

# Durability of Bonded-in BFRP Rods in Irish Timber

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# Two-Phase STSM

Phase 1: Vacuum-Pressure Soaking

Phase 2: Moisture Cycling



# Background

- BRFP as alternative to other materials in bonded-in rods
- Pull-out testing at home institute in ordinary conditions of temperature & relative humidity
- Limited work on durability of bonded-in rods
- NUIG have expertise in durability testing of timber elements

# Phase 1

## 2.5 Weeks - Oct/Nov 2014



Galway Cathedral, Galway, Ireland  
November 2014

# Phase 1: Vacuum-Pressure Soaking



- Submerge in water between 10 and 20 °C ensuring that all end-grain surfaces are exposed to the water
- Vacuum at 700 – 850 kPa for 30 minutes
- Pressurise at 500 – 600 kPa above atmospheric pressure for 2 hours
- Dry for 10-15 hours at 2 m/s up to 3 m/s circulation speed 65-75 °C temperature 8 - 10% and relative humidity



# Phase 1: Vacuum-Pressure Soaking



# Phase 1: Vacuum-Pressure Soaking

Average Failure Strengths:

Ordinary = 50.4kN, Aged = 39.1kN

Variation within Sample Set:

Ordinary = 0.149, Aged = 0.298



# Phase 1: Moisture Cycling

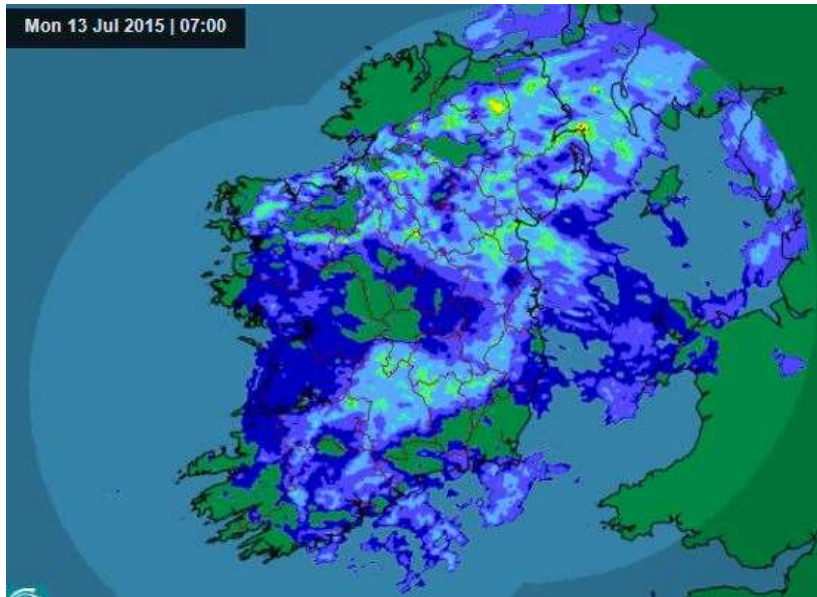


Image: TheJournal.ie

Temperature  
constant at 20°

Minimum RH = 65%

Maximum RH = 90%

One cycle = 8 weeks



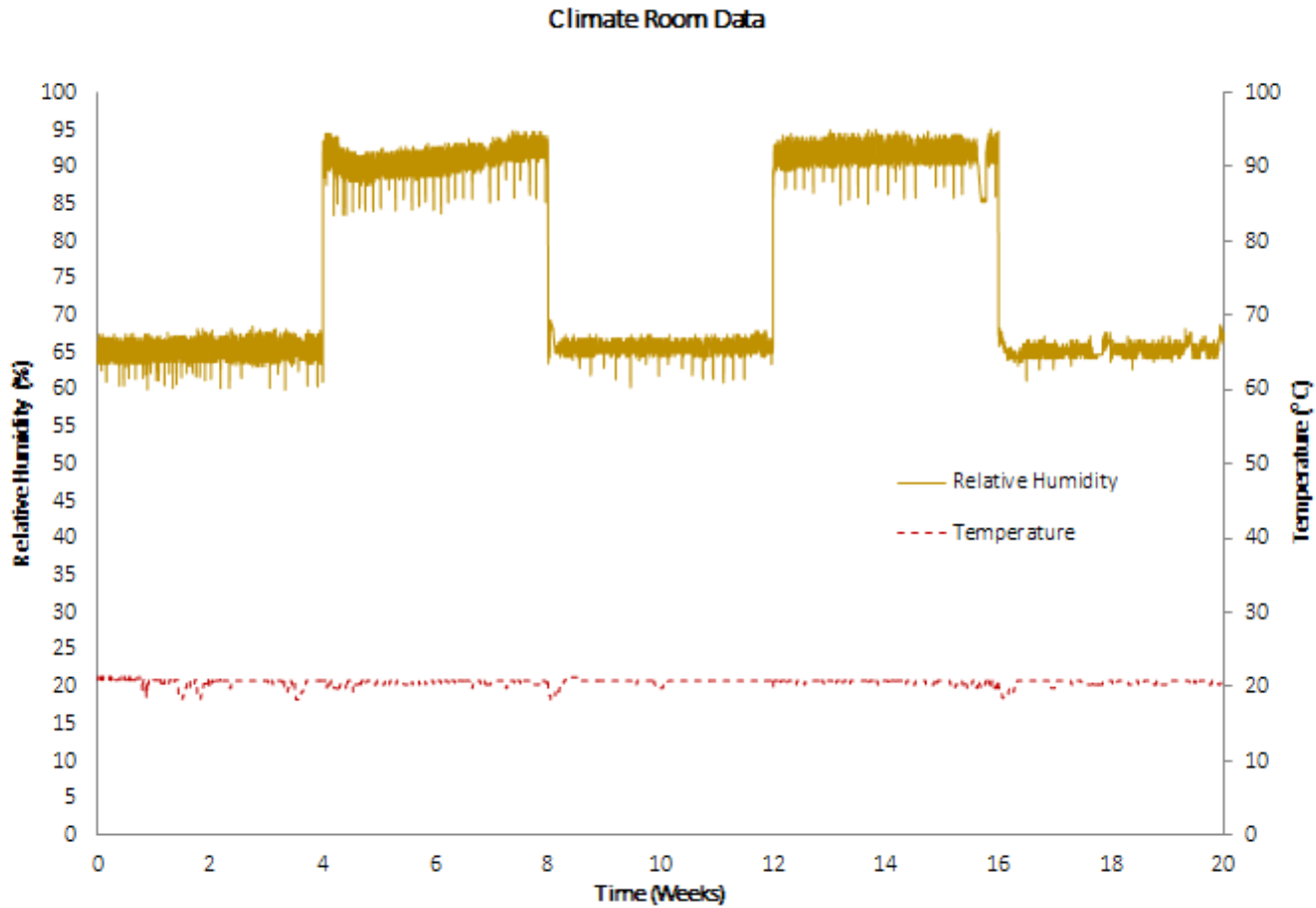
# Phase 2

## 1 Week - August 2015

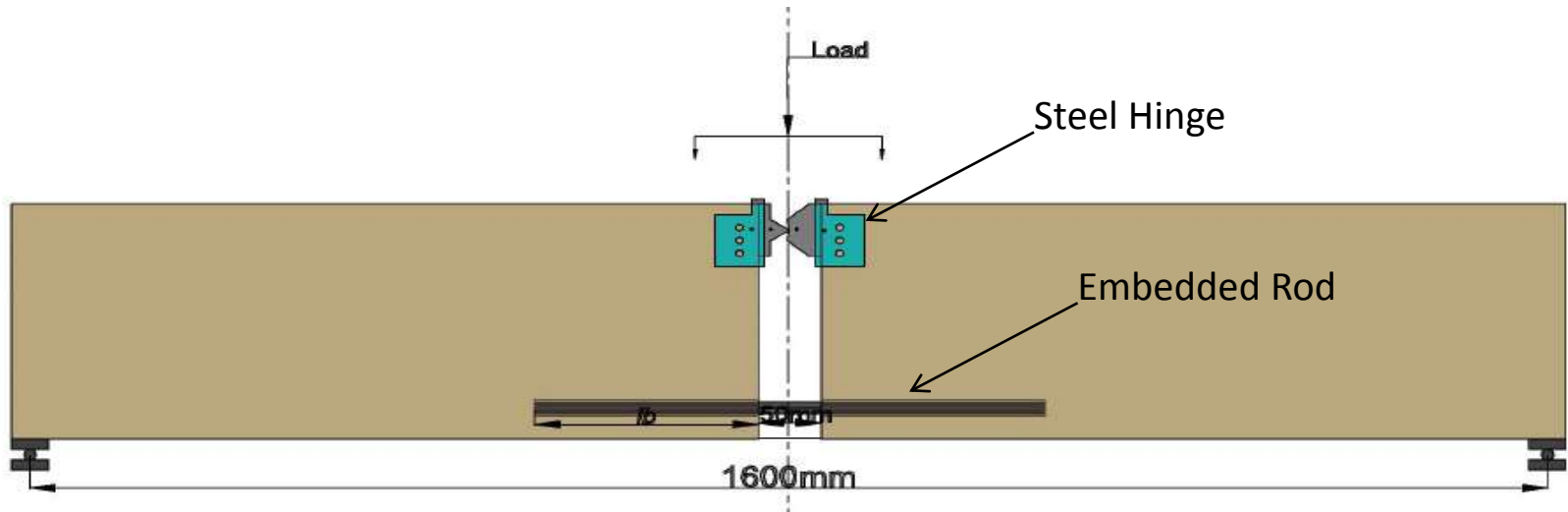


Salthill Promenade, Galway, Ireland  
August 2015

# Phase 2: Moisture Cycling



# Phase 2: Moisture Cycling



Pull-bending test set-up:

- Rod under combined axial and bending loading
- Resistance to loading from bonded-in rod only
- Test method adapted from RILEM 1982 Concrete Beam Test

# Phase 2: Moisture Cycling



Steel plate fixed at mid-span

LVDT mounted horizontally to timber surface

Vertical LVDTs either side of mid-span

# Phase 2: Moisture Cycling

	Un-aged specimens	Aged Specimens
Pull-out with timber plug	8	8
Failure between glue and rod	1	1



Pull-out Failure



Glue/Rod Failure

# Phase 2: Moisture Cycling

Average Failure Strengths:

Ordinary = 75.44kN, Aged = 74.47kN

Variation within Sample Set:

Ordinary = 0.11, Aged = 0.10

# Phase 2: Vacuum-Pressure Soaking

Specimen	Dry weight (g)	Saturated Weight (g)	Saturated Weight (%)	Weight after 20h drying (g)	Weight after 20h drying (%)	Failure load (kN)
P_001	2370	4540	191.56	3370	142.2	30.079
P_002	2245	3285	146.33	2455	109.4	43.566
P_003	2390	3480	145.61	2635	110.3	45.777
P_004	2220	4500	202.70	3290	148.2	42.045
P_005	2155	3025	140.37	2290	106.3	60.429
P_006	2075	3225	155.42	2450	118.1	47.833
P_007	2010	3410	169.65	2390	118.9	22.51
P_008	1955	3390	173.40	2455	125.6	23.04
P_009	2055	3325	161.80	2340	113.9	36.61

# Phase 2: Vacuum-Pressure Soaking

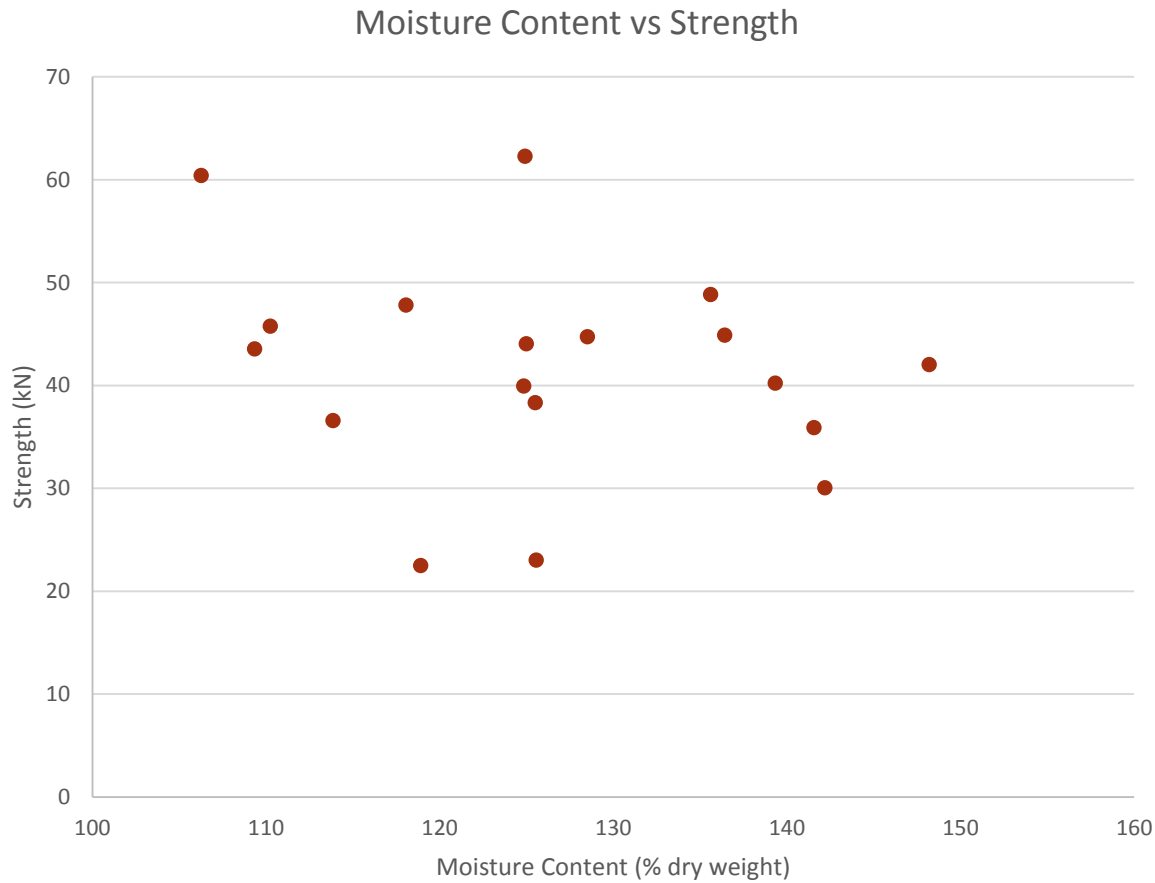
Specimen	Dry weight (g)	Saturated Weight (g)	Saturated Weight (%)	Weight after drying (g)	Weight after drying (%)	Failure load (kN)
20_01	2336.7	4018.9	171.99	3308.1	141.6	35.92
20_02	2449.5	4027.1	164.40	3341.6	136.4	44.92
20_03	2557.5	4178.6	163.39	3468.2	135.6	48.85
20_04	2363.8	3966.4	167.80	3293.8	139.3	40.25
20_05	2231.2	3639.4	163.11	2787.3	124.9	62.30
20_06	2352.0	3814.5	162.18	2940.0	125.0	44.08
20_07	2385.0	3995.3	167.52	3065.1	128.5	44.77
20_08	2530.0	4033.4	159.42	3158.7	124.8	39.96
20_09	2495.5	4077.7	163.40	3132.4	125.5	38.34

Specimens dried to 135-140% of dry weight: Average strength = 42.49kN

Specimens dried to 120-125% of dry weight: Average strength = 45.89kN



# Phase 2: Vacuum-Pressure Soaking



Phase 1:  
Average = 39.10kN  
CoV = 0.298

Phase 2:  
Average = 44.38kN  
CoV = 0.166

# Phase 2: Vacuum-Pressure Soaking



# Acknowledgements

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For more information...



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