

Composites CRC - Impact Testing of ELACO® Laminates

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Objective

- To explore the impact properties laminates fabricated using the ELACO[®] method for both E-glass and carbon fibre composites.
- Elements measured:
 - Absorbed Energy
 - Peak Force
 - Damage Size
 - Nature of Damage (Primary mechanism for energy absorption)
- Compare these properties with previous Composites CRC data on carbon fibre / epoxy laminates.

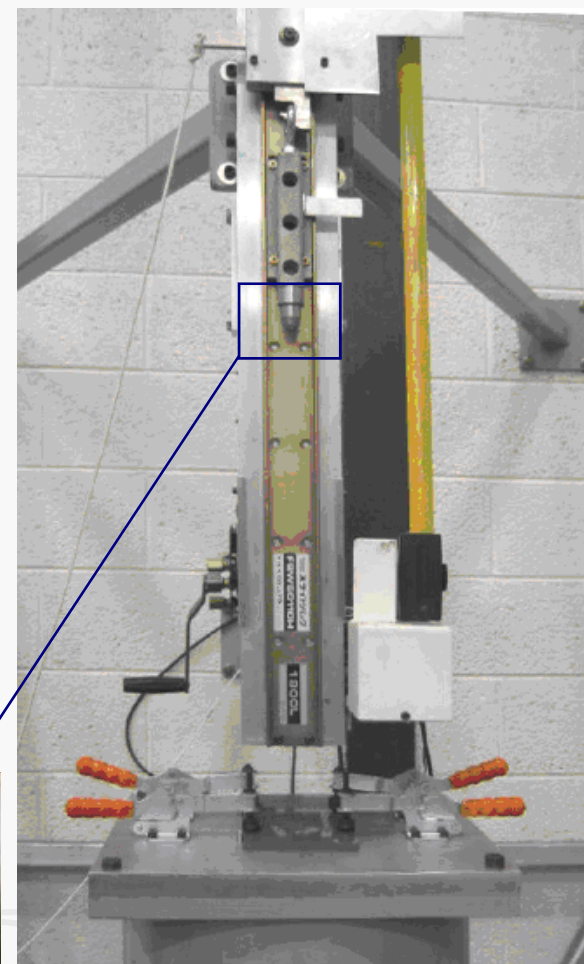
Impactor Details

- **Impactor:**

- Weight: 0.522 kg
- Hemispherical tip: $\varnothing 12.7$ mm
- Force transducer recorded the contact force during impact.
- Velocity transducer is used to record the impact and rebound velocities
- Data was recorded at 100 kHz

- **Impact Energy:**

- 16 Joules
 - Height: 3.4 meters



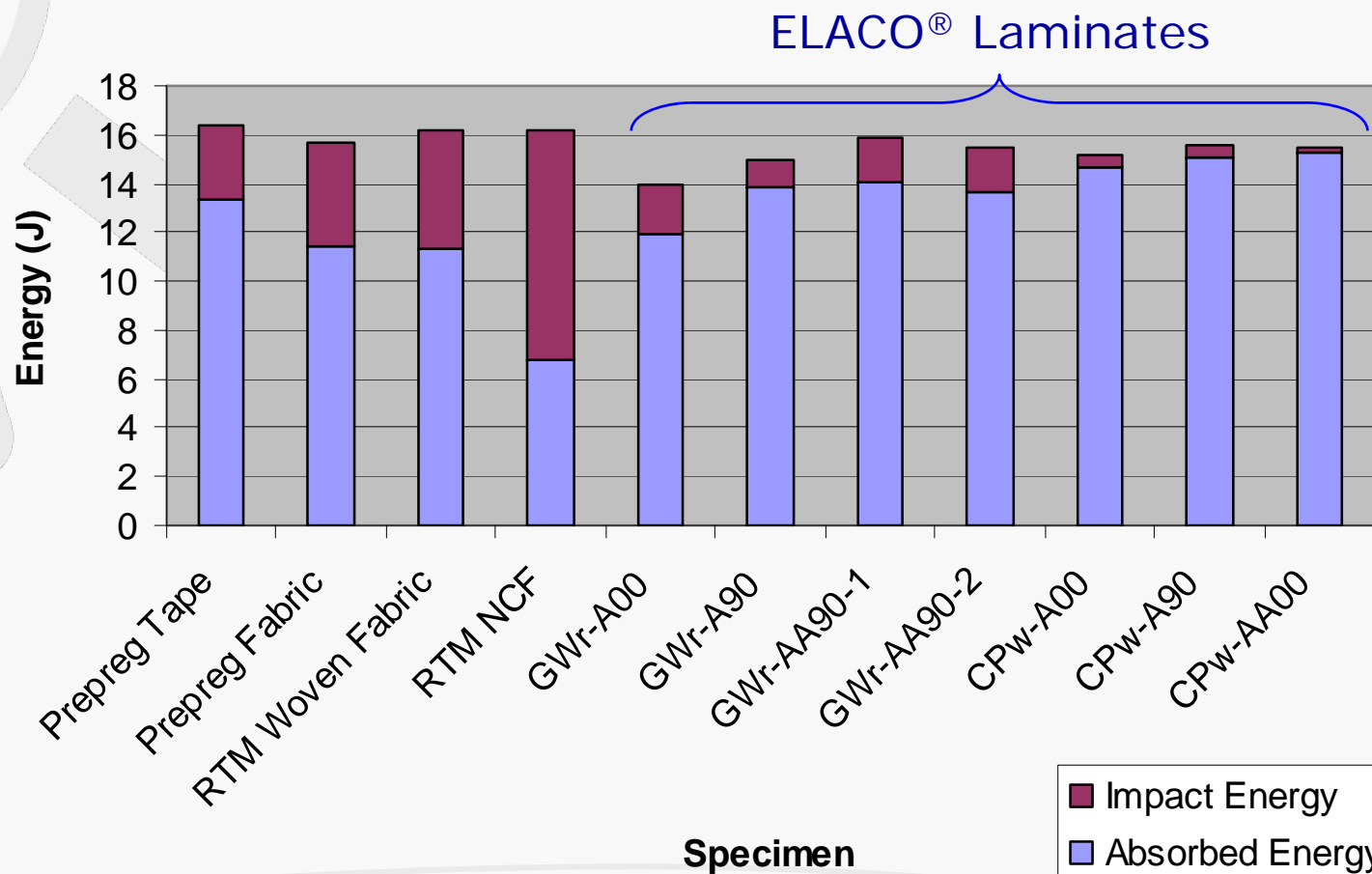
Comparative Data

- *“The Impact Performance of Composite Materials”*
Brett Anthony Hill, RMIT University, 2002
- Aerospace grade laminates
- Autoclave pre-preg specimens:
 - Autoclave cure cycle: 100 psi / 180°C for two hours
 - T2B8 – ((0/90)₄)s Unidirectional carbon tape (T300) / F593 epoxy
 - F1C8 – ((0/90)₇)s Plain-weave carbon fabric (T300) / F593 epoxy
- Resin Transfer Moulding (RTM) Specimens:
 - RFA4 – ((0/90)₃)s Plain-weave carbon fabric / RTM6 resin
 - RNA4 – ((0/90)₃)s RTM non-crimp, carbon fabric / RTM6 resin
 - Post-cure cycle: 180°C for two hours

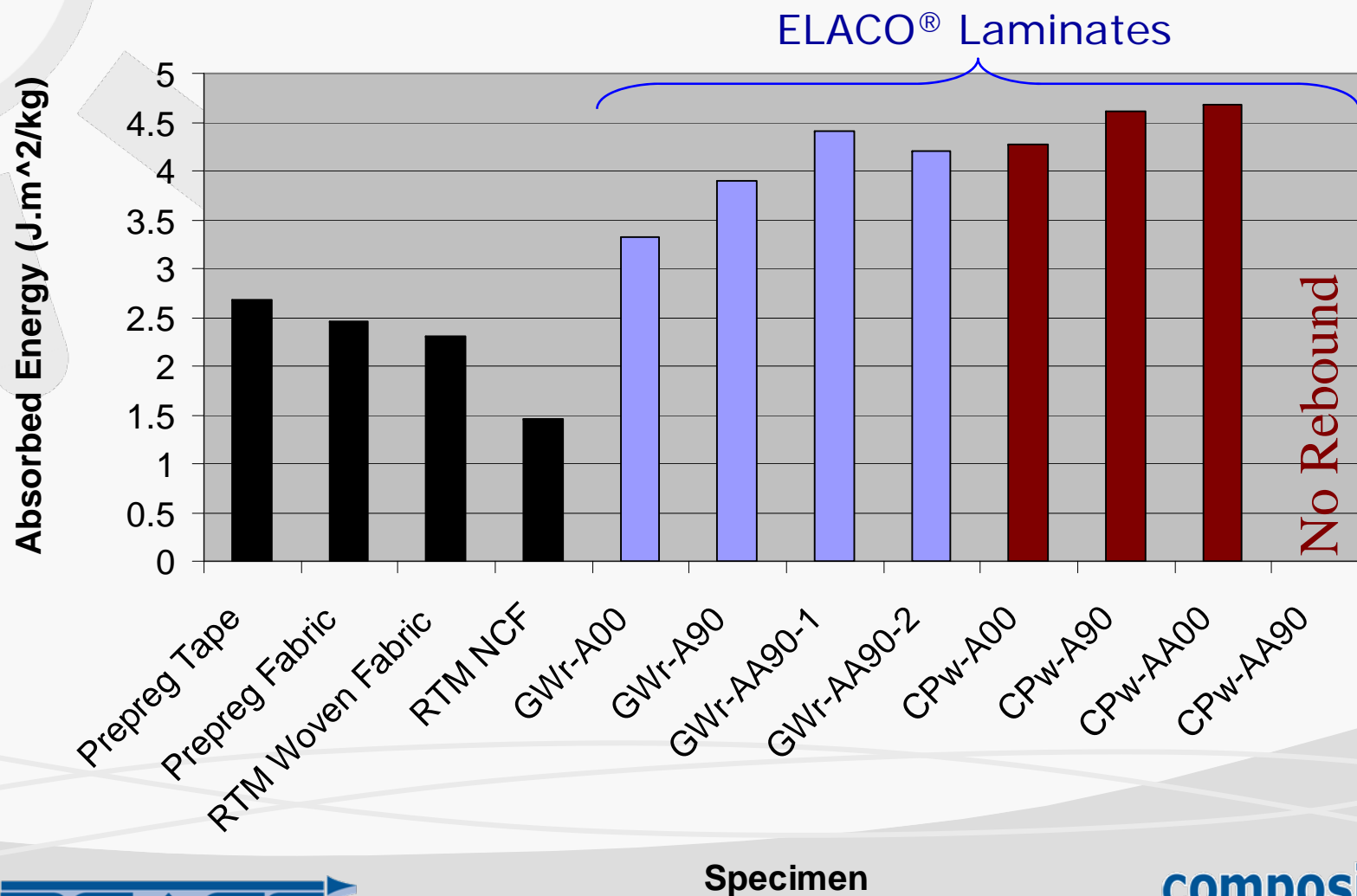
Results

	Specimen	Thickness	Weight	Areal Weight	Impact Velocity	Rebound Velocity	Impact Energy	Absorbed Energy	Peak Force	Damage Area
		mm	Grams	g/m ²	m/s	m/s	Joules	Joules	kN	Mm ²
Comparison Aerospace grade laminates	Prepreg Tape (T2B8)	3.28	76.18	4962	7.93	3.44	16.42	13.33	3.57	1225.97
	Prepreg Fabric (F1C8)	3.12	71.07	4629	7.75	4.05	15.66	11.39	2.61	852.68
	RTM Woven Fabric (RFA4)	3.43	75.80	4937	7.87	4.30	16.16	11.34	3.76	662.44
	RTM NCF (RNA4)	3.35	71.90	4683	7.87	5.99	16.16	6.81	N/A	599.41
Glass Fibre ELACO	GWr-A00	2.47	55	3583	7.31	2.81	13.95	11.89	2.00	785
	GWr-A90	2.48	55	3548	7.56	2.06	14.92	13.81	2.29	825
Carbon Fibre ELACO	CPw-A00	2.76	55	3434	7.63	1.42	15.20	14.67	1.43	1495
	CPw-A90	2.67	52	3257	7.73	1.47	15.60	15.03	1.55	900

Energy Absorbed



Absorbed Energy / Areal Weight

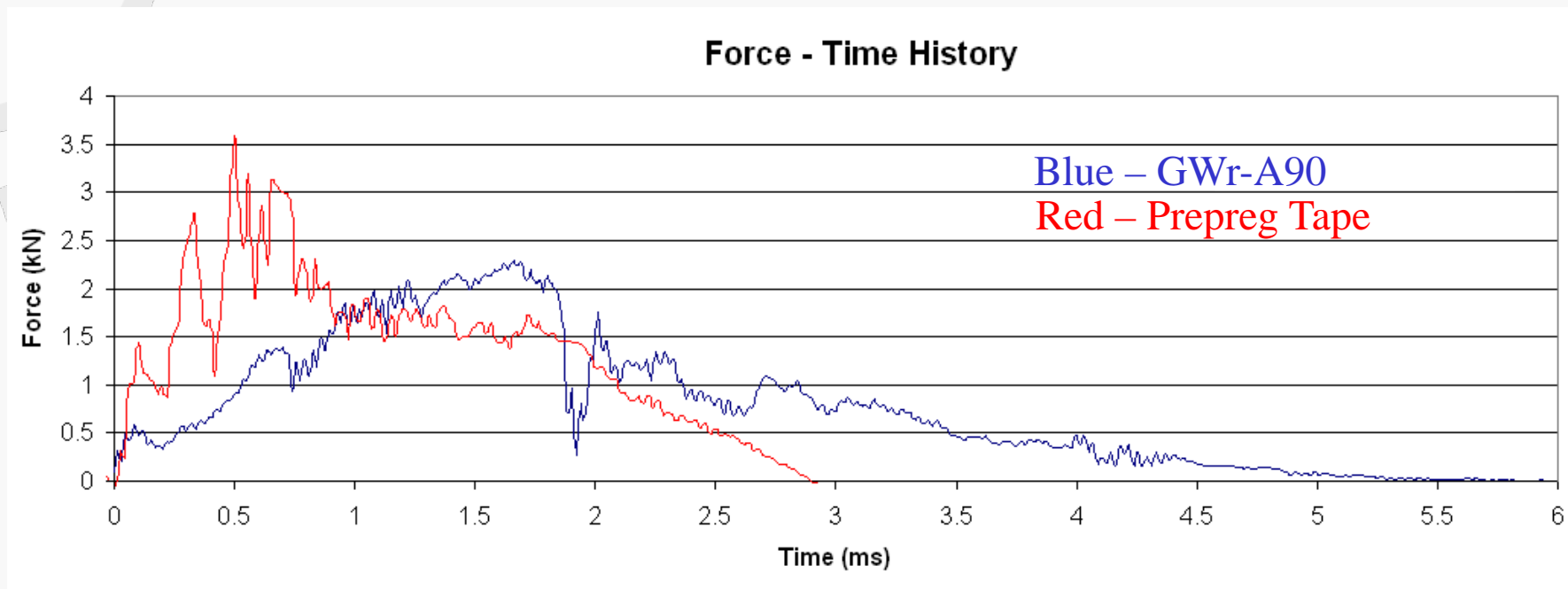


Comparison – Peak Force

- Peak force is related to the impact time. (A long impact will result in a low force.)
- In all cases, ELACO laminates had a lower peak force than the comparative data, hence a longer impact time indicating greater ductility than the comparison laminates.
- The graph on the following slide compares force – time histories of GWr-A90 and prepreg tape.
 - For a similar level of energy absorption, the ELACO laminate has a lower peak force as the impact is over a longer time.

Comparison – Peak Force

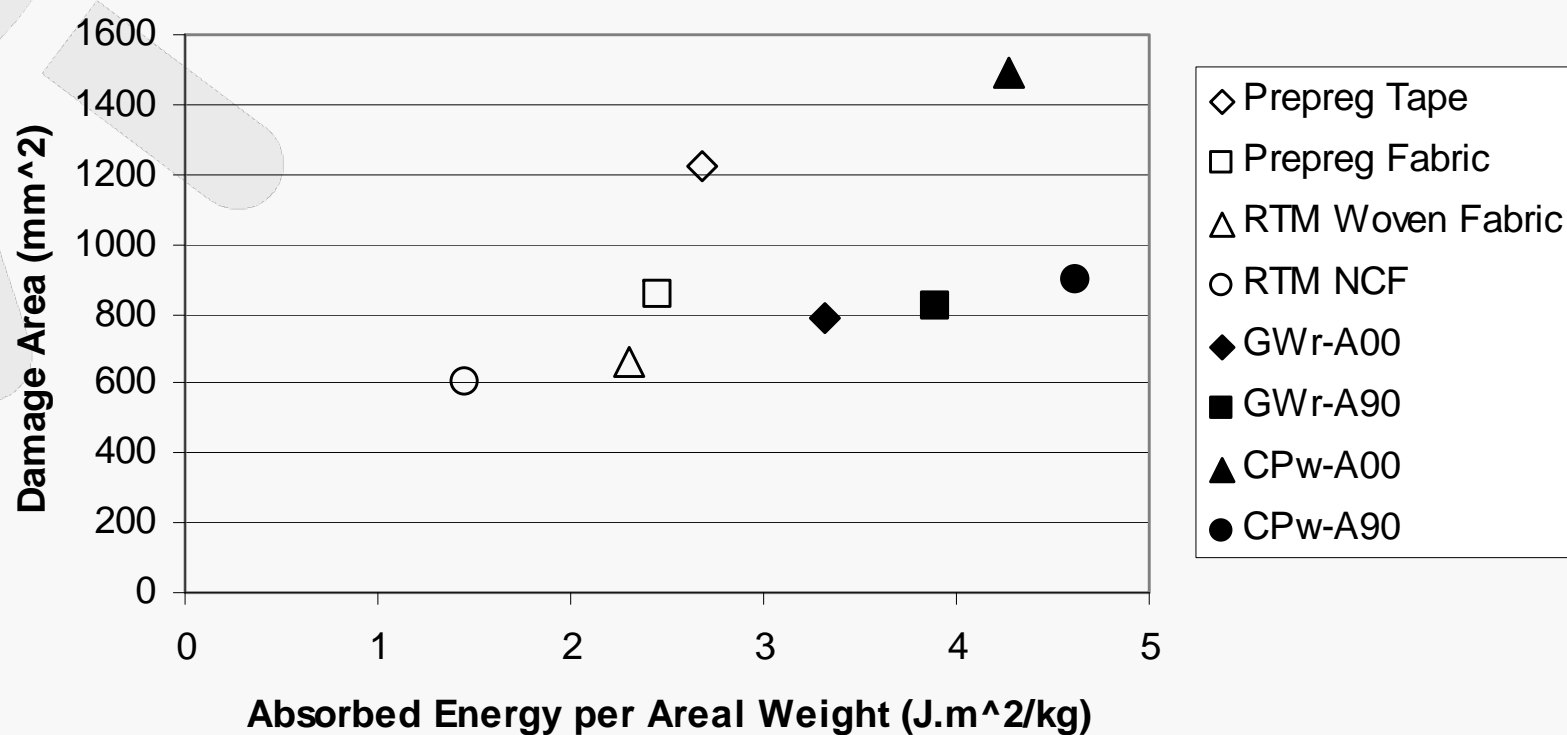
Time histories of GWr-A90 and prepreg tape



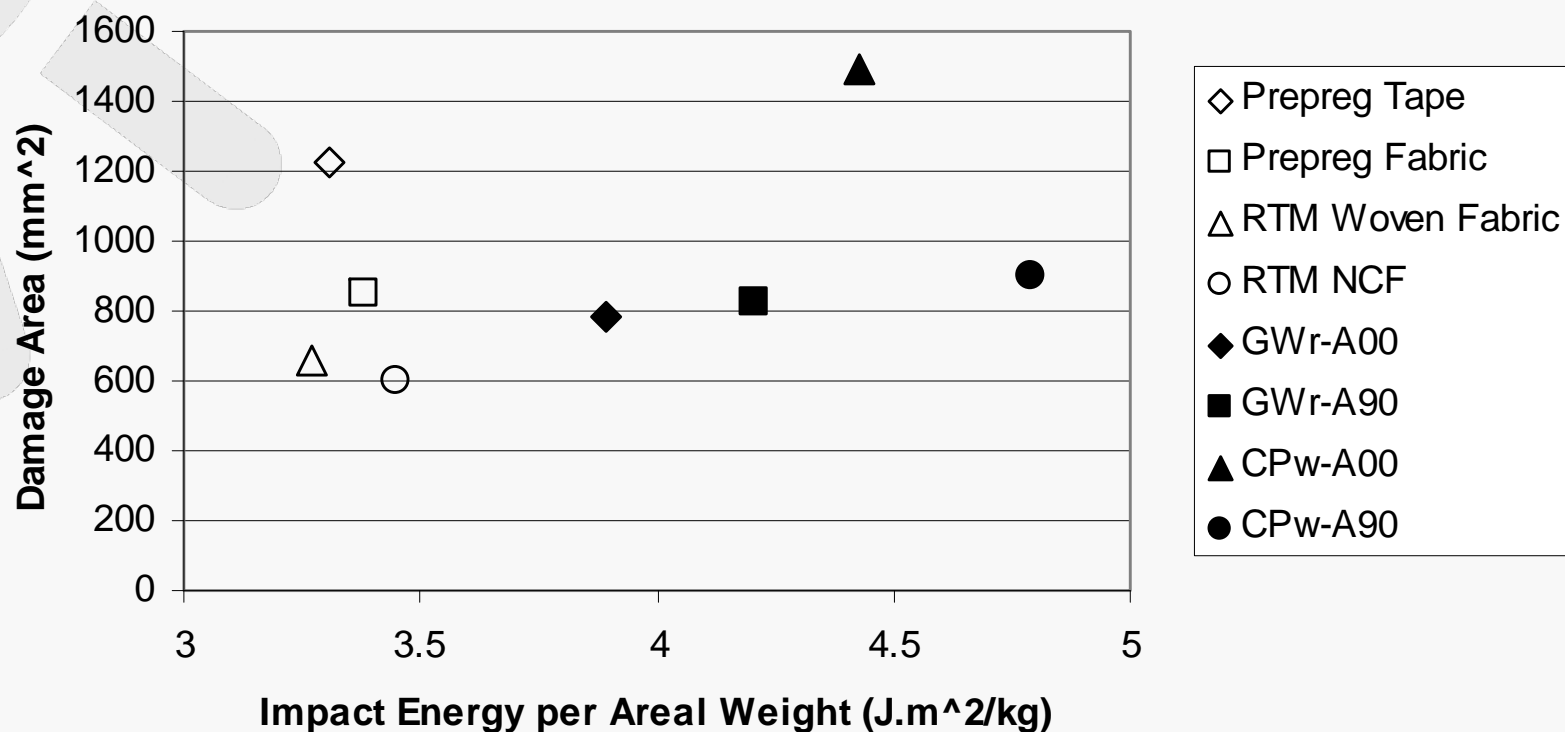
Comparison - Damage Area

- Damage areas were quantified by the area physically punctured and / or delaminated.
- Damage of the comparative carbon fibre laminates are localised to the impact area and immediate radius.
- Similar results were observed for the fully vacuum-bagged ELACO laminates.
- Adhesively bonded ELACO laminates almost completely delaminated, resulting in an extensive damage area.

Comparison - Damage Area



Comparison - Damage Area



Results and Discussion

- Prepreg and RTM plain weave carbon fibre specimens have almost identical damage area vs Impact Energy
- ELACO laminates absorbed more energy per areal weight than the autoclave or RTM carbon fibre laminates.
- ELACO laminates had an average areal weight of 30% lower than the carbon laminates and achieved 17% higher absorbed energy.
- ELACO laminates were fabricated using low-cost materials and manufacturing method.

Conclusions

- The orientation of the ELACO[®] dissipating element did not have any influence on impact properties or damage.
- Adhesively bonded ELACO[®] laminates did not sustain as much local damage as the vacuum-bagged laminates. They did however sustain significant delamination.
- E-glass fibre laminates were more resistant to impact damage than carbon fibre laminates, where carbon fibre laminates cracked at the impact region while the E-glass laminates deformed on the back face.
- Carbon fibre laminates absorb more local energy than E-glass fibre laminates, most likely due to the higher degree of damage.