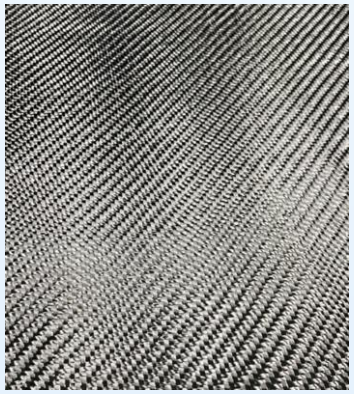
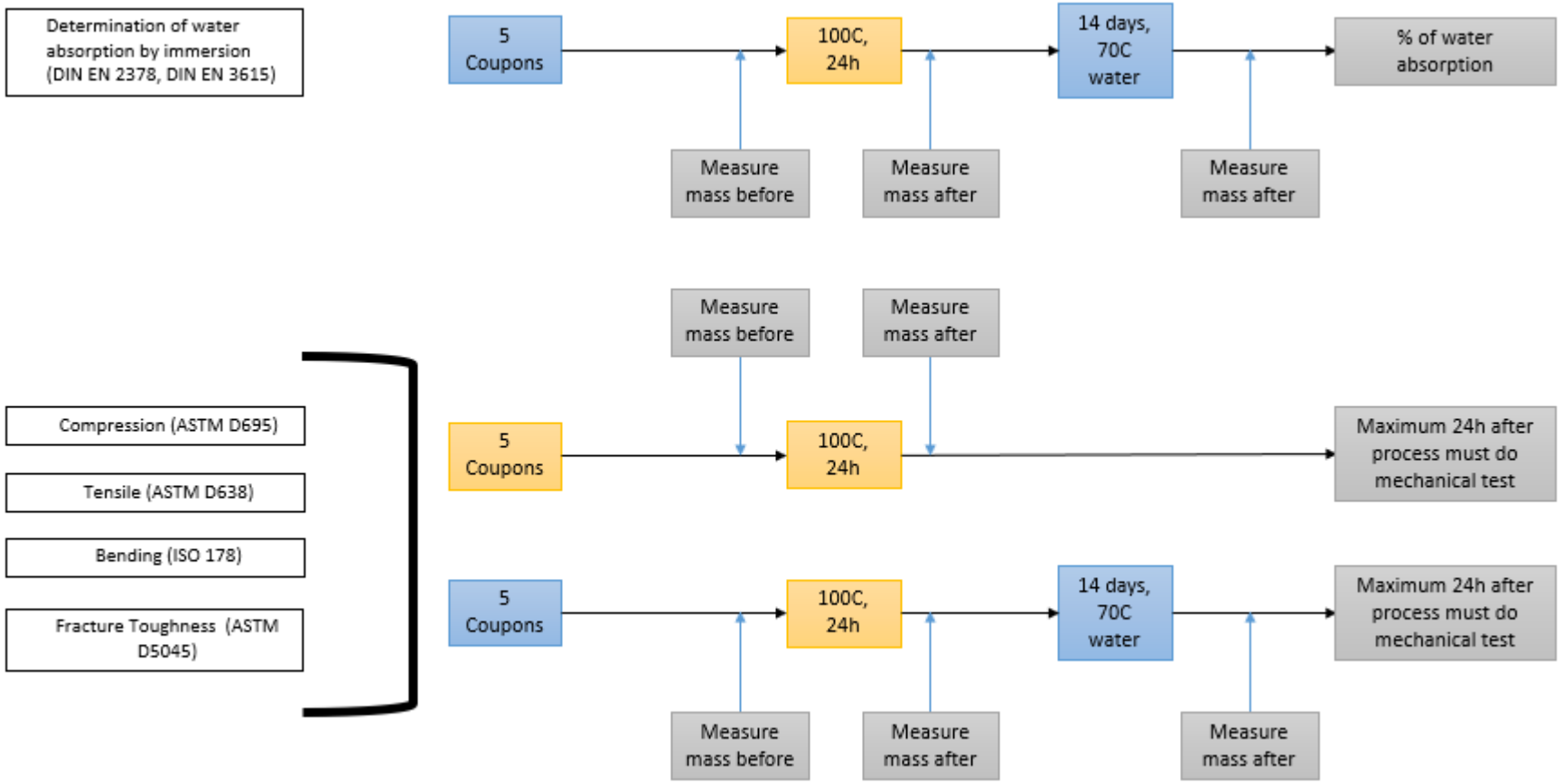
MECHANICAL PROPERTIES OF BIO-EPOXY AND RECYCLABLE BIO-EPOXY WITH MOISTURE ABSORPTION STUDY FOR AEROSPACE APPLICATIONS



B. Phettong
L. Mezeix,
B. Castanie,
C. Bouvet and
V. Rachpech

Mechanical tests to perform on bio-epoxy



Experimental results

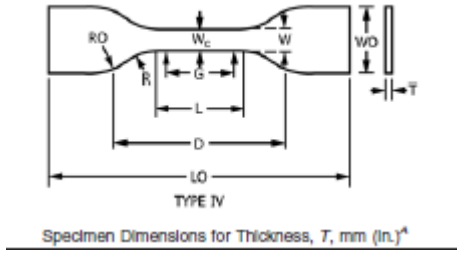
Tensile tests

Designation: D638 – 14

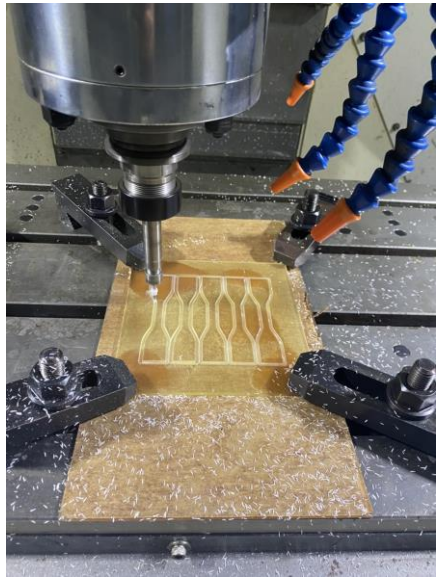
Standard Test Method for Tensile Properties of Plastics[1]

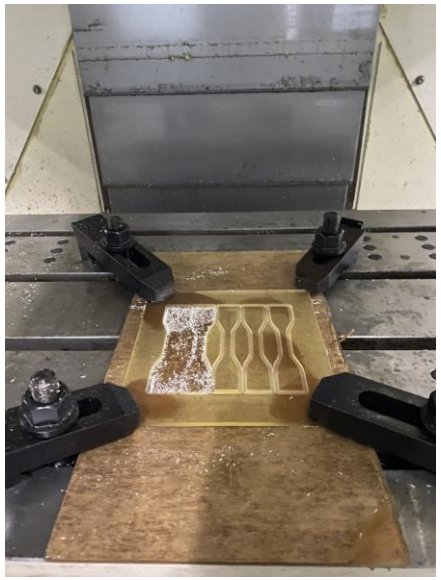
Specimen Dimensions for Thickness, *T*, mm

Dimensions (see drawings)	7 (0.28) or under		Over 7 to 14 (0.28 to 0.55) incl	4 (0.16) or under		Tolerances
	Type I	Type II	Type III	Type IV[B]	Type V[C,D]	
W—Width of narrow section[E,F]	13 (0.50)	6 (0.25)	19 (0.75)	6 (0.25)	3.18 (0.125)	±0.5 (±0.02)[B,C]
L—Length of narrow section	57 (2.25)	57 (2.25)	57 (2.25)	33 (1.30)	9.53 (0.375)	±0.5 (±0.02)[C]
WO—Width overall, min[G]	19 (0.75)	19 (0.75)	29 (1.13)	19 (0.75)	...	+ 6.4 (+ 0.25)
WO—Width overall, min[G]	...	...	...	...	9.53 (0.375)	+ 3.18 (+ 0.125)
LO—Length overall, min[H]	165 (6.5)	183 (7.2)	246 (9.7)	115 (4.5)	63.5 (2.5)	no max (no max)
G—Gage length[I]	50 (2.00)	50 (2.00)	50 (2.00)	...	7.62 (0.300)	±0.25 (±0.010)[C]
G—Gage length[I]	...	...	...	25 (1.00)	...	±0.13 (±0.005)
D—Distance between grips	115 (4.5)	135 (5.3)	115 (4.5)	65 (2.5)[J]	25.4 (1.0)	±5 (±0.2)
R—Radius of fillet	76 (3.00)	76 (3.00)	76 (3.00)	14 (0.56)	12.7 (0.5)	±1 (±0.04)[C]
RO—Outer radius (Type IV)	...	...	...	25 (1.00)	...	±1 (±0.04)



Specimen Dimensions for Thickness, *T*, mm (in.)[A]

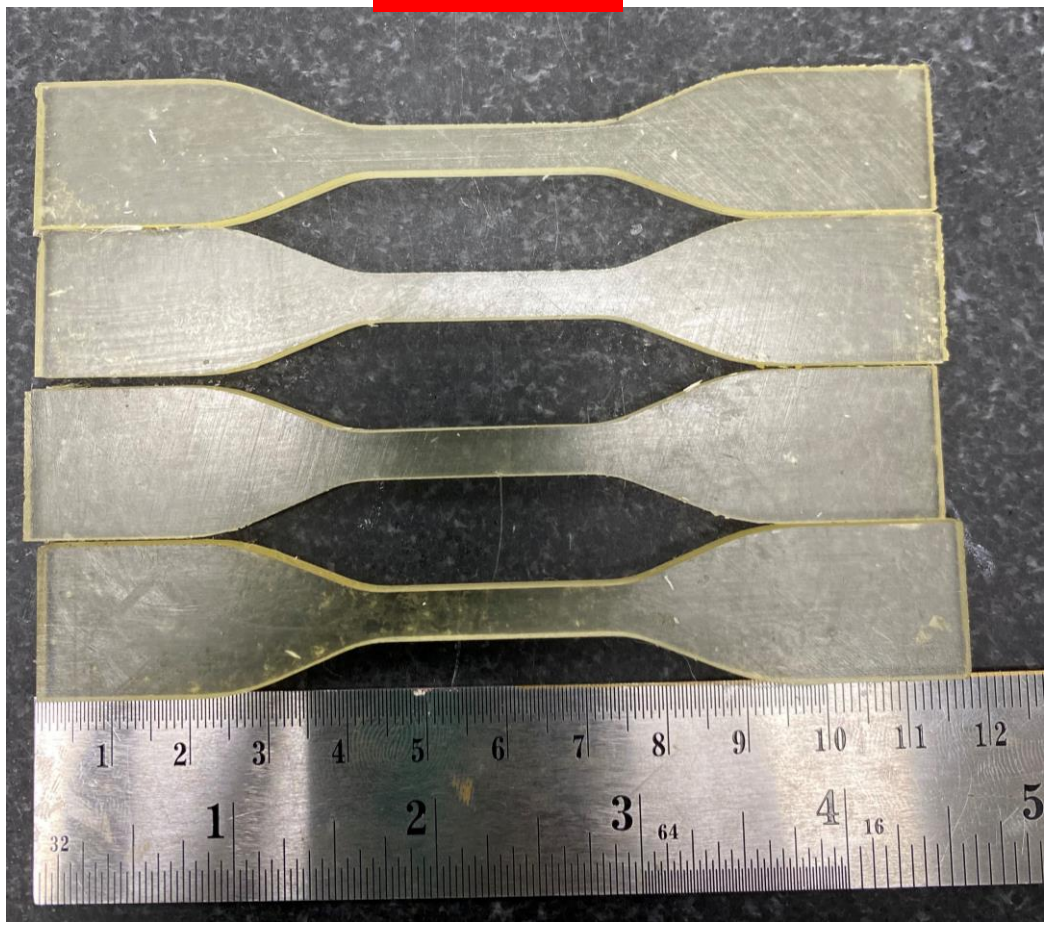




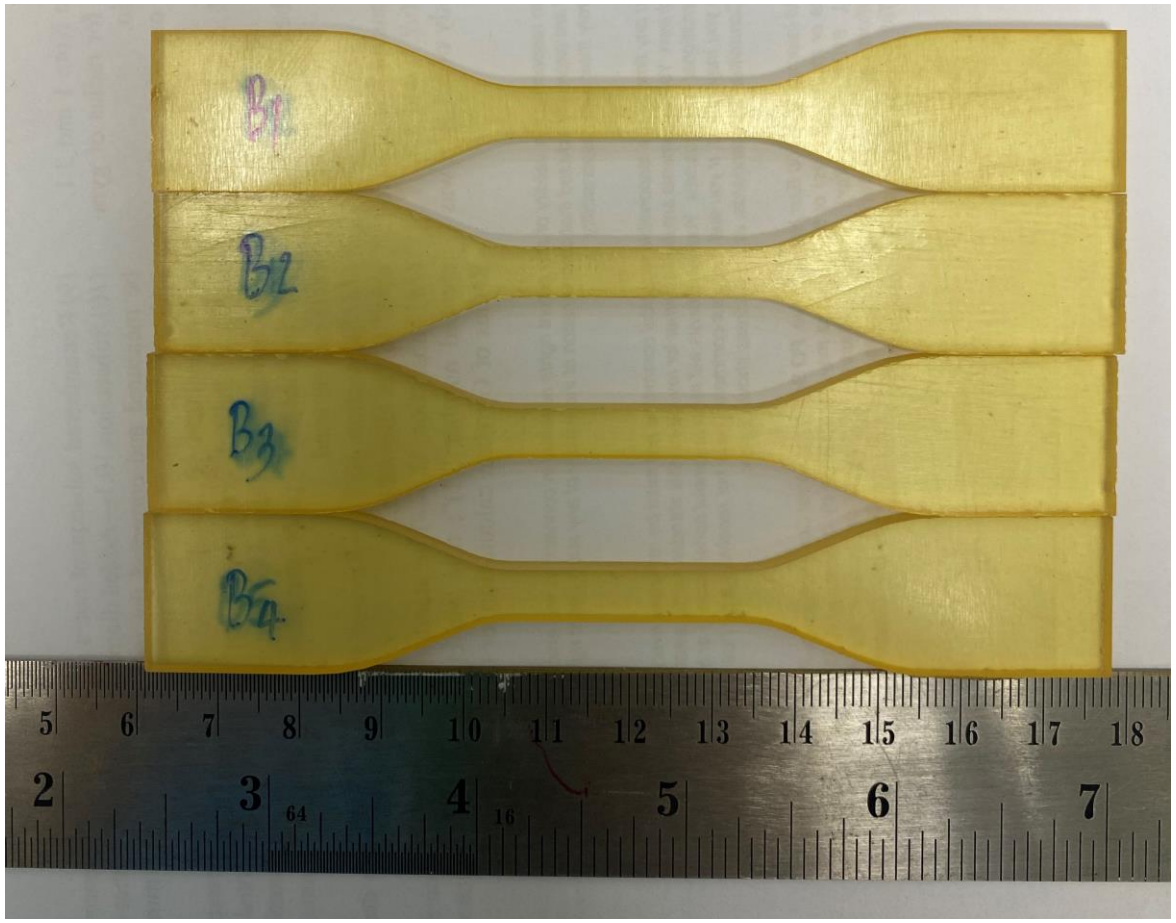
CNC Process in GALAXI LAB

Tensile tests

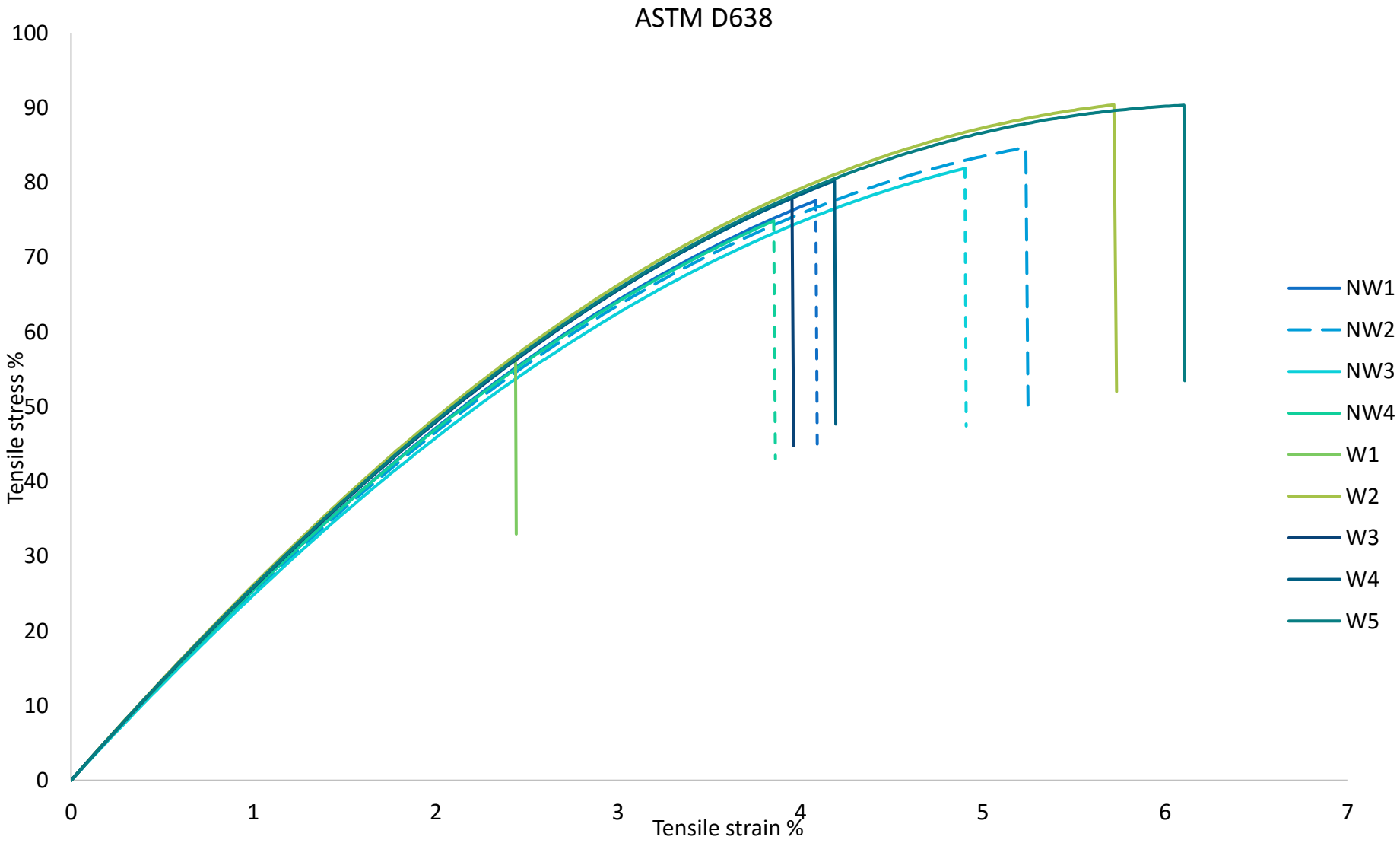
No water



Water Condition



Tensile tests

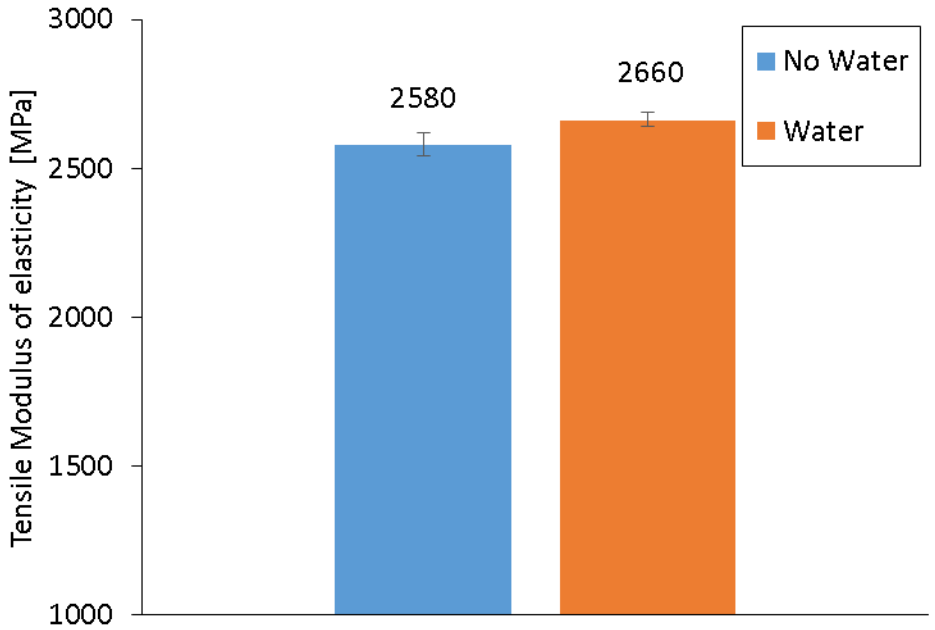


Tensile tests

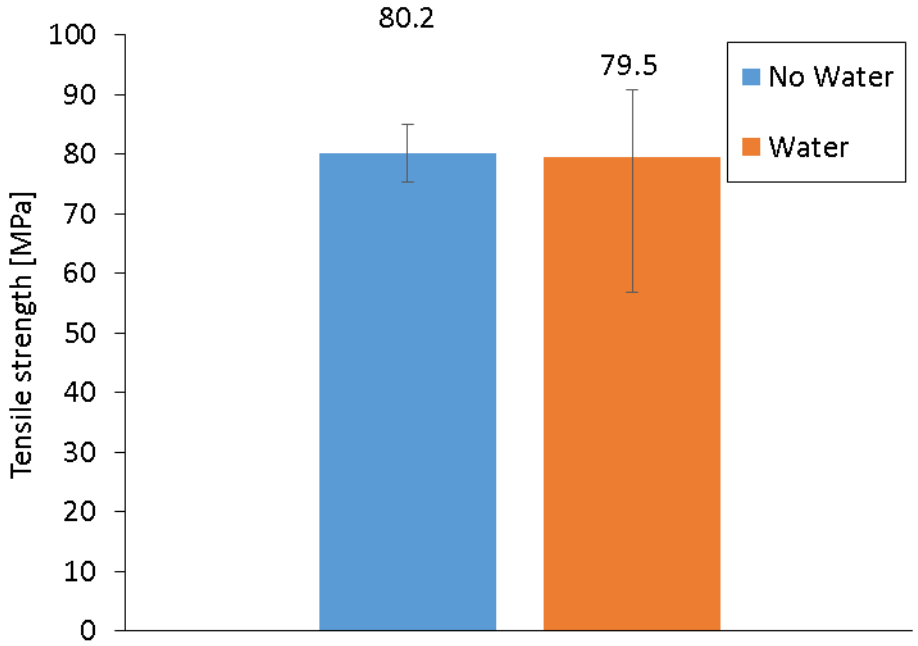
Mechanical Properties of Neat Cured Epoxy System*		
Tensile strength	MPa	75 - 85
Tensile strain	%	5 - 7
E-modulus	MPa	2,700 - 3,000
Flexural strength	MPa	130 - 150
Flexural strain	%	6 - 8
E-modulus	MPa	2,800 - 3,200

* Curing condition: 80°C/ 25 minutes + 140°C/ 4 hrs.

Experimental results validate the data provided by Aditya Birla



Modulus of elasticity



Tensile strength

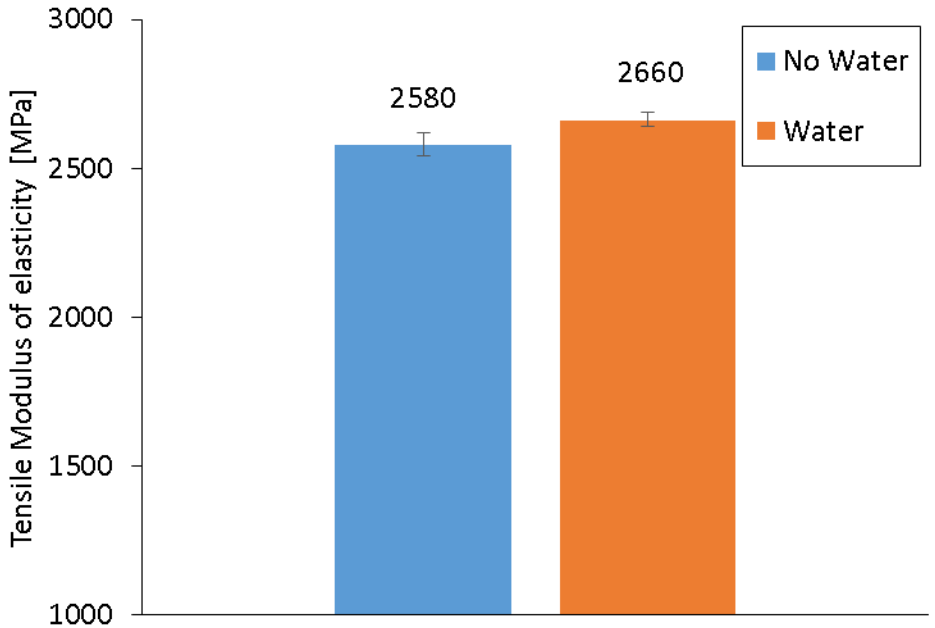
Tensile tests

Table 4
Tested modulus E, Poisson's ratio ν and tensile strength σ_T for each specimen.

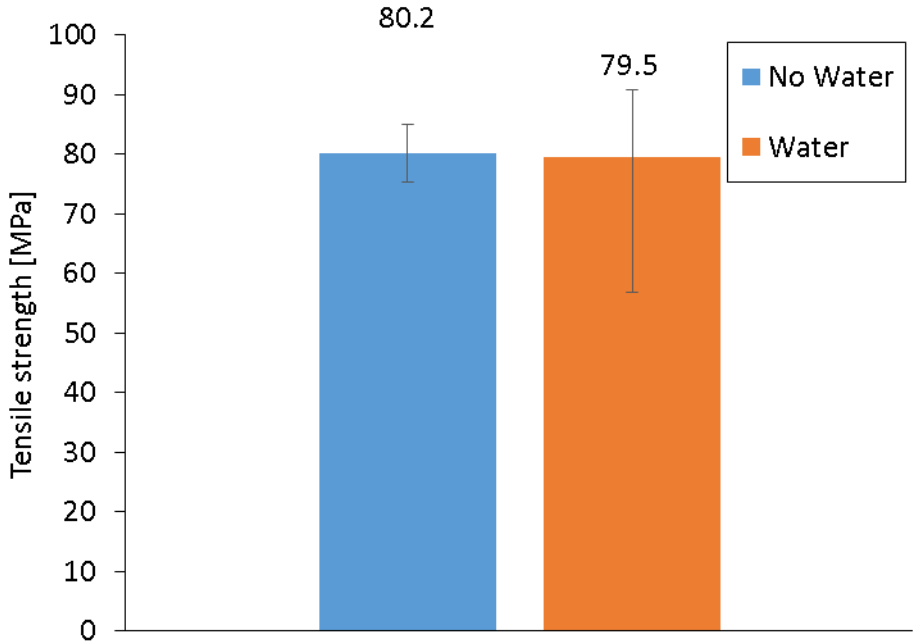
Material	Specimen No.	E, GPa	ν	σ_T, MPa
PR 520	T1	3.51	.36	80.2
	T2	3.47	.36	85.1
	Mean	3.49	.36	82.7
LT-5078	T1	3.05	.36	68.6
	T2	3.02	.36	68.6
	Mean	3.04	.36	68.6

RTM epoxy

[Yukun Li et al., 2022]

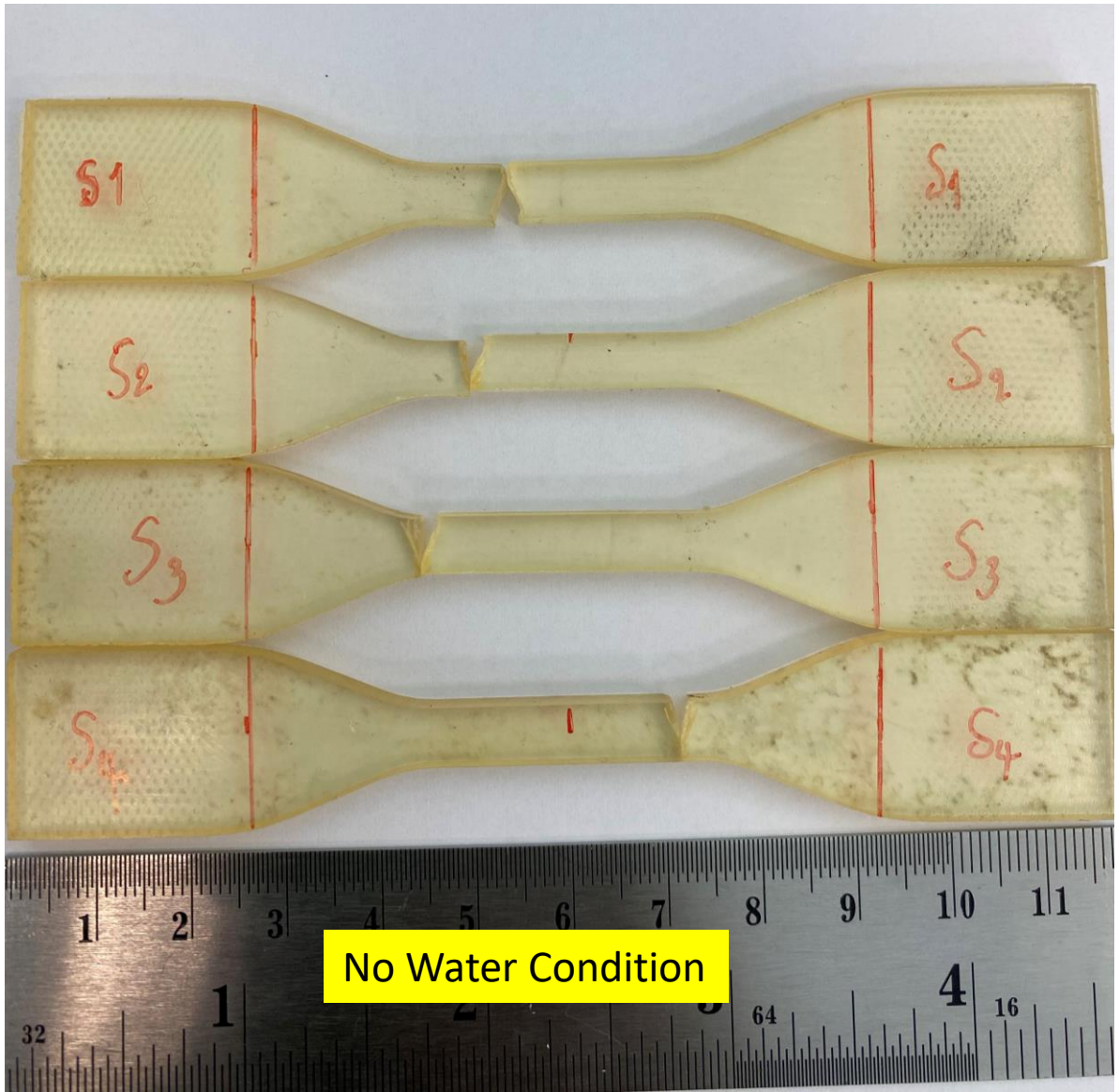


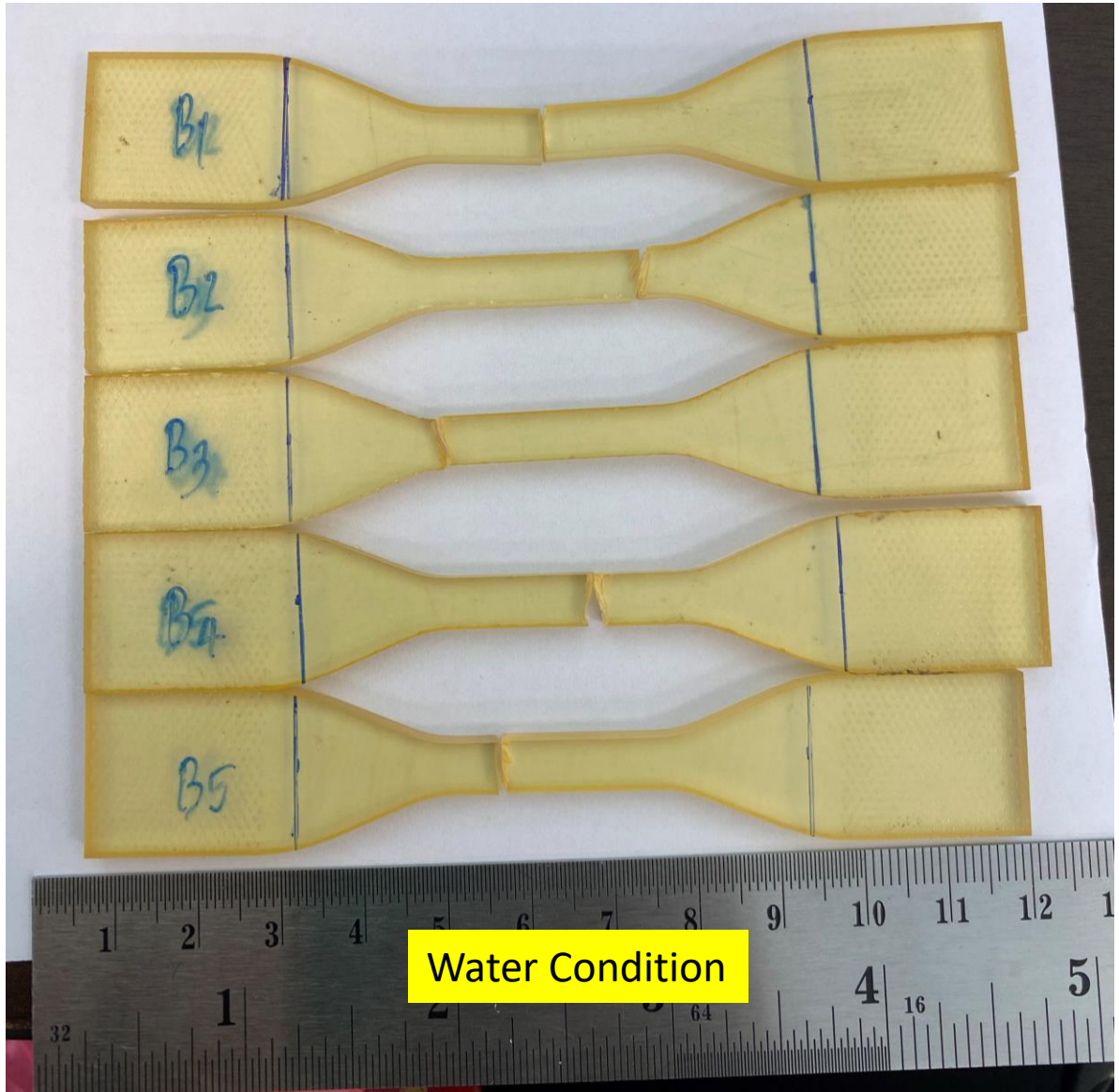
Modulus of elasticity



Tensile strength

Tensile tests





Compression tests

Designation: D695 – 15

Standard Test Method for Compressive Properties of Rigid Plastics[1]

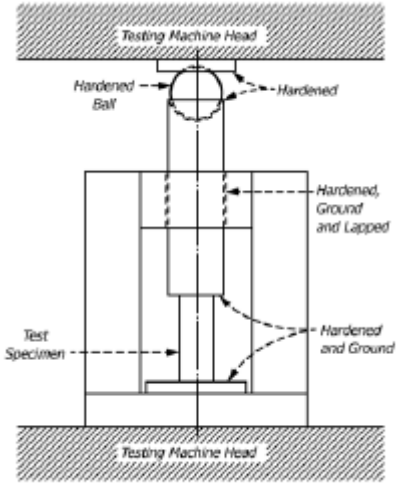
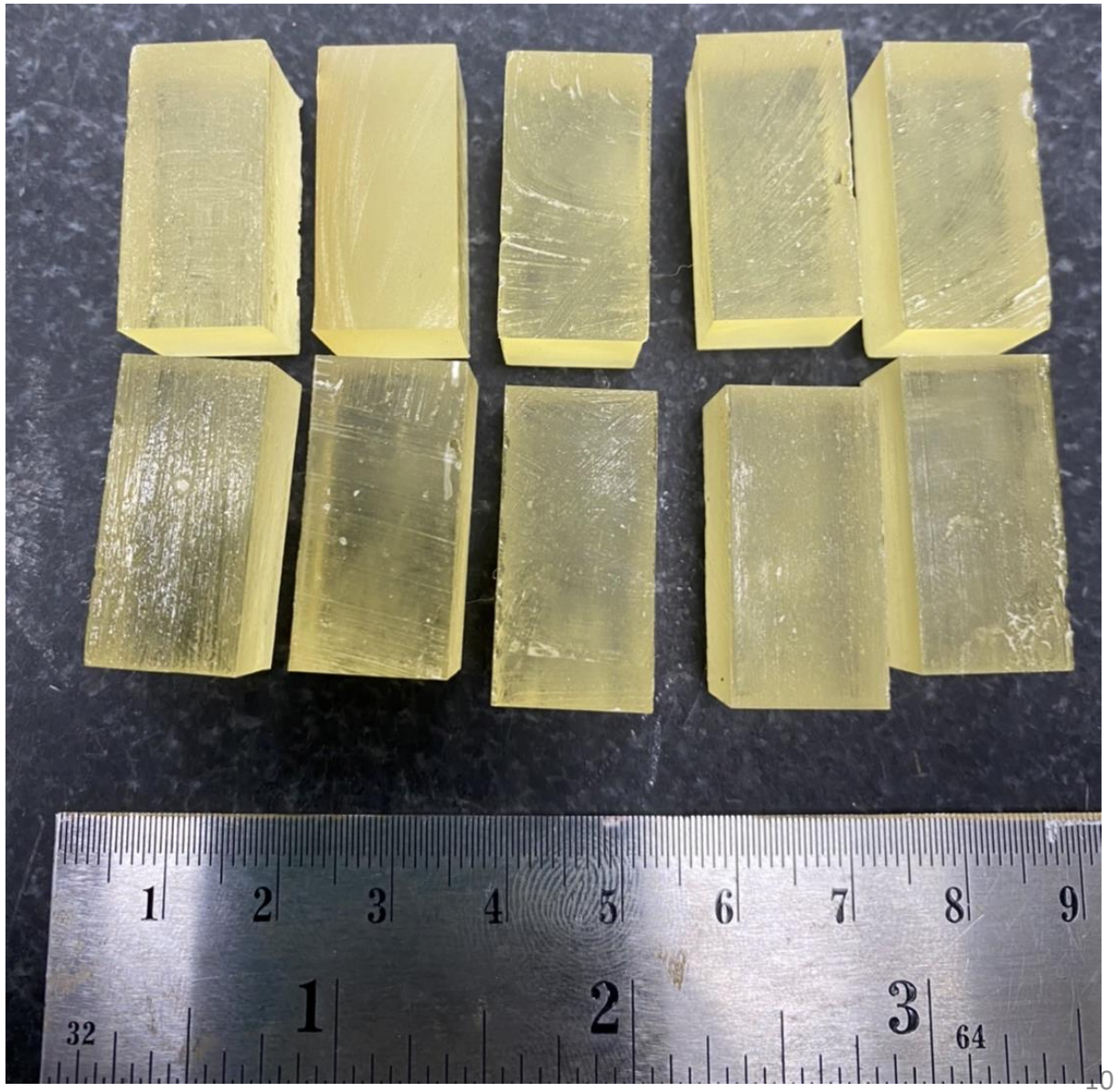
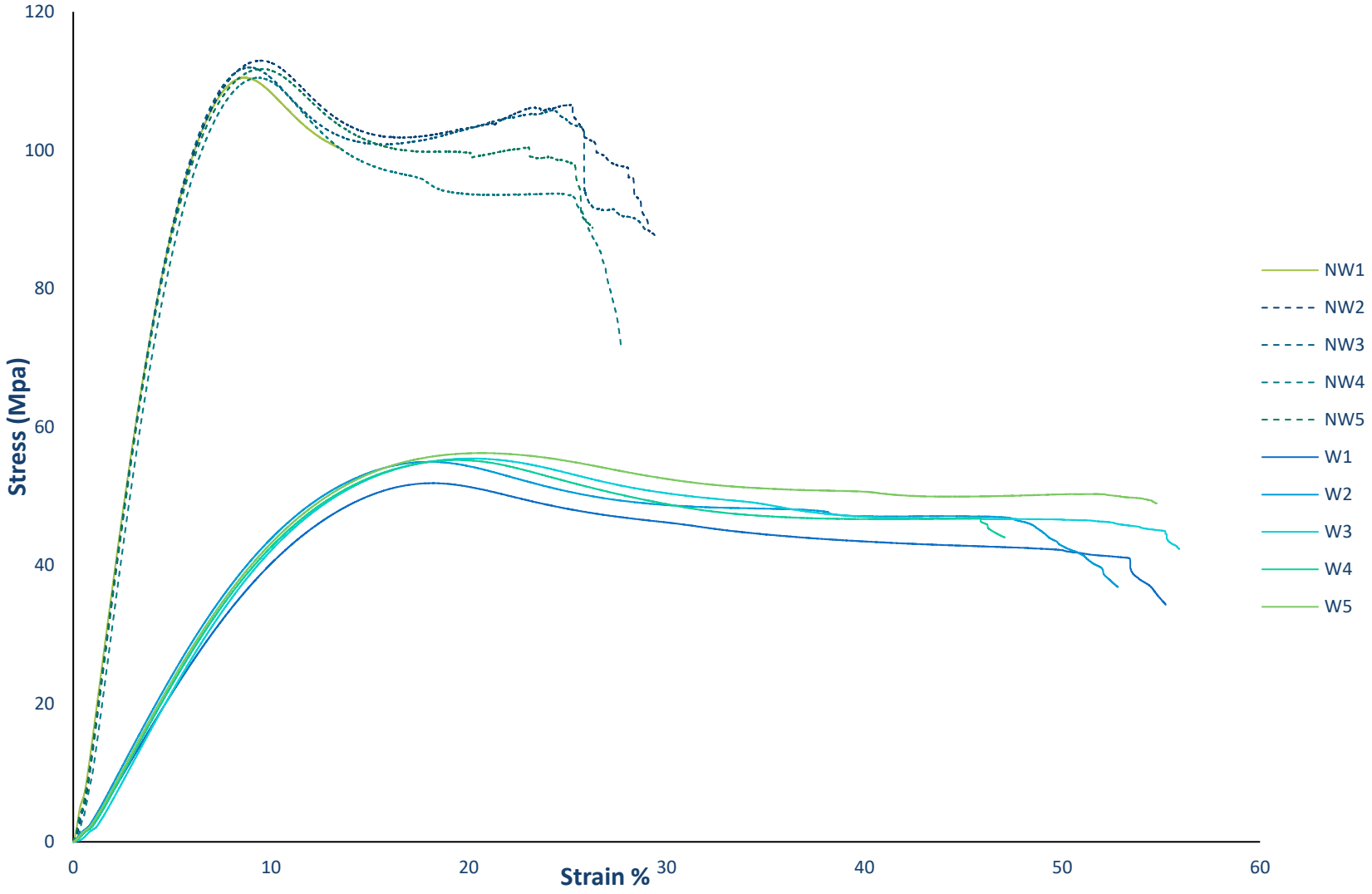


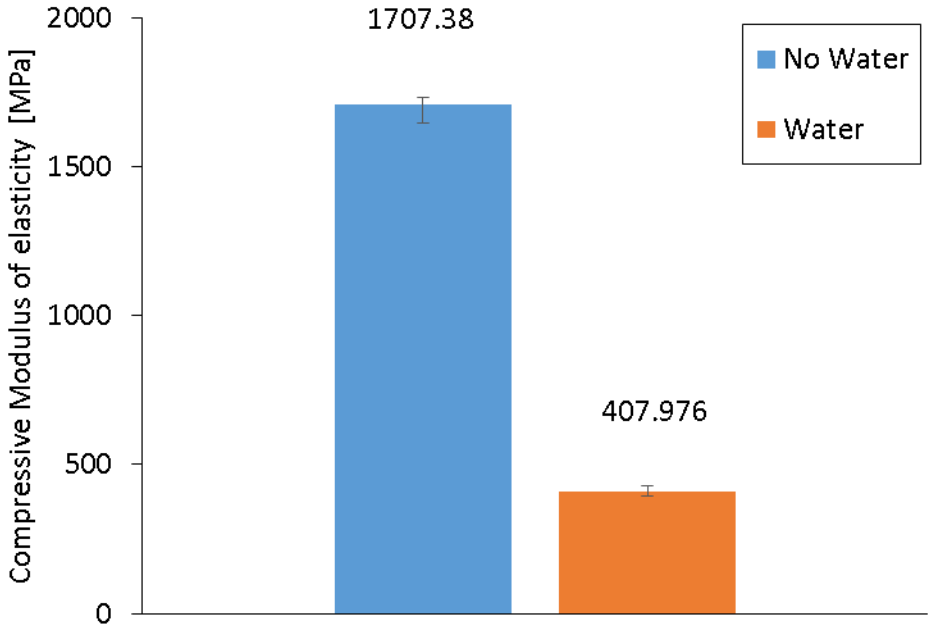
FIG. 2 Compression Tool



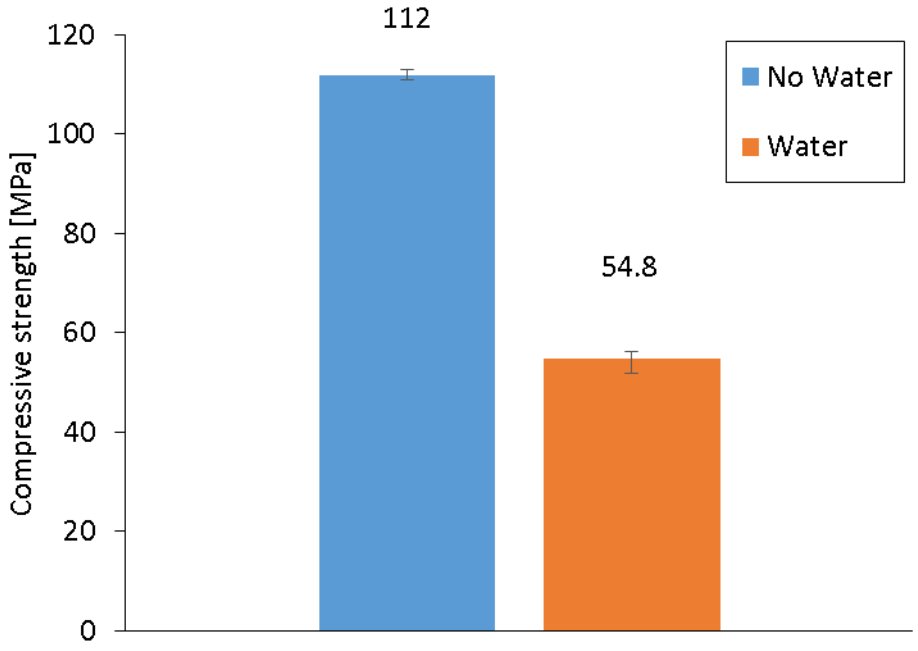
Compression tests



Compression tests

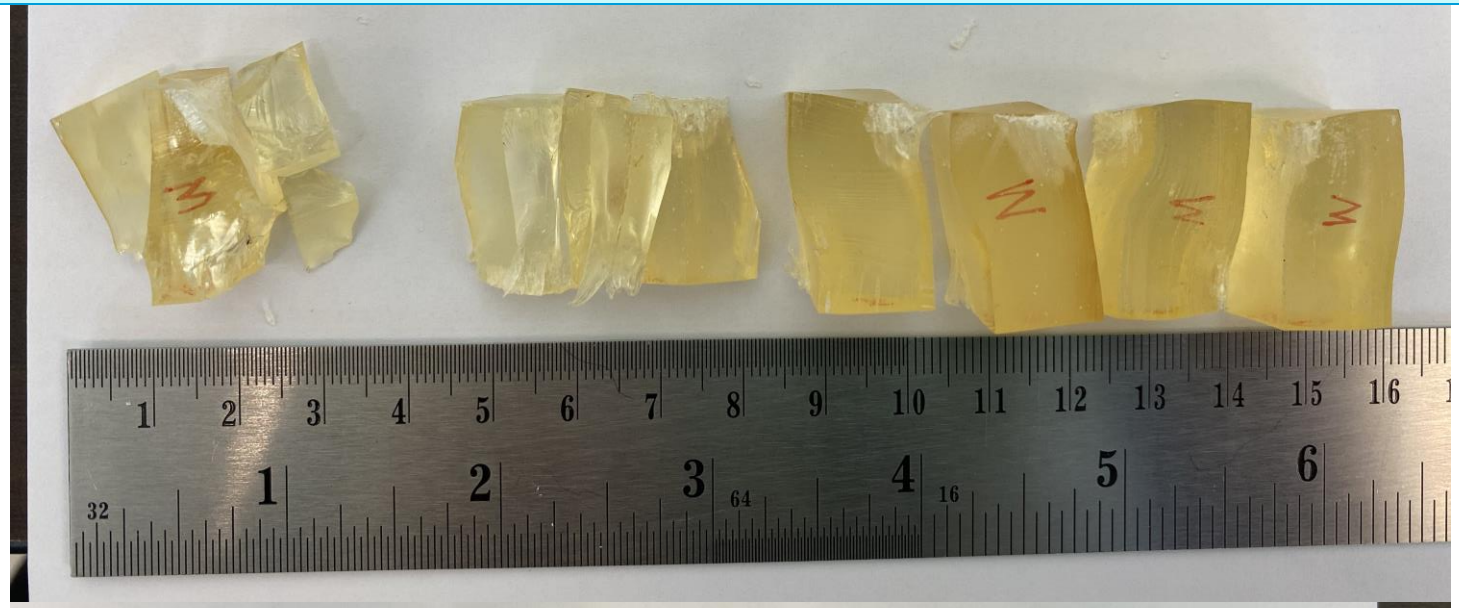


Modulus of elasticity



Compressive strength

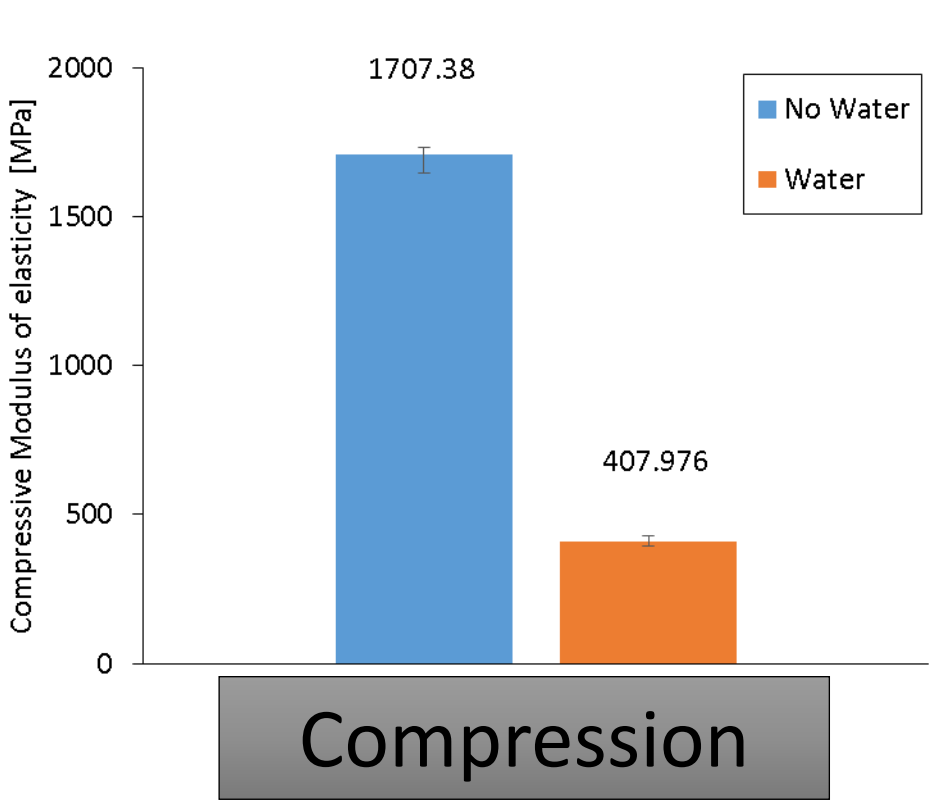
MECHANICAL PROPERTIES OF BIO-EPOXY AND RECYCLABLE BIO-EPOXY WITH MOISTURE ABSORPTION STUDY FOR AEROSPACE APPLICATIONS

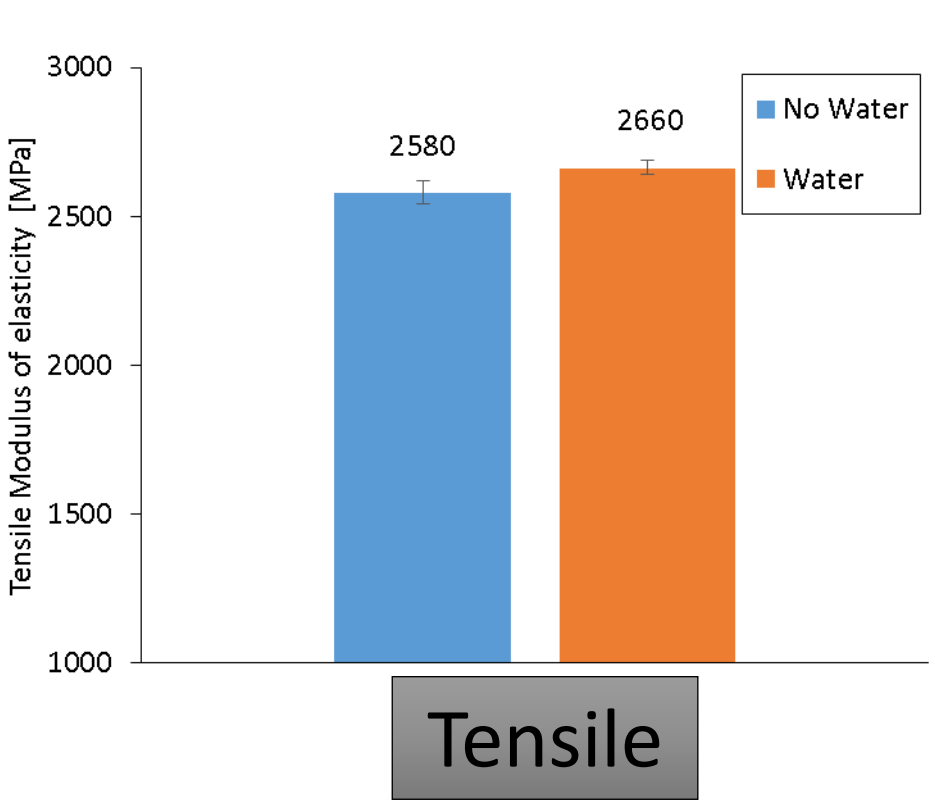


No Water Condition

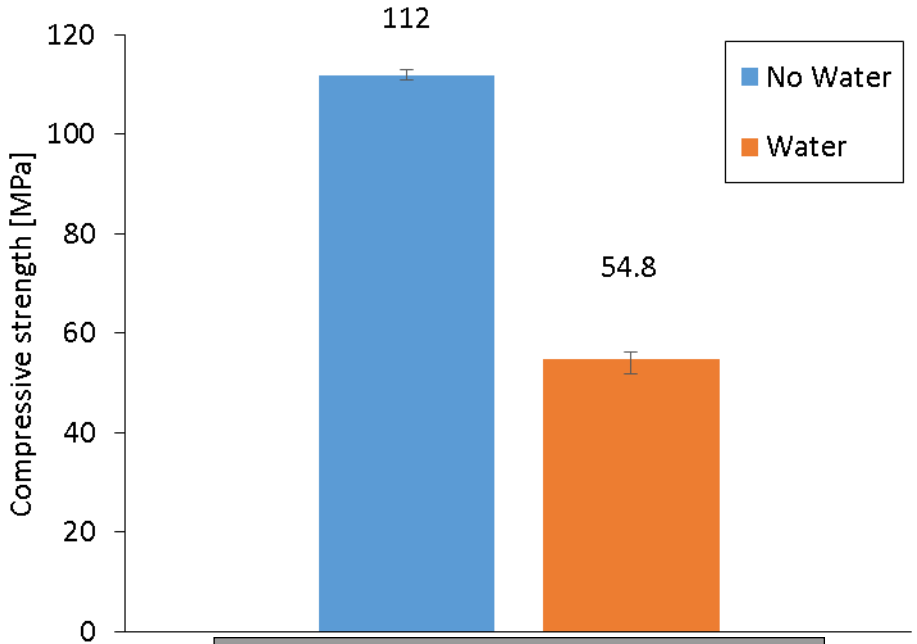
Water Condition

Comparison Young modulus tensile/compression

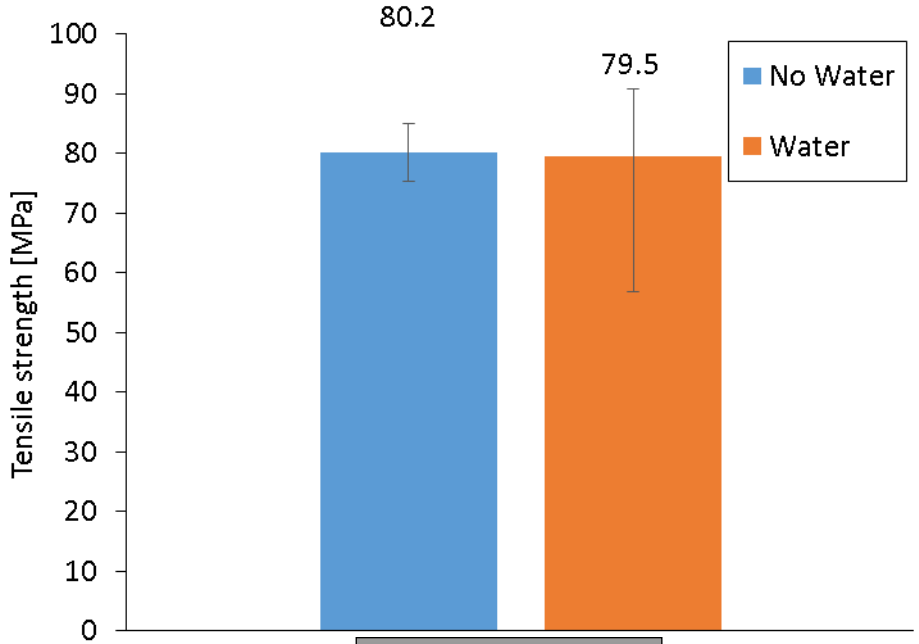




Comparison strength tensile/compression

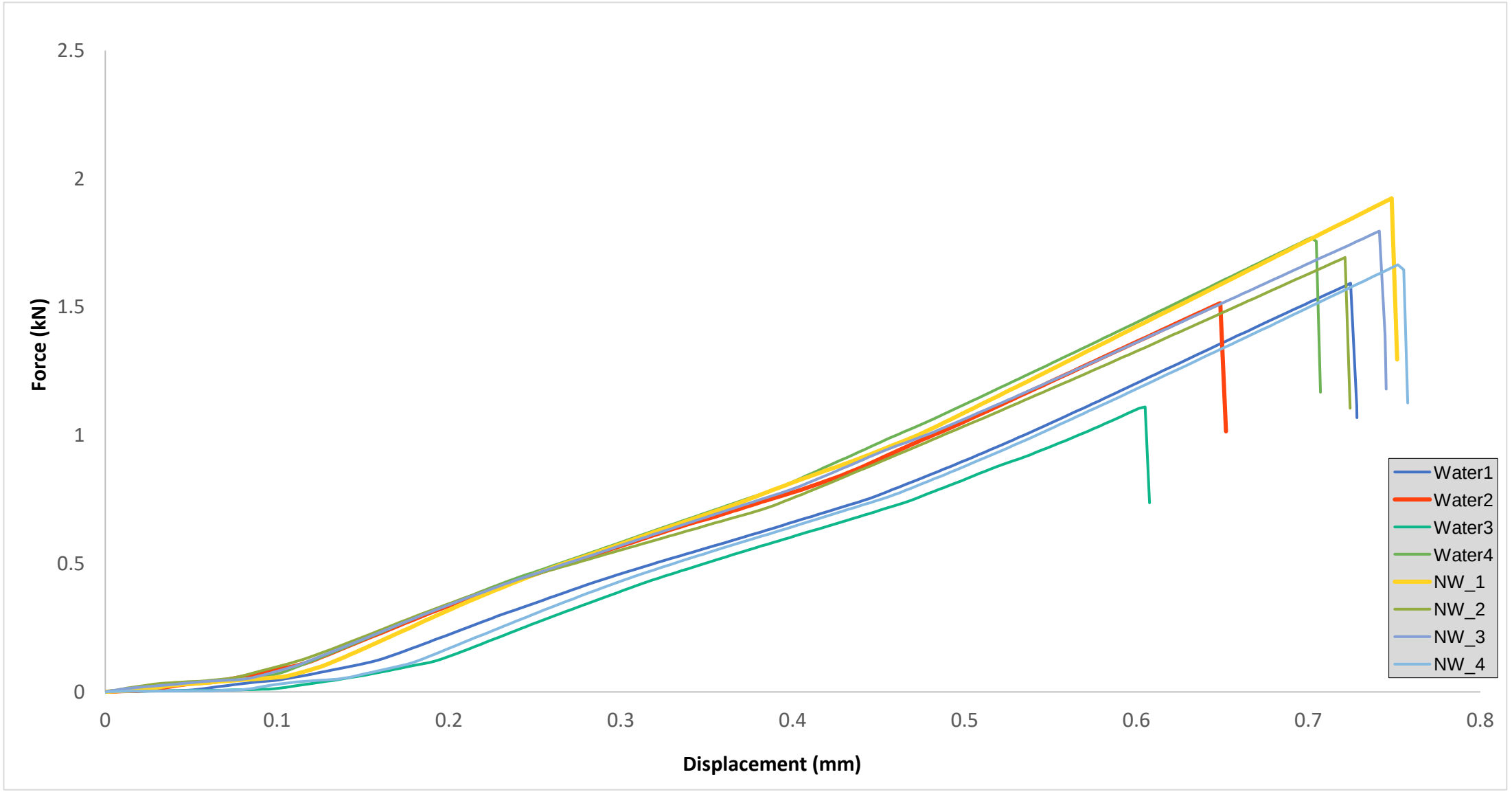


Compression



Tensile

MECHANICAL PROPERTIES OF BIO-EPOXY AND RECYCLABLE BIO-EPOXY WITH MOISTURE ABSORPTION STUDY FOR AEROSPACE APPLICATIONS



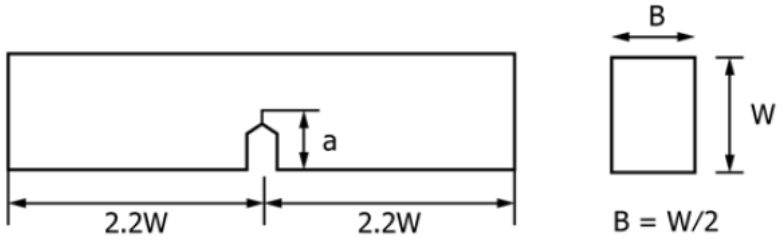
MECHANICAL PROPERTIES OF BIO-EPOXY AND RECYCLABLE BIO-EPOXY WITH MOISTURE ABSORPTION STUDY FOR AEROSPACE APPLICATIONS

$$K_Q = \left(\frac{P_Q}{BW^{1/2}} \right) f(x)$$

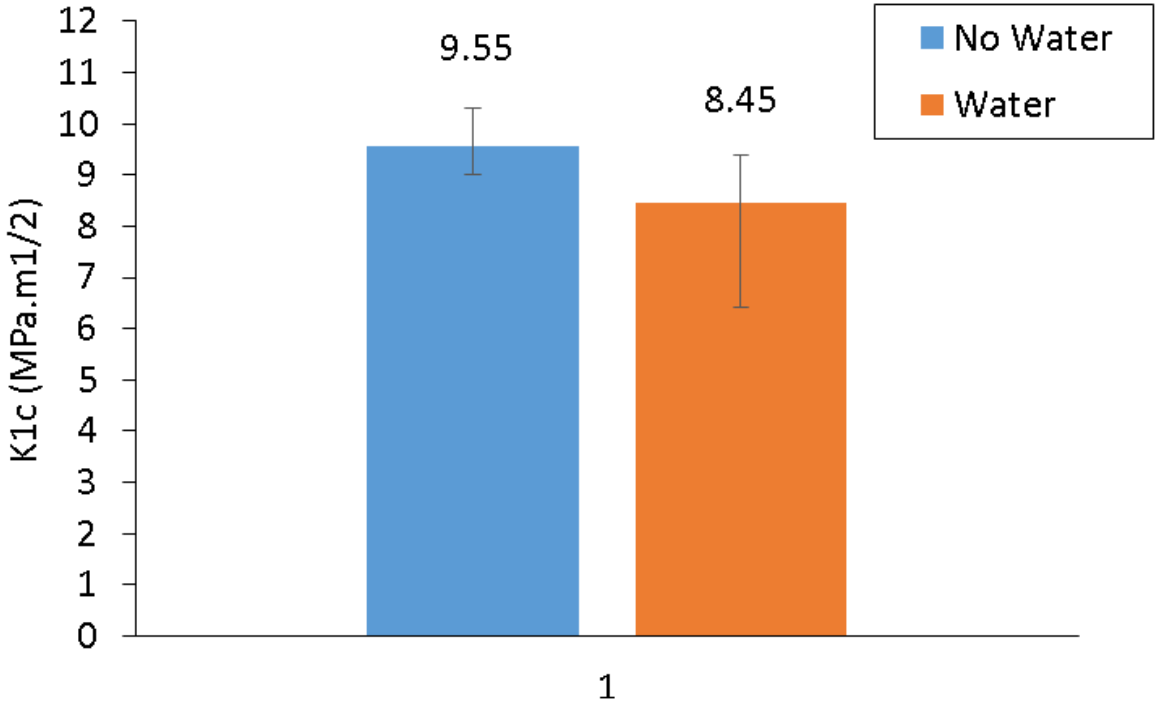
where $(0 < x < 1)$:

$$f(x) = 6x^{1/2} \frac{[1.99 - x(1-x)(2.15 - 3.93x + 2.7x^2)]}{(1+2x)(1-x)^{3/2}}$$

$$x = a/W$$



a Three Point Bend Specimen (SENB)



MECHANICAL PROPERTIES OF BIO-EPOXY AND RECYCLABLE BIO-EPOXY WITH MOISTURE ABSORPTION STUDY FOR AEROSPACE APPLICATIONS

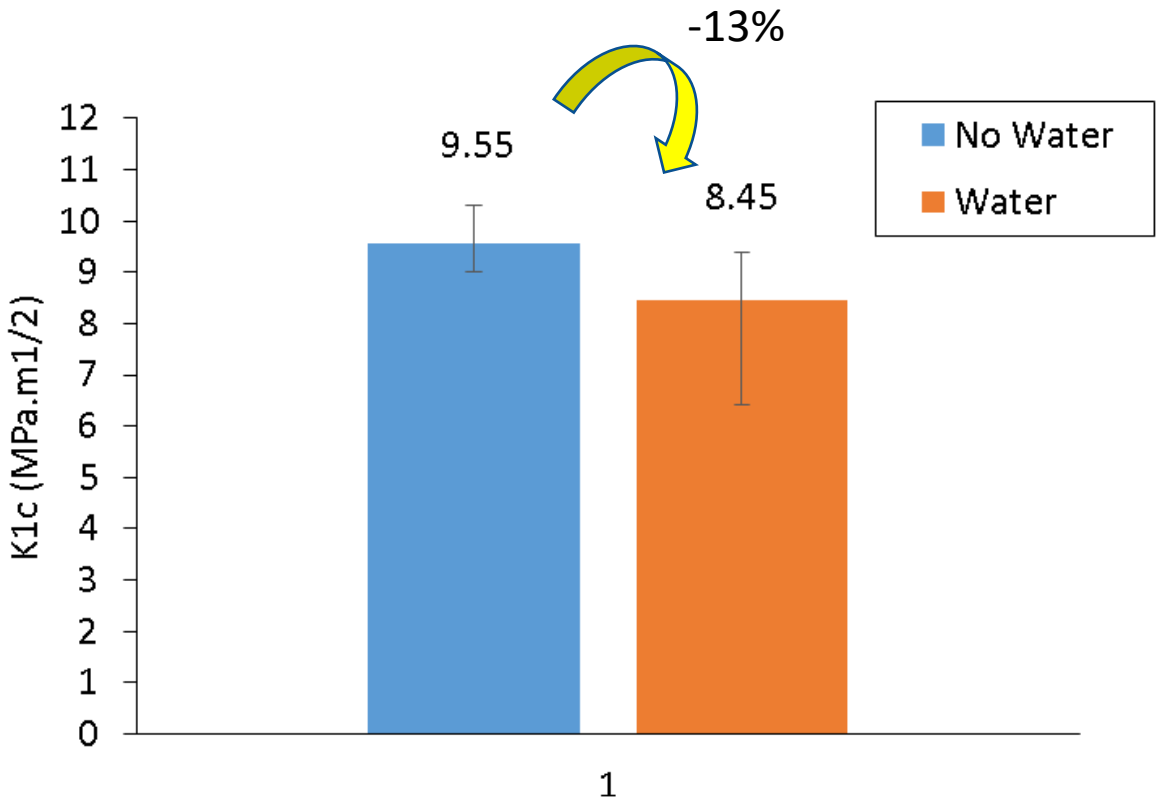


Table 5
Tested qualified critical load P_Q and fracture toughness K_{Ic},G_{Ic} for each specimen.

Material	Specimen No.	P_Q, N	K_{Ic}, MPa $\sqrt{m}$	G_{Ic}, MPa · mm
PR 520	B1	86.7	2.01	1.01
	B2	91.9	2.09	1.09
	Mean	–	2.05	1.05
LT-5078	B1	98.1	2.29	1.50
	B2	97.3	2.34	1.57
	Mean	–	2.32	1.54

RTM epoxy

[Yukun Li et al., 2022]

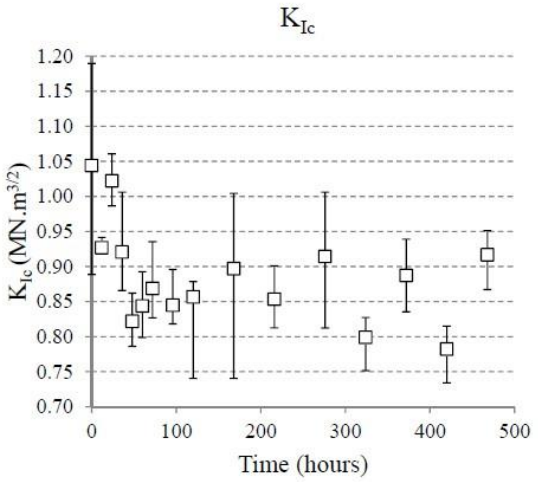


Figure 4.10: Hygrothermal aging effects in K_{Ic}

EPOLAM 2063

K1c decreases of 20% with the water absorption

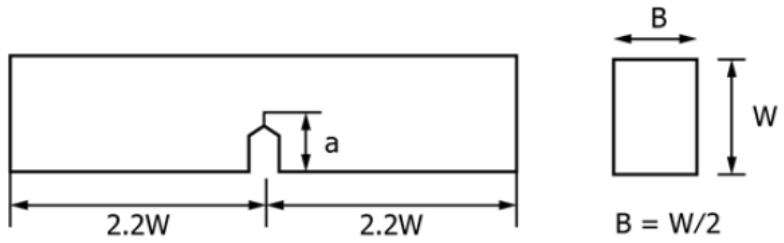
[Gustavo Q.Q. Characterisation of fracture toughness of epoxy resin after hydrothermal aging, 2013]

To validate the test, the following value

$$2.5\ (K_Q/\sigma_y)^2$$

must be lower than:

- B
- W-a
- a

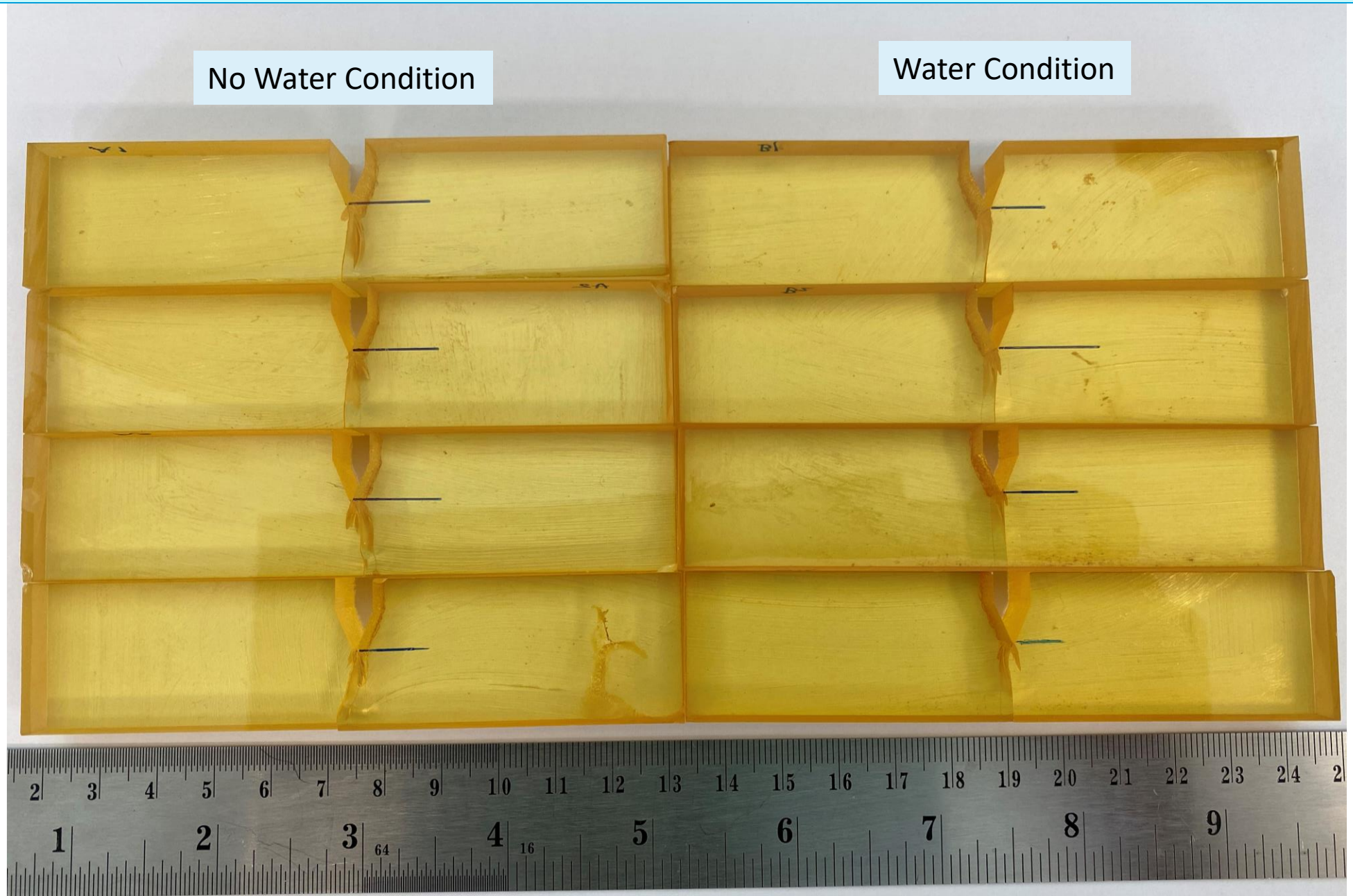


a Three Point Bend Specimen (SENB)

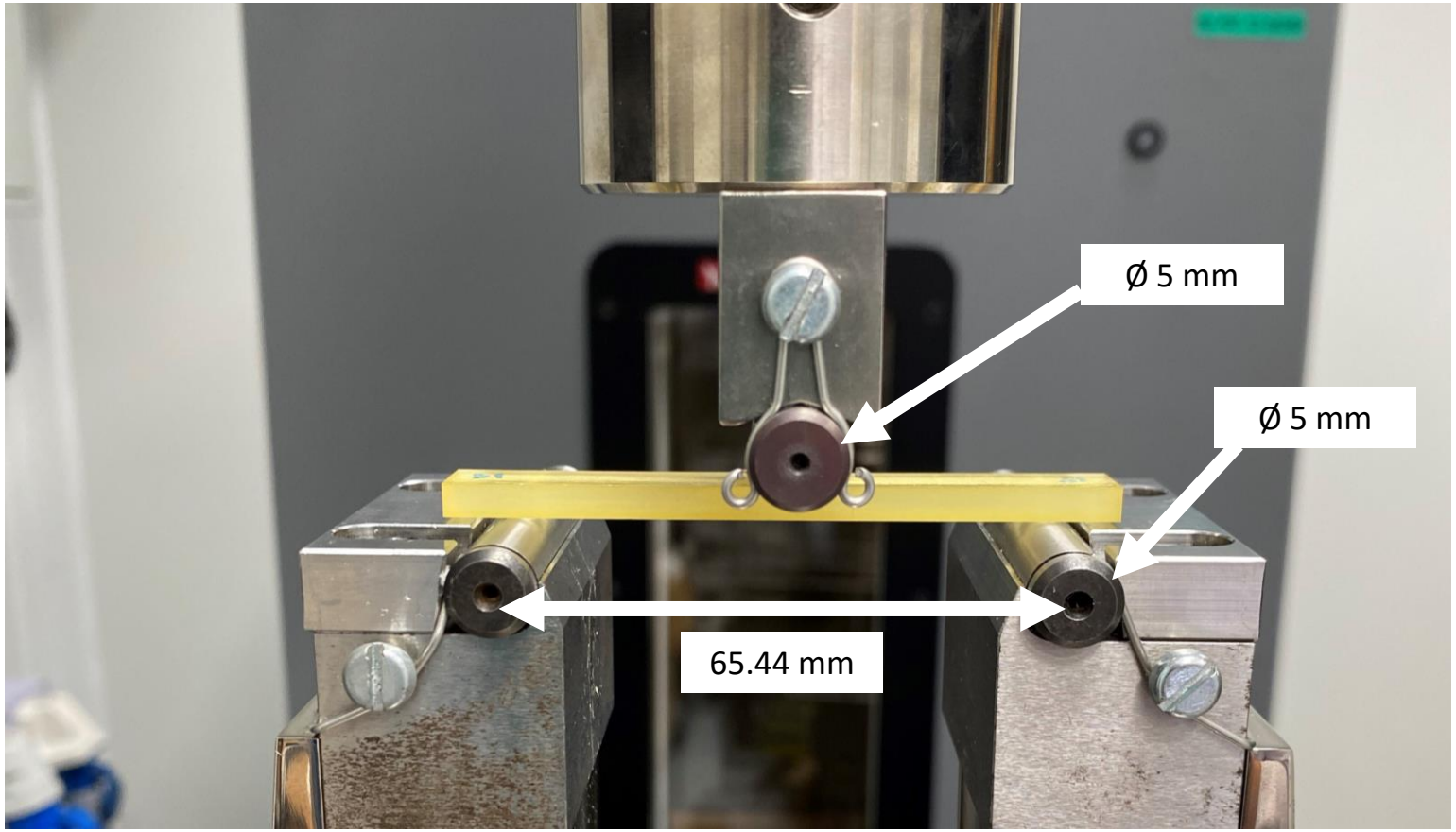
Using experimental value $2.5\ (K_Q/\sigma_y)^2$ = 32 mm

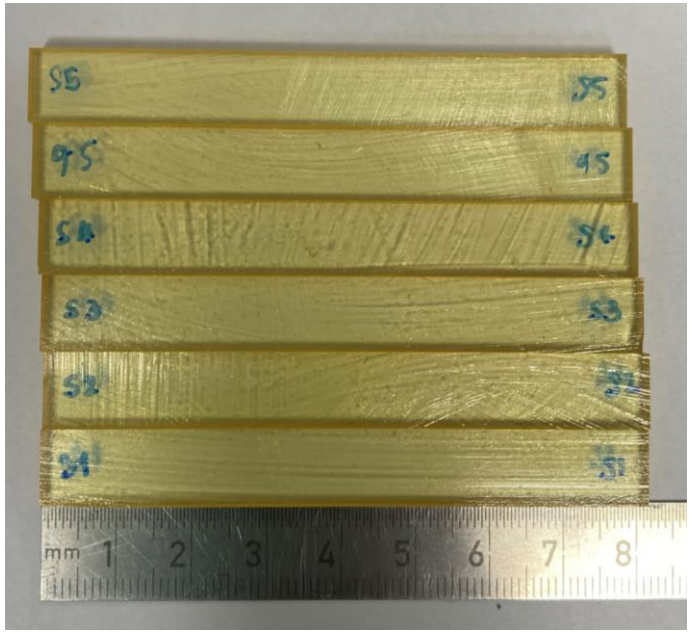
Value does not comply with the ASTM 5054 Standard and therefore the test is not a valid K_{Ic} test.

MECHANICAL PROPERTIES OF BIO-EPOXY AND RECYCLABLE BIO-EPOXY WITH MOISTURE ABSORPTION STUDY FOR AEROSPACE APPLICATIONS

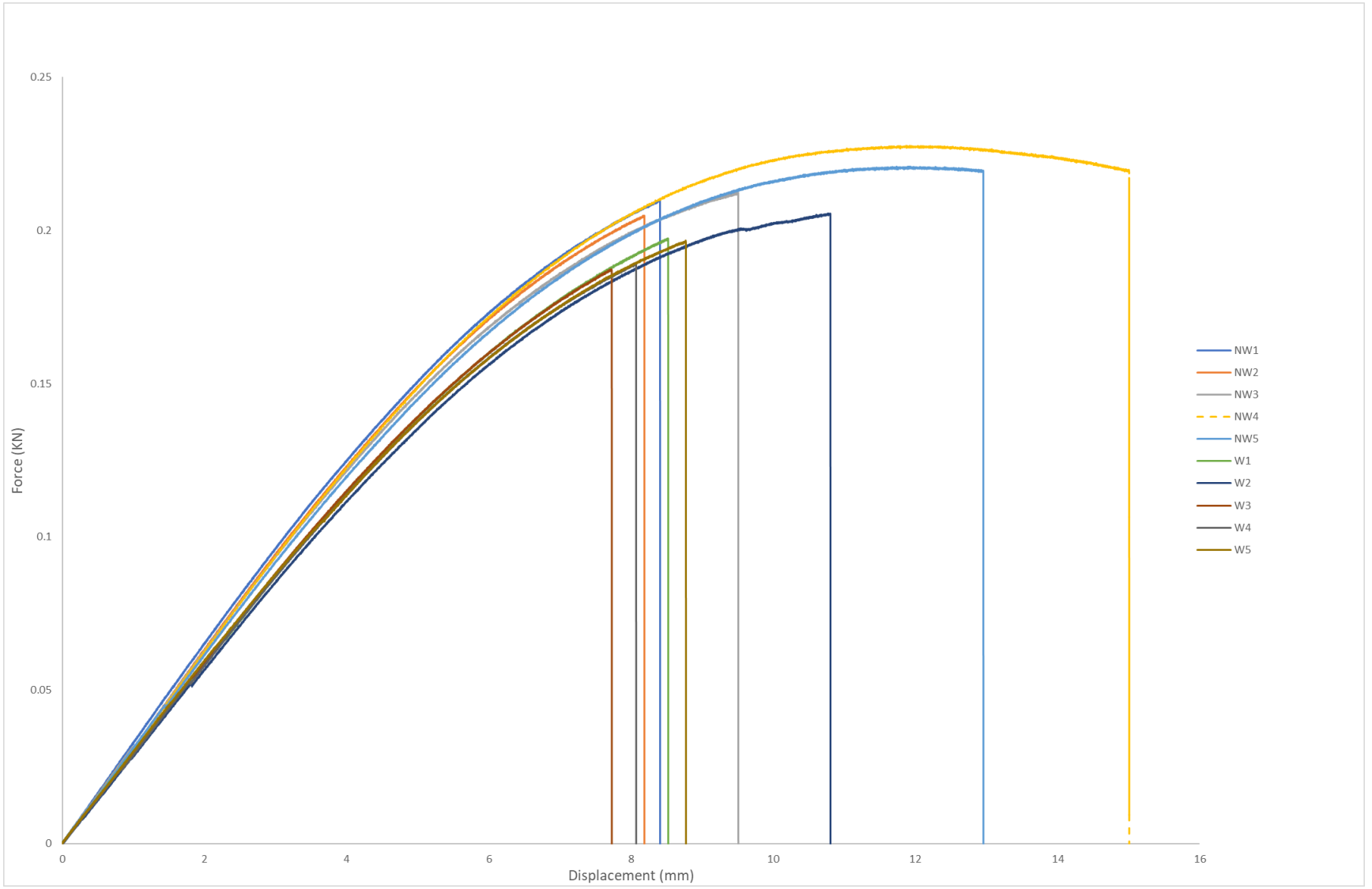


Bending ISO 178

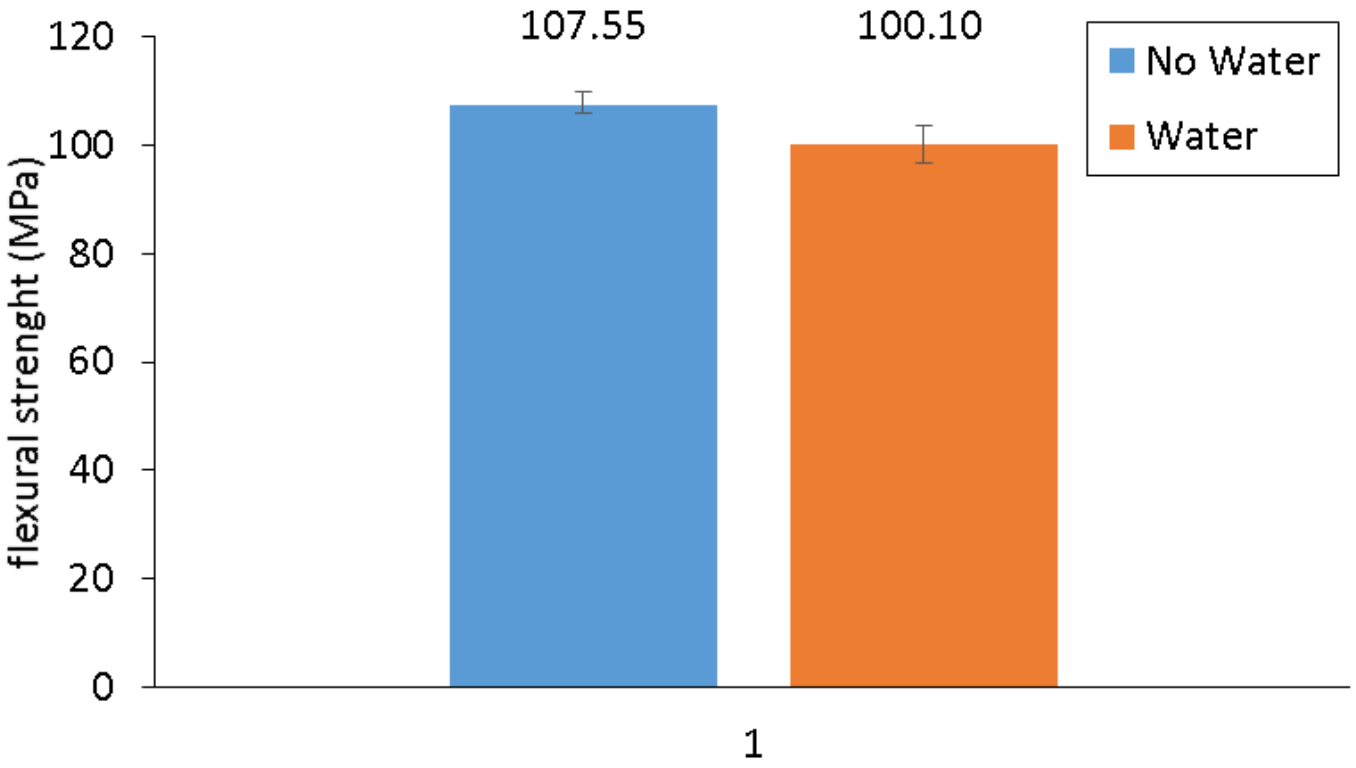




MECHANICAL PROPERTIES OF BIO-EPOXY AND RECYCLABLE BIO-EPOXY WITH MOISTURE ABSORPTION STUDY FOR AEROSPACE APPLICATIONS



MECHANICAL PROPERTIES OF BIO-EPOXY AND RECYCLABLE BIO-EPOXY WITH MOISTURE ABSORPTION STUDY FOR AEROSPACE APPLICATIONS



Mechanical Properties of Neat Cured Epoxy System*		
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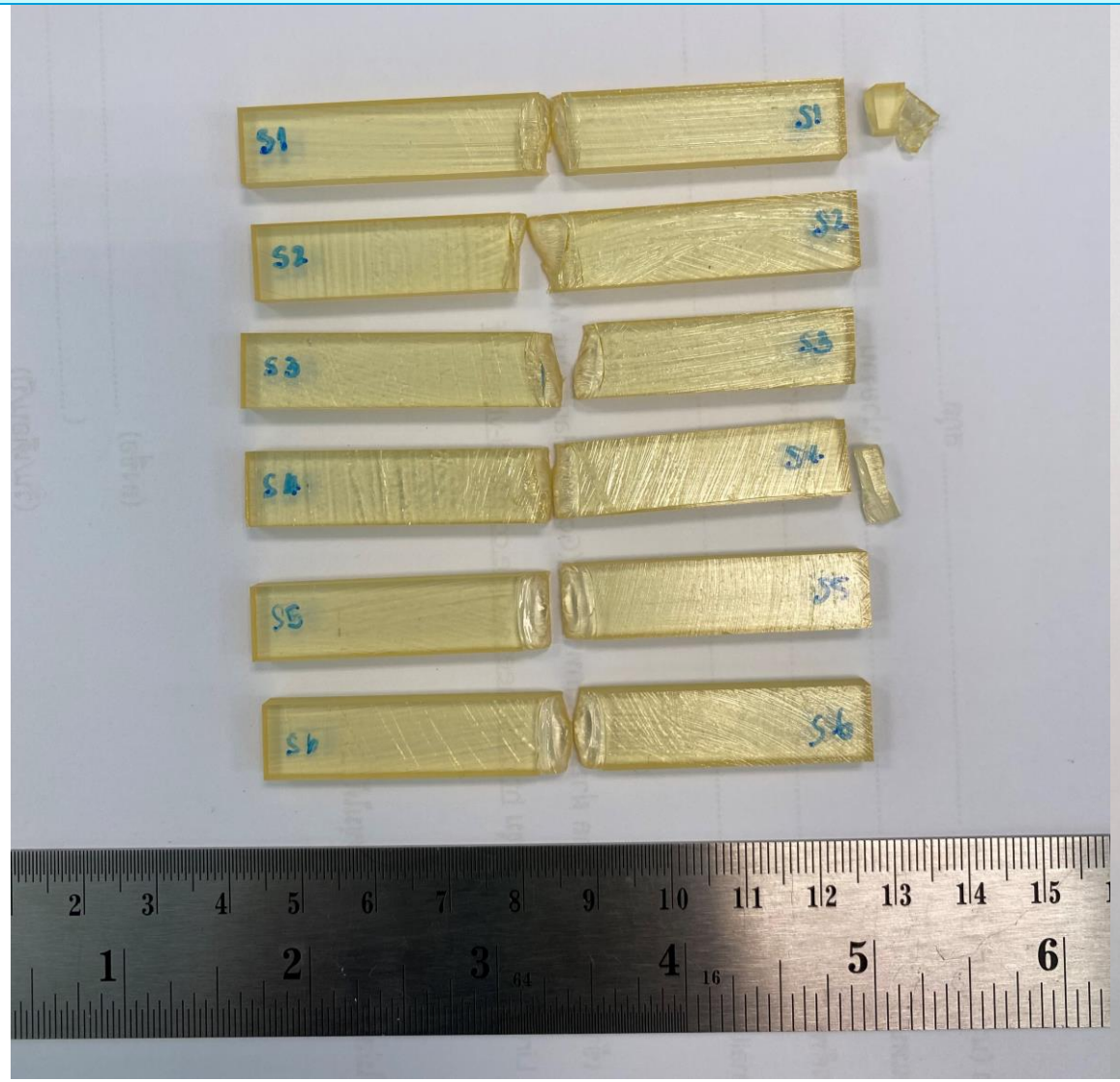
E-modulus	MPa	2,700 - 3,000
Flexural strength	MPa	130 - 150
Flexural strain	%	6 - 8
E-modulus	MPa	2,800 - 3,200

* Curing condition: 80°C/ 25 minutes + 140°C/ 4 hrs.

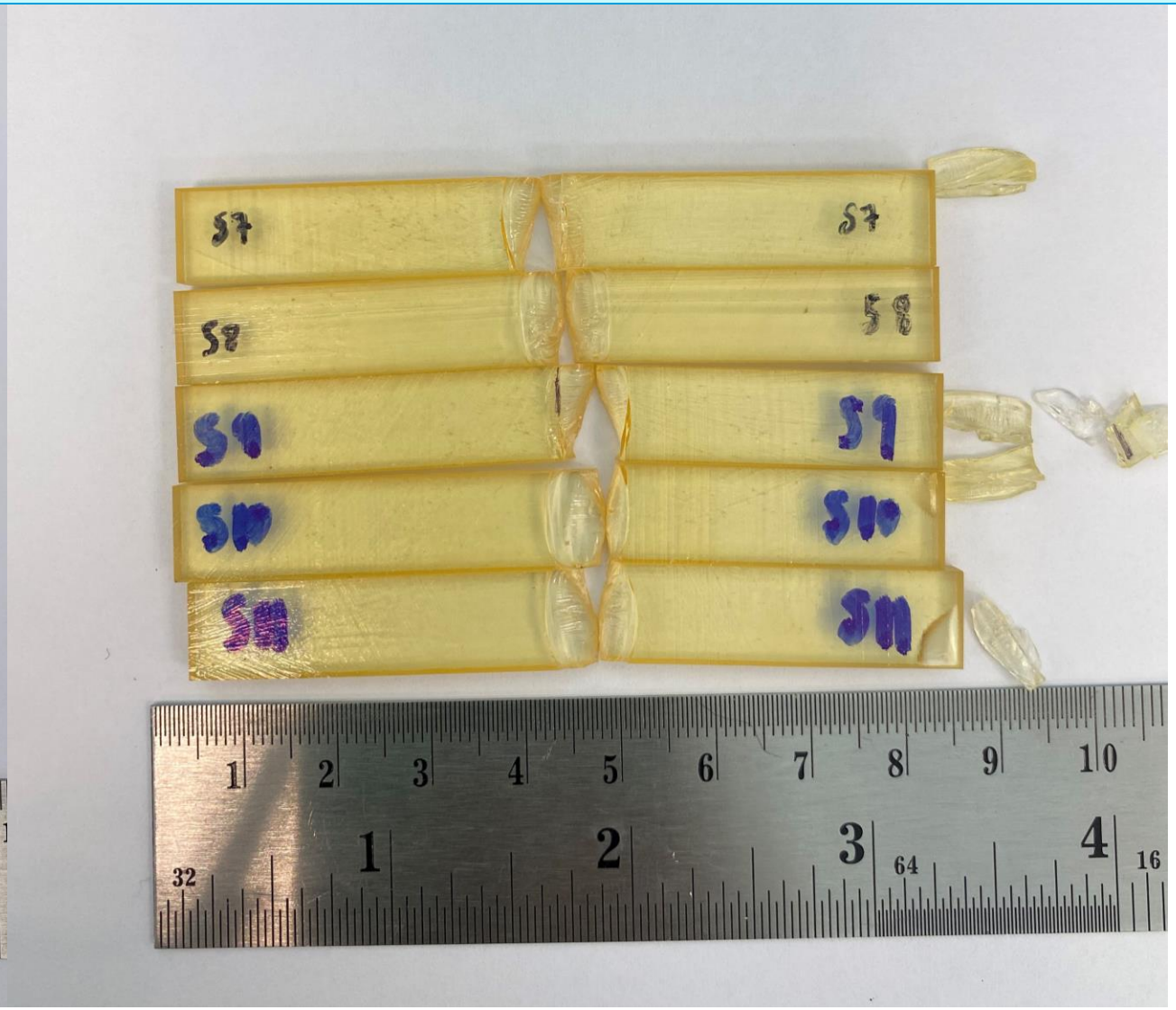
Average Experimental flexural is lightly lower than data provided by Aditya Birla

*shear modulus will be determined by FEA

MECHANICAL PROPERTIES OF BIO-EPOXY AND RECYCLABLE BIO-EPOXY WITH MOISTURE ABSORPTION STUDY FOR AEROSPACE APPLICATIONS



No Water Condition



Water Condition

Thank you

- the Faculty of Engineer Academic year 2021, Prince of Songkla University, Thailand.
- Aditya Birla Chemicals (Thailand) (ABCTL) for support bio resin.