Evaluation of common structural joining techniques in the marine industries

F. Delzendehrooy (INEGI, Porto, Portugal), A. Akhavan-Safar, A. Q. Barbosa, R. Pereira, R.J.C. Carbas, E.A.S. Marques, L.F.M. da Silva

Advanced Joining Processes Unit

Introduction

In order to maintain the integrity of the structure and transfer loads between various modulus, different joining techniques are employed in the marine industry such as welding, adhesive bonding, mechanical fastening, and hybrid joining. Despite the advantages of each joining method, the challenges confronted in using each joining approach are crucial design requirements to be taken into account. To compare the static mechanical performance of the aforementioned joining techniques in connecting similar and dissimilar fiber-reinforced composites, the current study has been conducted.

Material and Properties

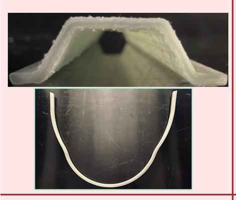
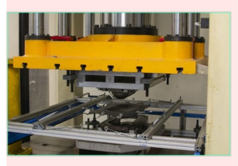
Table 1 – Mechanical properties of the methacrylate Plexus MA560-1 adhesive

Mechanical Property	Tensile Strength (MPa)	Young's Modulus (MPa)	Shear Strength (MPa)	Tensile Fracture Energy (Nmm)	Shear Fracture Energy (Nmm)
Value	14.6±2%	668±6%	11.6±15%	2.4±11%	8.6±13%
Standard (ASTM)	D638-14	D638-14	D5656	D3433	D7905

Table 2 – Mechanical properties of the A2-70 bolt (ASTM F738M–02)

Type	Diameter (mm)	Alloy	Class	Tensile Strength (MPa)	Extension (mm)
Socket screw	2	Austenitic (321)	70	700	0.8

Table 3 – Material and stacking sequence of the composites

	Name	Matrix	Type	Fiber	Manufacturing technology	Stacking sequence
	C1.1	Acrylate	Thermoset	Glass	Out of die UV cured pultrusion	[0/+45/90/-45]
	C1.2	Epoxy	Thermoset	Glass	Adaptive Mold	[0/90/+45/-45]
	C2.1	Polypropylene	Thermoplastic	Carbon	Hot Stamping	Quasi-isotropic manufactured with UD fibers
	C2.2	Polypropylene	Thermoplastic	Glass	3D Printing	Reinforced with short fibers

Parameters	Value (mm)
B	12.5
W	25
t_a	0.2-0.3
L	100.7

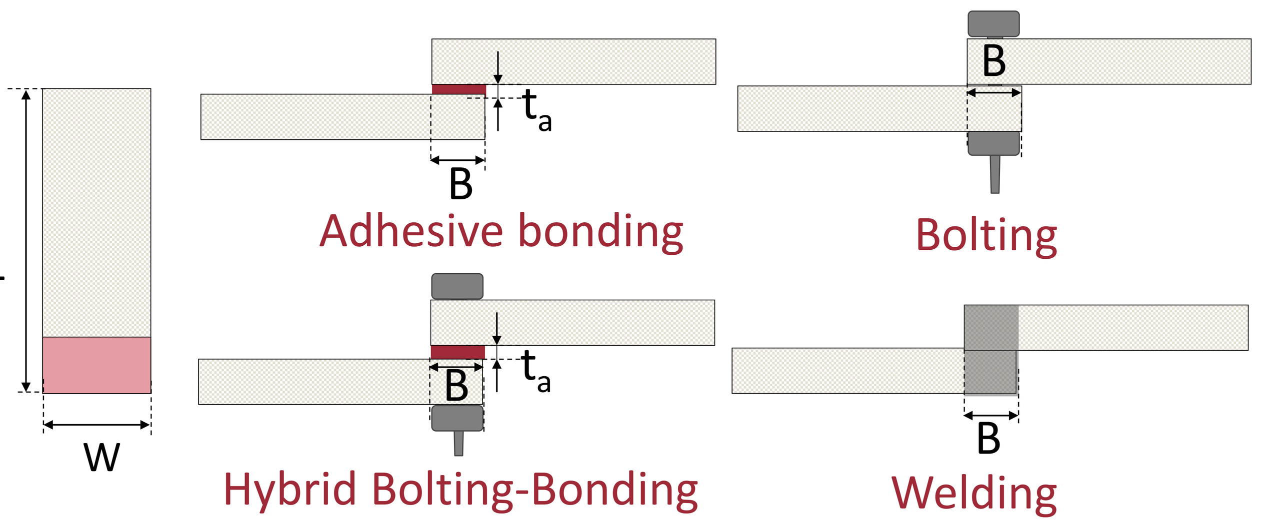


Figure 1 – Joint geometry and dimensions

Results and Discussion

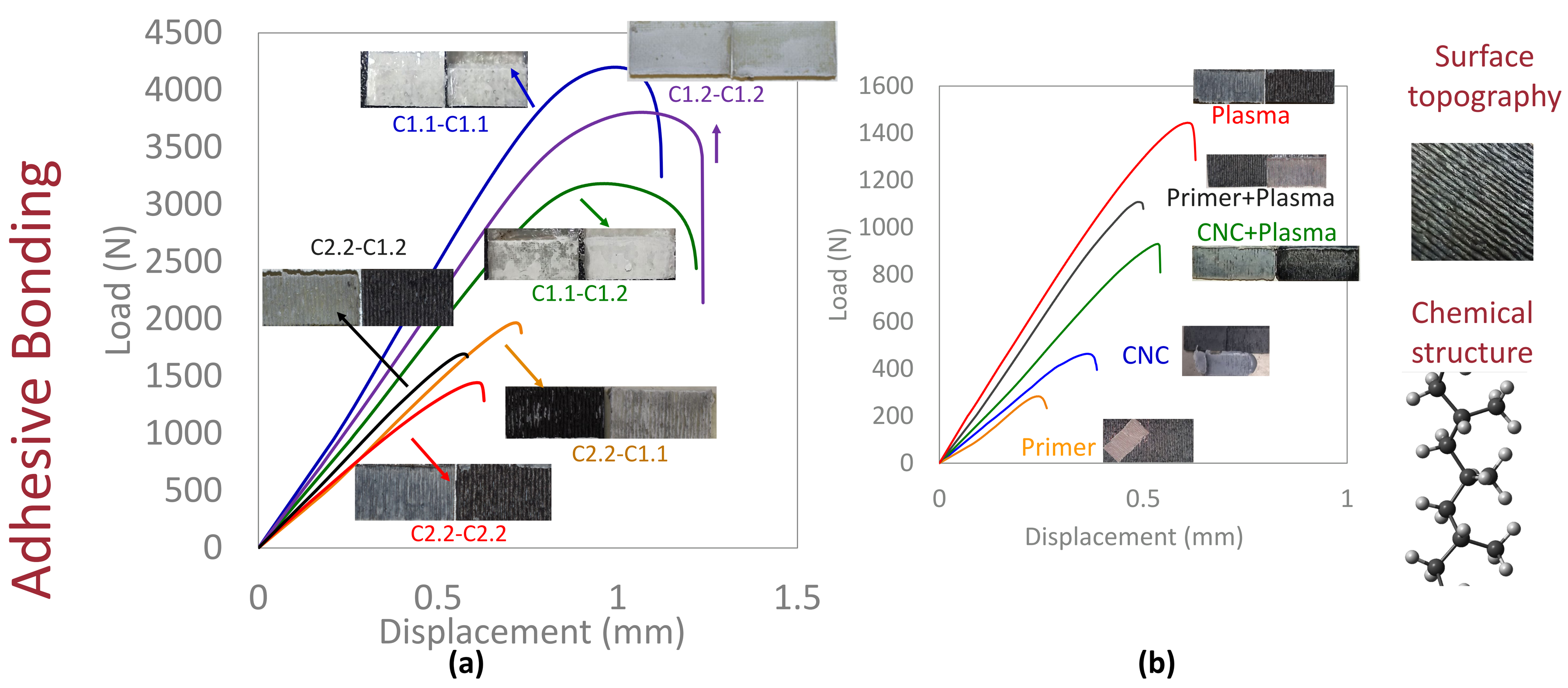


Figure 2 – Typical load-displacement curves of adhesively bonded joints a)FRP samples b) C2.2 composites treated with various methods

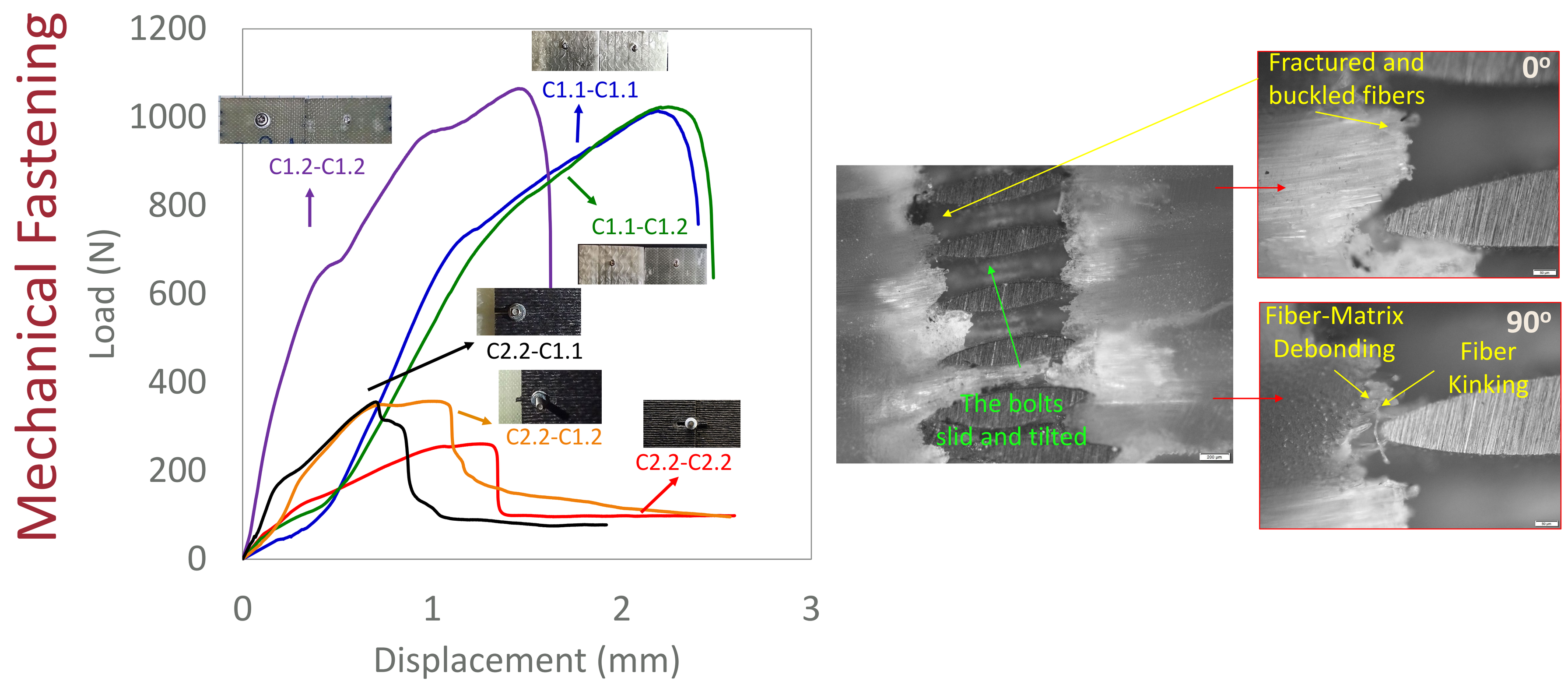


Figure 3– Typical load-displacement curves of bolted joints a)FRP samples b) microscopic images of welded C1.2 composites

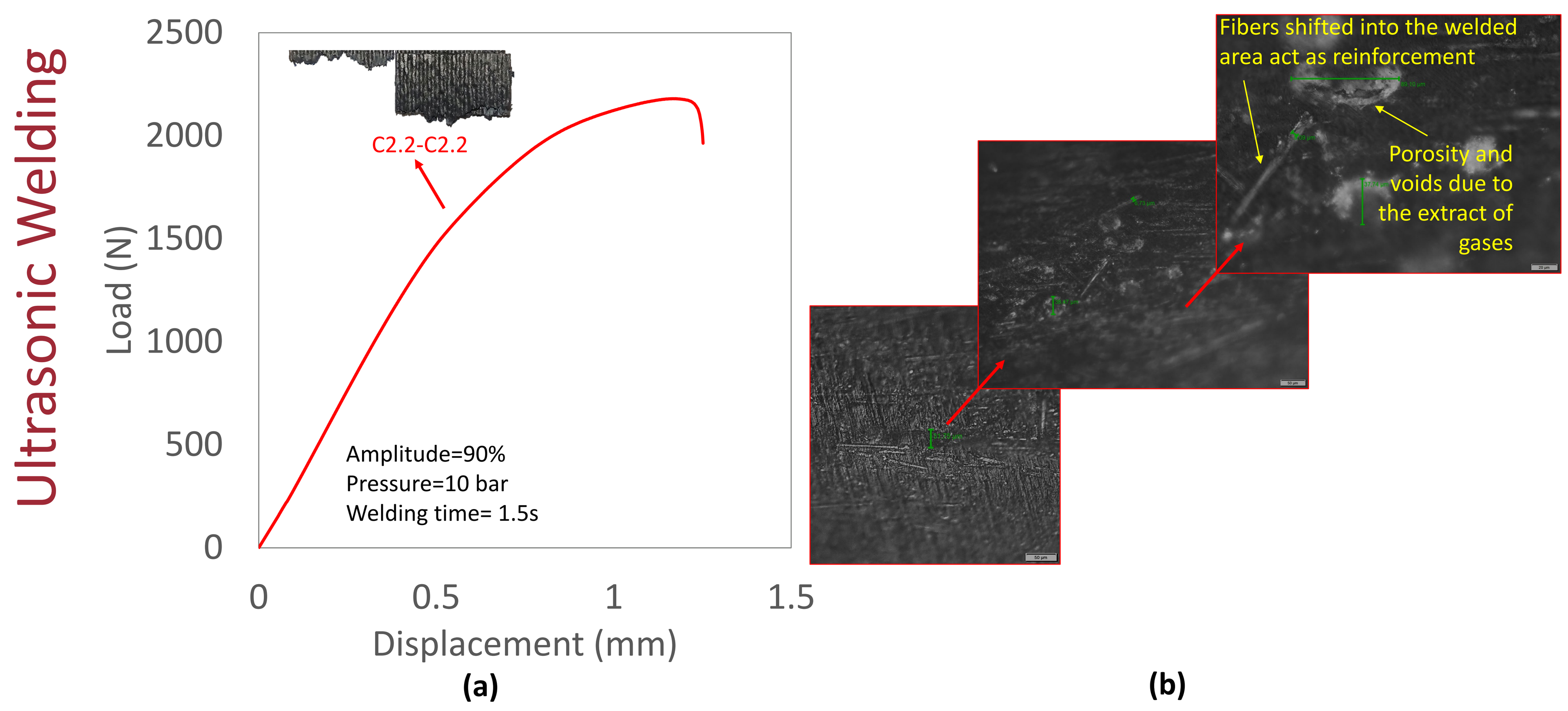


Figure 4 – Typical load-displacement curves of welded joints a)FRP samples b) microscopic images of welded C2.2 composites

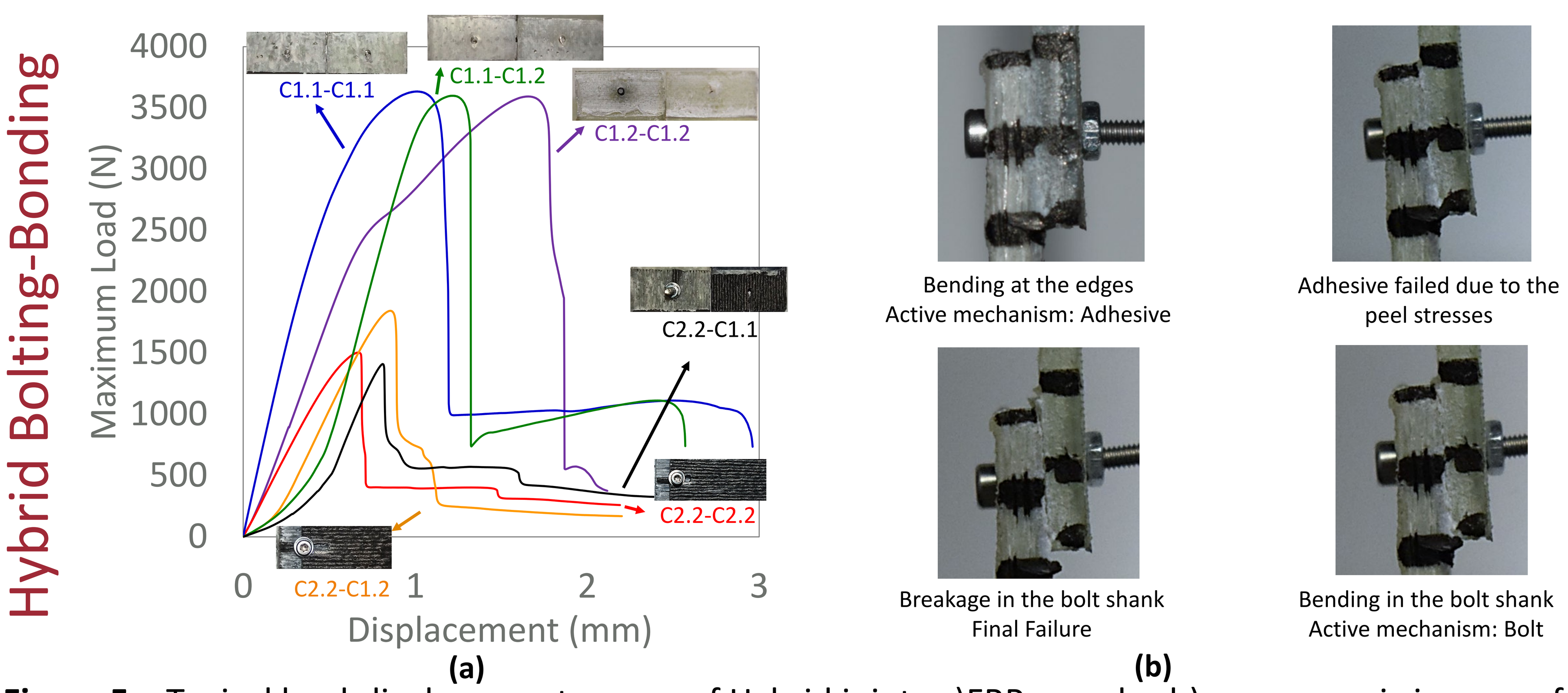
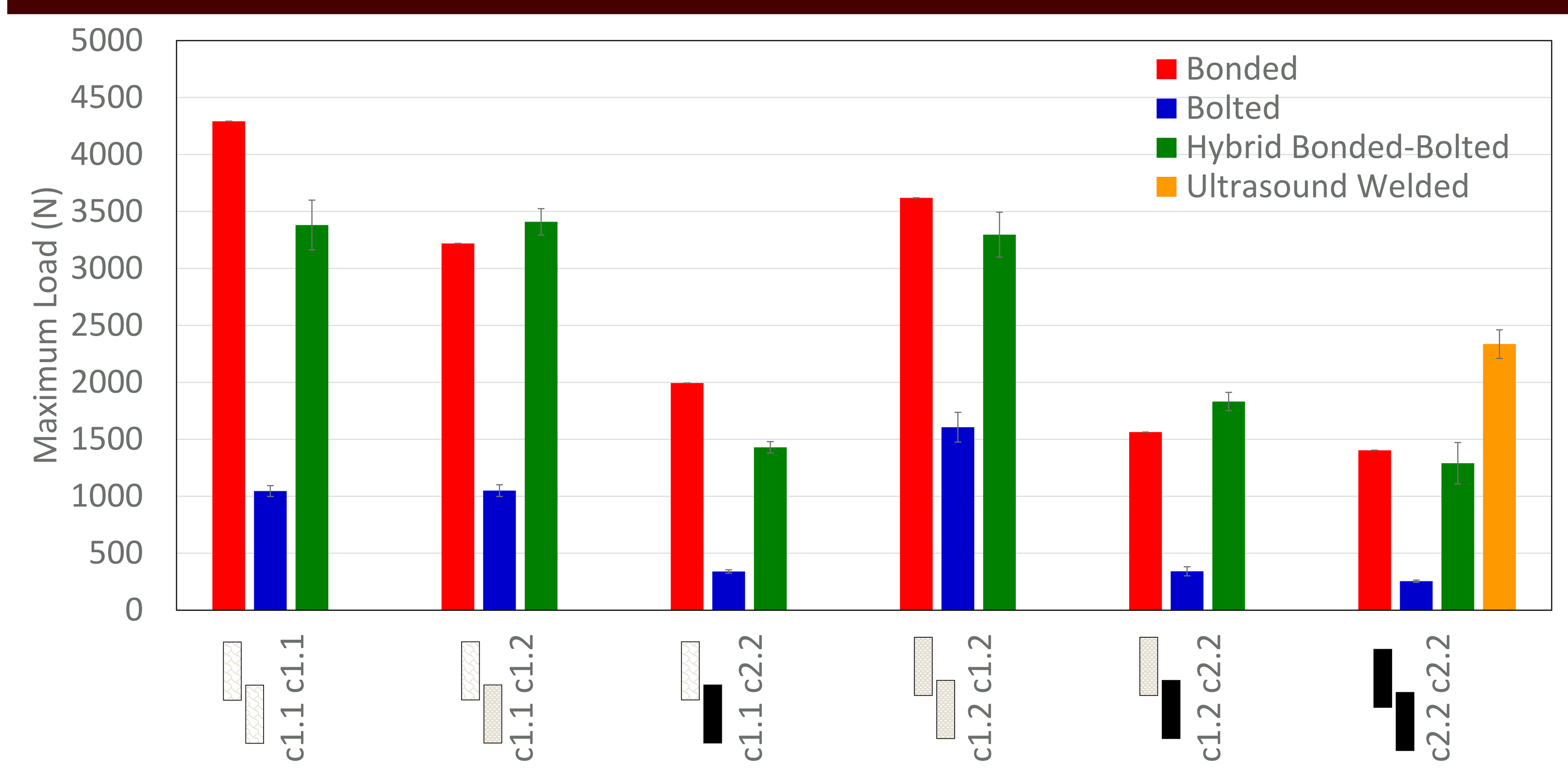


Figure 5 – Typical load-displacement curves of Hybrid joints a)FRP samples b) macroscopic images of the failure progress in the C1.1 C1.2 joints

Conclusions



According to the above Figure, generally in the case of thermoset composites, adhesive bonding is the best joining technique. Nevertheless, it should be pointed out that hybrid joining provides a fail-safe mode failure. In the case of thermoplastic composites, welding is the best joining approach. Nevertheless, to join dissimilar thermoset and thermoplastic composites, in general, hybrid joining is preferable.

Acknowledgements

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