

# Structural Effects of Moisture Ingression of Aramid Core Composites



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## Background

This project examines the impact of moisture on honeycomb sandwich composites used in aircraft. Moisture can enter through defects or diffusion, causing issues like disbonding, increased weight, core degradation, and disrupted control surfaces. Standard maintenance may involve drying and subsequent repairs or replacement. We aim to simulate aircraft conditions and test the structural effects of moisture and repairs.

### Honeycomb Sandwich Test Panels

- > Composed of a honeycomb core, two composite facesheets, and an adhesive that bonds the facesheets to the top and bottom sides of the core
- > The core was composed of aramid, a composite paper coated in phenolic resin
- > The core had  $\frac{1}{8}$  inch cell sizes
- > Fiberglass facesheets were utilized to see the core cells

## Design Methodology

- > Research on similar projects was first conducted. Two methods for getting water into the core were tested based on our findings, and "The Drilling Method" was chosen to move forward with.
- > However, this method also proved to be a challenge. First, the coupons were cut into 4" x 4" squares to be drilled using CNC milling machines, after which they were cut into 2" x 2" coupons.
- > Once drilled and cut to size, the coupons were filled with water using a vacuum pump, measuring the amount absorbed via dimensional analysis.
- > The coupons were filled either to 50% or 100% of their volume, and were allowed to soak for 1, 14, and 30 days.
- > Some coupons were dried to simulate repair conditions. Other coupons were tested with standing water still in them in the case they were not repaired. A select few were frozen to simulate flight conditions.
- > Coupons were then tested using uniaxial compression to evaluate changes in structural properties.

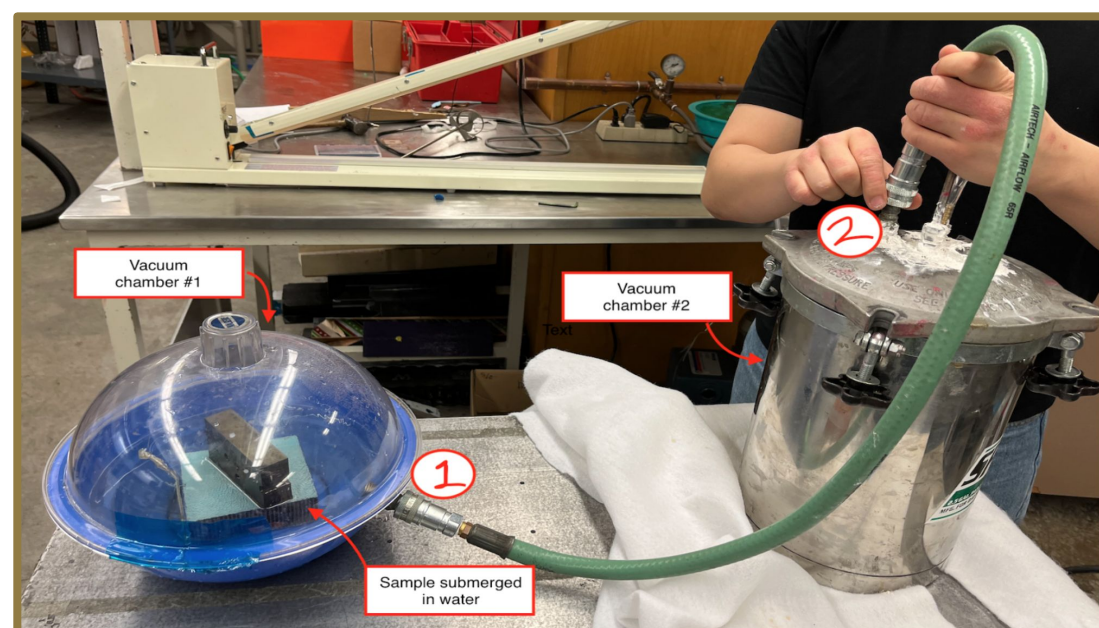


Fig.1 Water Intrusion method

## Manufacturing and Testing

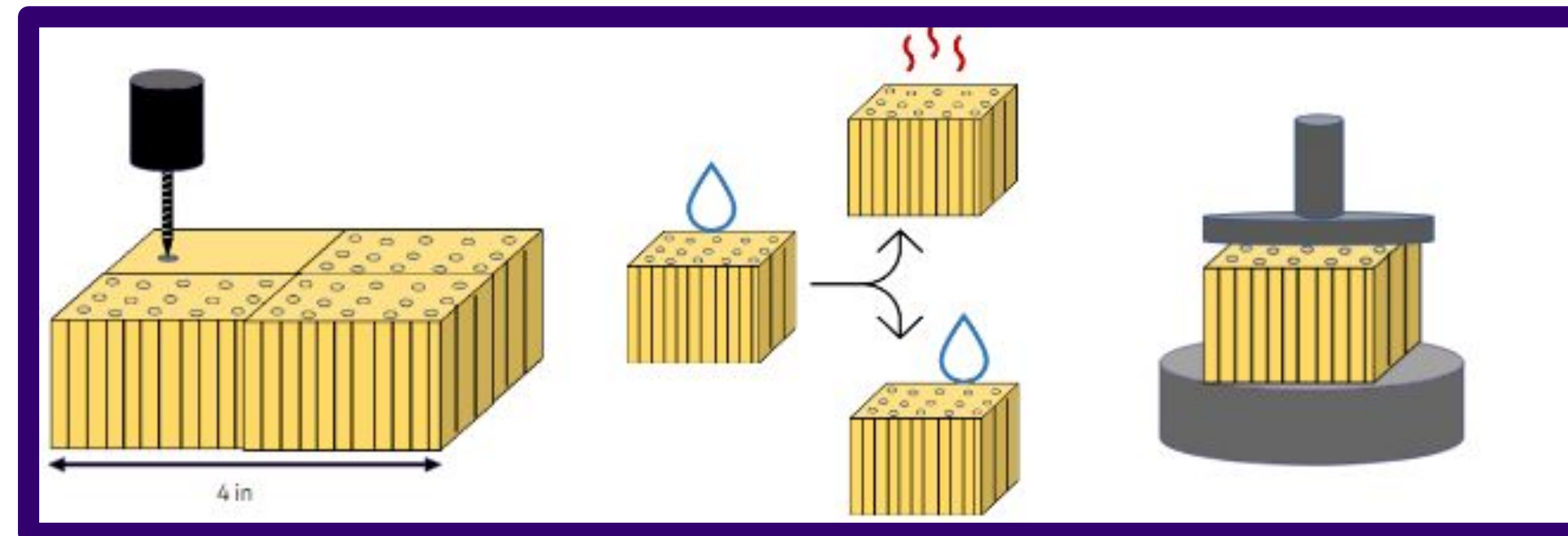


Fig.2. Overview of Design Method

## Elastic Modulus

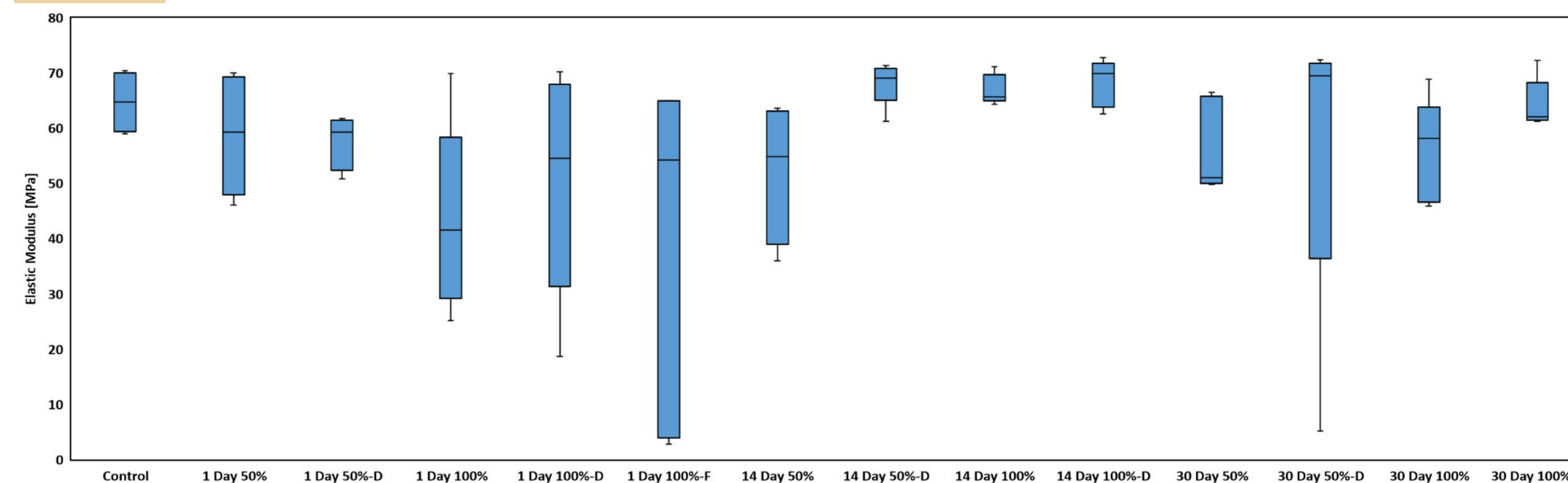


Fig.3. Box and Whisker Plot of the Elastic Modulus of Samples

## Compressive Strength

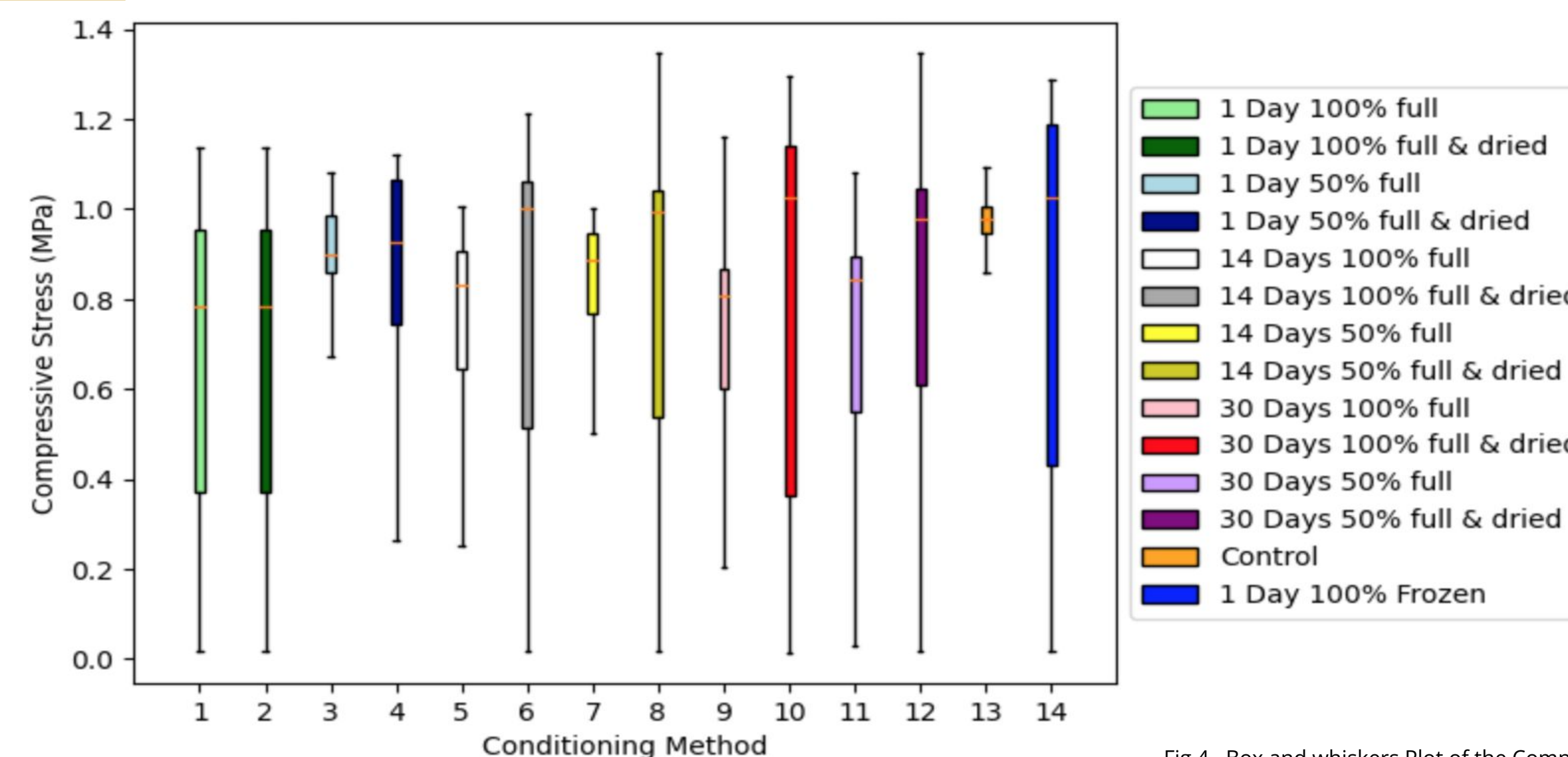


Fig.4. Box and whiskers Plot of the Compressive Stress (MPa) of the samples

## Results

- > There were no discernable differences between 50% and 100% filled samples when comparing the conditioning method
- > The elastic moduli of wet samples were found to be lower than those of the dried samples. However, soaking the samples for different durations (1, 14, and 30 days) did not result in any significant variations in the elastic modulus.
- > Wet samples had lower elastic moduli and compressive strength but subsequent drying prior to mechanical testing restored their elastic moduli and max compressive stress, albeit with greater variability than the control.
- > The frozen samples yielded inconclusive data due to the fact that freezing the filled samples caused them to bulge, creating an uneven contact surface with the compression fixture

## Discussion

- > The coupons showed variety in elastic modulus and compressive strength, but were not detrimental.
- > The frozen condition caused bulging in the facesheets, which created an uneven surface. This created issues in mechanical testing. We recommend only partially filling samples to help combat this.
- > Water is known to plasticize the matrix of adhesives, therefore it is recommended to investigate the effect of water on the adhesive in honeycomb sandwich panels.
- > Panels composed of aramid core with larger cell sizes is recommended, as this would ease drilling and our alternative room temperature adhesive method could be used.
- > Cyclic testing of temperatures is recommended to represent the ground air ground (GAG) cycle that an airplane experiences

## Conclusions

- > The experimental data shows that wet honeycomb aramid core can regain its strength once fully dried.
- > The effect of varying levels of standing water is not immediately apparent, both tested water levels seem to have equally weakening effects on the honeycomb structure.
- > It is recommended that further testing be conducted to understand the effects of the freeze thaw cycle.

## Acknowledgements

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