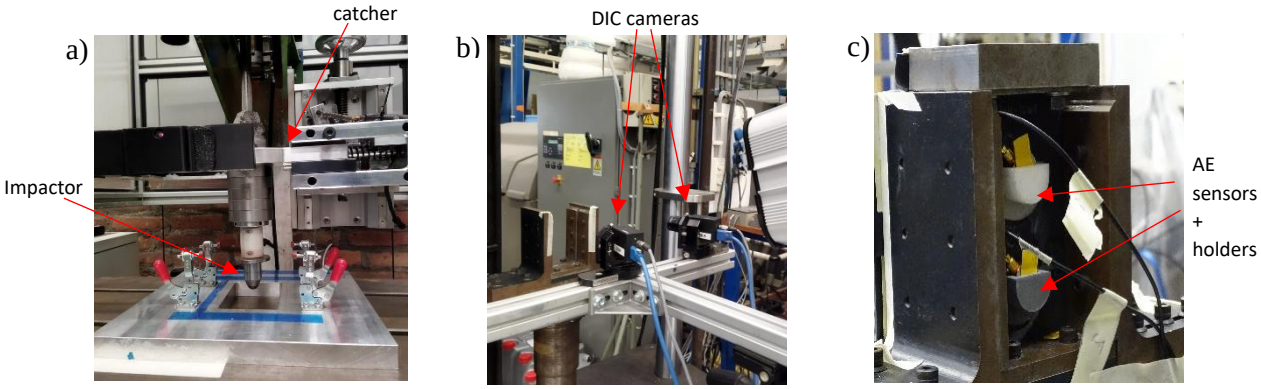
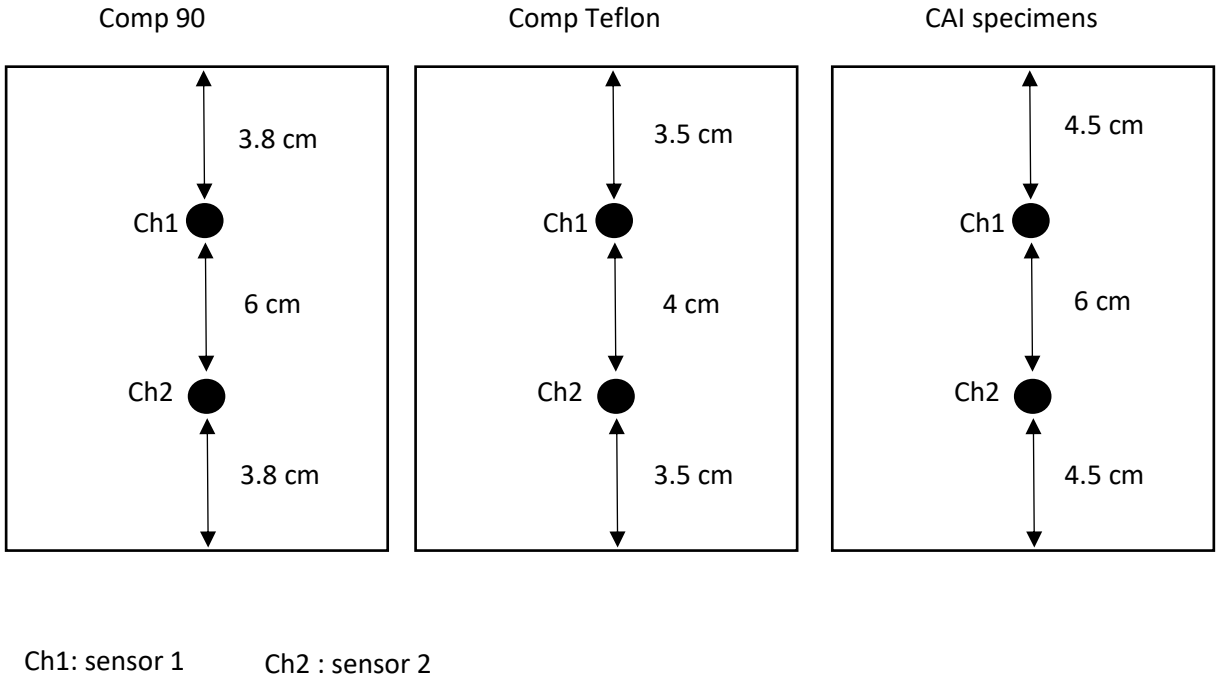


Fig.1) a) impact test setup with catcher to avoid bounce-back of the impactor; b) 'front' view showing two DIC cameras pointed at the CAI setup; c) 'back-side' view of the CAI setup with the two acoustic emission sensors positioned inside the respective holders.



2. Structure of the dataset

- Acoustic data: .tradb files containing the full recorded waveforms
  .pridb files containing the acoustic emission hits descriptors

  To analyse acoustic tradb and pridb files use the open source python tools:
  https://pyvallenae.readthedocs.io/en/stable/
  https://github.com/biaginidavide/AcousticEmissionAnalysis

- MTS data: .csv files containing force (kN) displacement (mm) and time (s) of each test

- C-scan data: .jpg files containing the C-Scan of the three impact damage for the three CAI tests

3. Nomenclature of the specimens:

Comp0	preliminary compression test on $[90]_{24}$
Comp90	preliminary compression test on $[0]_{12}$
Compteflon	preliminary compression test with Teflon insert
CAI_spec1	Compression after impact specimen 1
CAI_spec2	Compression after impact specimen 2
CAI_spec3	Compression after impact specimen 3