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Adhesive Lap Test - July 7, 2017 - Acuren

Acuren Group Inc. conducted tensile and lap shear testing on fiber glass reinforced plastic (FRP) specimens provided by Just Biofiber Structural Solutions Corp. The testing followed ASTM D638 and ASTM D3163 standards to evaluate tensile strength, modulus, elongation, and lap shear strength across different material formulations and adhesive layer thicknesses.

The test results provide valuable insights for optimizing FRP formulations and adhesive bonding techniques. PG 1200H-30 appears most promising for high-stress applications, while adjustments to adhesive thickness can enhance joint performance.

ASTM C432-09a Noise Reduction - November 9, 2018 - MEANU

Sound absorption measurements were conducted at the request of JUST BIOFIBER STRUCTURAL SOLUTIONS CORP. of Calgary, AB, for their hemp-block wall. Testing was conducted in the small reverberation chamber (227 m3) at the Mechanical Engineering Acoustics and Noise Unit (the “MEANU”) of the University of Alberta in Edmonton, Alberta, Canada. These measurements were conducted in accordance with ASTM C423-08 “Standard Test Method for Sound Absorption And Sound Absorption Coefficients By The Reverberation Room Method”.
A rectangular specimen comprised of blocks was laid on the test chamber floor; the overall dimensions of the completed test specimen were 2483mm (97.8in) by 2730mm (107.5in). The overall specimen was laid out using a “running bond” pattern with mortar applied per standard practice. The entire perimeter of the specimen was enclosed with starter-strip and wood 1x4, with all gaps in this surround covered with common duct tape. For the first test the hemp-block specimen was left in its “factory condition” (face of blocks provided with scratch coat); for the second test the entire face of the specimen was equipped with a layer of plaster coat (20mm [3/4in] thick). (A more detailed description of the two test configurations is given in the body of this Report.)

The Noise Reduction Coefficient (“NRC”), Sound Absorption Average (“SAA”) and octave-band sound absorption coefficients are summarized in the following table.

	SOUND ABSORPTION COEFFICIENTS							
Frequency (Hz)	125	250	500	1000	2000	4000	**NRC**	**SAA**
Hemp Block with scratch-coat	**0.72**	**0.59**	**0.57**	**0.56**	**0.42**	**0.35**	**0.55**	**0.53**
Hemp Block with plaster-coat	**0.11**	**0.13**	**0.11**	**0.07**	**0.05**	**0.03**	**0.10**	**0.09**

ASTM C1046 & C1155 In-Situ R-Value - Sept 14, 2018 - SMT Research

South and north walls were characterized using the TEM Kit, which measures both the temperature and heat flux of the interior and exterior walls. Different criteria, such as time of day and temperature differential were considered and used to assess the thermal performance of the walls. For this assessment, the most reliable data was observed at night and between temperature differences of approximately 5-10°C. Below is the data summary of the thermal resistance evaluated at specific criteria.

Summary of Overall Dynamic Thermal Resistance		
	North Side	**South Side**
Full Test	19.49	20.61
Night Time	40.15	25.33
Day Time	1.13	5.60
Δ5<ΔT<Δ10	41.00	25.37

ASTM C1363 Thermal Performance - Exova

The wall configuration tested in accordance with ASTM C1363-11, achieved the following thermal resistance value:

Table 3 – Summarized Thermal Resistance Results in Accordance with ASTM C1363-11

Exova Specimen No.	Specimen Description	SI Units		British Units	
17-06-M0123	Super SSR Modular Block	3.76	K.m²/W	21.36	°F.ft².h/Btu

ASTM E72-15 (Section 9, 11, 14) Structural - July 26, 2018 - Intertek R0

The test results for the Hemp Shiv (Hurd) Block Wall System are shown in Table 1 below. A copy of the data sheets can be found in the Appendices.

Table 1. Test Results

Description	Sample	Result	Average
Compressive Load	1	100,000 lbs	**95667 lbs**
	2	95,000 lbs	
	3	92,000 lbs	
Transverse Load	1	108.2 psf	**139.6 lbs**
	2	163.9 psf	
	3	146.7 psf	
Racking Shear Load	1	15048 lbs	**14762 lbs**
	2	15493 lbs	
	3	13746 lbs	

ASTM E72-15 (Section 11) Transverse - October 19, 2018 - Intertek R0

The Just Biofiber Structural Solutions Corp. modular block wall system identified and evaluated in this report has been evaluated per the selected sections of the following: ASTM E72-15, Standard Test Methods of Conducting Strength Tests of Panels for Building Construction

- Section 11 – Transverse Load – Specimen Horizontal

As there is no pass/fail criteria, only the product test results are presented in Section 2 of the full report.

ASTM E90-09 Sound Transmission - November 27, 2018 - MEANU

The Sound Transmission Class (STC) ratings determined for this system were :

TEST #	DESCRIPTION STC	Rating
18-03-A1	Hemp Block Wall (scratch-coat only)	STC-32
18-03-A2	Hemp Block Wall (with plaster, both sides)	STC-42

ASTM E2357-17 Air Leakage - September 14, 2018 - Intertek

Intertek has completed testing on a modular block wall system which was submitted and installed at our lab through Just BioFiber Structural Solutions Corp. Testing was performed in accordance with ASTM E2357-17, “Standard Test Method of Determining Air Leakage of Air Barrier Assemblies”.

For each loading stage of the air pressure conditioning for geographical areas where pressure design value is Q10 > 0.20 kPa, there was observed to be no sign of fracture, delamination, loosening of fasteners or deleterious effects.

ASTM S101 2h Fire - June 26, 2018 - Intertek R1

The load bearing symmetrical Hemp Shiv (Hurd) block wall assembly was tested as described in section 6 of this report in accordance with CAN/ULC 101-14 – Standard Methods of Fire Endurance Tests of Building Construction and Materials
Result: The tested wall assembly met the conditions of acceptance as per section 7 of CAN/ULC 101-14
– Standard Methods of Fire Endurance Tests of Building Construction and Materials
FIRE RESISTANCE RATING 120 min.

ASTM S102 Flame Spread - June 25, 2018 - Intertek

The samples of Hemp Shiv (Hurd) Block, submitted by Just BioFiber Structural Solutions Corp., exhibited the following flame spread characteristics when tested in accordance CAN/ULC S102-10, Standard Method of Test for Surface Burning Characteristics of Building Materials and Assemblies.
A series of three test runs of material was conducted to conform to the requirements of the National Building Code of Canada.

Sample Material	Flame Spread Rating	Smoke Developed Classification
Hemp Shiv (Hurd) Block	0	0

ASTM S135 Combustibility - March 6, 2017 - Exova

The hemp lime insulation material identified in this report, when tested at an approximate thickness of 55 mm, meets the Total Heat Release requirement outlined in Article 3.1.5.1 of the National Building Code. The material affords a Total Heat Release average of 1.0 MJ/m2 and a Total Smoke Extinction Area average of 0.2 m2, when tested according to CAN/ULC-S135 at an imposed heat flux of 50 kW/m2.

EN 772-22 Freeze-Thaw Resistance - May 22, 2019 - Lucideon

After 100 freeze thaw cycles the panel was inspected and a large surface crack had formed on the face of the panel. It was also noted that a small amount of surface material had come away from the face of the panel during testing.
From the test carried out damage greater than type 3 (see Table 1) was observed after 100 freeze-thaw cycles and therefore the units would be classified as being F1 i.e. suitable for use in conditions of moderate exposure, if clay bricks had been tested.

FEA Compressive & Shear Strength - May 24, 2017 - ENA2

As part of the FEA analysis, 125 mph wind pressure were applied to JBF Frame struts with scaled value without hemp area, however JBF's frames were scaled the wind force to get same magnitude of wind pressure on the struts.

In Frame Analysis, the bottom face of the first (lowest) frame and the top face of the uppermost frame assumed fixed connection. The glue strength was not added to the FEA analysis which mean the results are conservative. All JBF frames modeled as bonded together.

In Building Analysis, again, the bottom face of the first (lowest) frame assumed as fixed connection, however top connection modeled as free to rotate and translate with wind direction.

All results could be reviewed from the table which was added as part of this document. The results indicate that the average values are below the material's estimated yield values, except JBF-Residential Frame at 30'-00", however JBF Residential frame will not be used for over 24'-00" free wall.

	Wall Height	Compressive Strength (Mpa)	Shear Modulus (Mpa)	Equivalent Stress (Mpa)	Equivalent Elastic Strain (mm/mm)	Total Deformation (mm)	Shear Stress (Mpa)
JBF-HD Frame- Heavy Commercial Structure	20'-00"	131	318	11.95	0.0010	8.45	4.65
	30'-00"			26.48	0.0019	31.62	5.58
	40'-00"			41.51	0.0033	76.53	9.23
JBF-Standard Frame- Light Commercial & Residential Structures	20'-00"	140	318	13.71	0.0011	8.36	3.07
	30'-00"			28.48	0.0020	31.62	5.58
	40'-00"			40.59	0.0033	76.54	9.23
JBF - Residential Frame	20'-00"	140	318	53.79	0.0056	10.98	24.91
	30'-00"			158.58	0.0147	40.86	55.57
	40'-00"			N/A	N/A	N/A	N/A

FEA Ductility & Seismic - June 7, 2019 - ENA2

ENA2 Innovative consulting Inc., was contracted by JustBioBiber Structural Solutions Corp, to perform Cyclic loading FEA analysis in accordance with of ASTM E2126 -11: Standard Test Methods for Cyclic (Reversed) Load Test for Shear Resistance of Vertical Elements of the Lateral Force Resisting Systems for Buildings. The purpose of this study is to find JBF block's Ductility Ratio.

Two test reports as per ASTM E72-15, were supplied to ENA2. These reports are INTERTEK Test Report and MecSIM FEA reports which both used JBF blocks without post-tension bar. Both reports also proofed that the Hempcrete blocks have little contribution to the load and stiffness of the wall system.

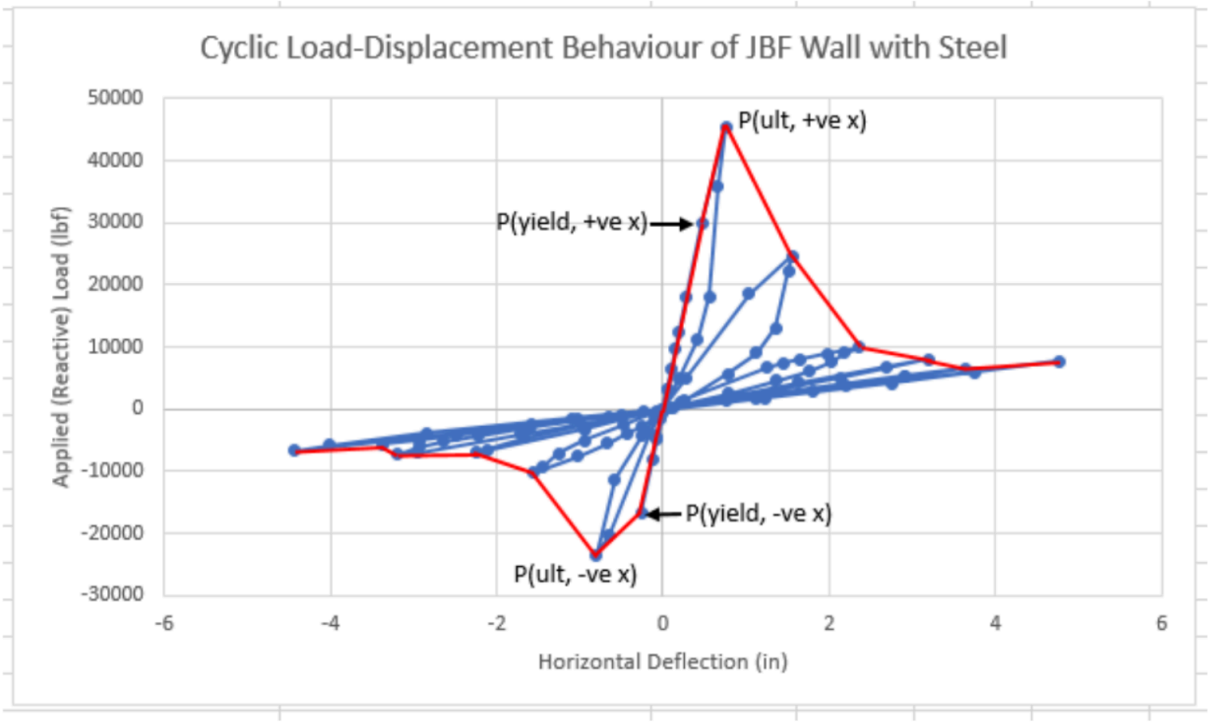


Figure 12. Load – deflection graph.

FEA Simulation - November 2018 - MecSim Part 1 R1

1. The system exhibits brittle behavior. This has a major effect on the development of the design equations to be developed latter in this project.
2. The assemblage investigation using two blocks revealed that the Hempcrete blocks have a minor effect on the load bearing of the system and was therefore neglected in further modeling.
3. Under bending the glue has a determinable effect on the behavior of the panel.
4. The behaviour of the wall under bending was replicated when the glue strength was

incorporated in the model. It is hypothesized that the fracture of the FRP components observed in the bending tests occurred after some local failure in the glued areas which would have created some concentrated loads in the system.

5. The behaviour of the wall under compression was replicated in terms of the maximum load and initial stiffness. A decrease in the stiffness was observed in the experiments that was not captured by the current model.

6. The behaviour of the wall under shear was replicated in terms of the maximum load and initial stiffness.

7. The flexural-axial load behaviour of the hempcrete resembles that of reinforced concrete block masonry, but the shear strength of masonry panels is significantly higher than the hempcrete walls.

8. It is important to note that the flexural-axial load capacity of the masonry was attained with significant ductility and large deformations, while the response of the hempcrete block was linear until failure (brittle).

FEA Strip Wall & Building - January 29, 2018 - ENA2

All these ANSYS and SAP2000 FEA results demonstrated that JBF Composite Frame (Struts and base assembly) is suitable for compressive and tensile type of forces for every type of building structures.

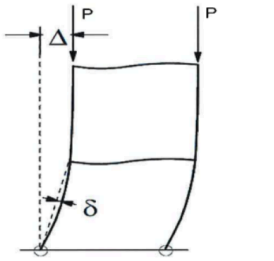
In plane and out of plane shear strength and stiffness are also good to withstand against lateral loads which are wind and Seismic forces. However, over 125 mph wind forces demonstrated that our wall system need some reinforcements. Without this reinforcement system, JBF wall create extremely high deflections which cause structure to be failed.

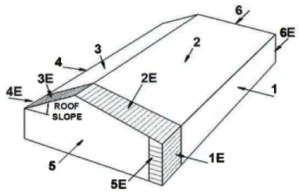
Because we define whole structure boundary conditions easily in SAP2000 software, we obtained most reasonable results.

California seismic data used for the building system, and results are way better than we were expected. Again, if we solve proper post tensioning system for JBF wall system, we can easily model and build structures.

FEA Wind - April 28, 2018 - ENA2

		Wall # 1	Wall # 2 - 3	Wall # 4	Story Drift - Δ	Servicability - Δ	Member - δ	Servicability - δ
8'-0" x 50'-0" Wall (Fixed)	250 mph	86 (psf) 4.11 (kPa)	129 (psf) 6.18 (kPa)	70 (psf) 3.35 (kPa)	139 mm	FAIL	708 mm	FAIL
	125 mph	22 (psf) 1.05 (kPa)	32 (psf) 1.53 (kPa)	18 (psf) 0.86 (kPa)	35 mm	OK	173 mm	FAIL
8'-0" x 50'-0" Wall (Pinned)	250 mph	86 (psf) 4.11 (kPa)	129 (psf) 6.18 (kPa)	70 (psf) 3.35 (kPa)	152 mm	FAIL	1149 mm	FAIL
	125 mph	22 (psf) 1.05 (kPa)	32 (psf) 1.53 (kPa)	18 (psf) 0.86 (kPa)	38 mm	OK	256 mm	FAIL
8'-0" x 40'-0" Wall (Fixed)	250 mph	82 (psf) 3.92 (kPa)	124 (psf) 5.94 (kPa)	67 (psf) 3.20 (kPa)	109 mm	FAIL	289 mm	FAIL
	125 mph	21 (psf) 1.0 (kPa)	31 (psf) 1.48 (kPa)	17 (psf) 0.81 (kPa)	27 mm	OK	79 mm	FAIL
8'-0" x 40'-0" Wall (Pinned)	250 mph	82 (psf) 3.92 (kPa)	124 (psf) 5.94 (kPa)	67 (psf) 3.20 (kPa)	128 mm	FAIL	483 mm	FAIL
	125 mph	21 (psf) 1.0 (kPa)	31 (psf) 1.48 (kPa)	17 (psf) 0.81 (kPa)	32 mm	OK	129 mm	FAIL
8'-0" x 30'-0" Wall (Fixed)	250 mph	78 (psf) 3.73 (kPa)	117 (psf) 5.6 (kPa)	63 (psf) 3.0 (kPa)	65 mm	FAIL	85 mm	FAIL
	125 mph	20 (psf) 0.95 (kPa)	30 (psf) 1.44 (kPa)	16 (psf) 0.77 (kPa)	16 mm	OK	22 mm	OK
8'-0" x 30'-0" Wall (Pinned)	250 mph	78 (psf) 3.73 (kPa)	117 (psf) 5.6 (kPa)	63 (psf) 3.0 (kPa)	85 mm	FAIL	151 mm	FAIL
	125 mph	20 (psf) 0.95 (kPa)	30 (psf) 1.44 (kPa)	16 (psf) 0.77 (kPa)	21 mm	OK	45 mm	OK
8'-0" x 20'-0" Wall (Fixed)	250 mph	72 (psf) 3.45 (kPa)	107 (psf) 5.12 (kPa)	58 (psf) 2.78 (kPa)	20 mm	OK	15 mm	OK
	125 mph	18 (psf) 0.86 (kPa)	27 (psf) 1.29 (kPa)	15 (psf) 0.72 (kPa)	5 mm	OK	4 mm	OK
8'-0" x 20'-0" Wall (Pinned)	250 mph	72 (psf) 3.45 (kPa)	107 (psf) 5.12 (kPa)	58 (psf) 2.78 (kPa)	40 mm	OK	38 mm	OK
	125 mph	18 (psf) 0.86 (kPa)	27 (psf) 1.29 (kPa)	15 (psf) 0.72 (kPa)	10 mm	OK	9 mm	OK



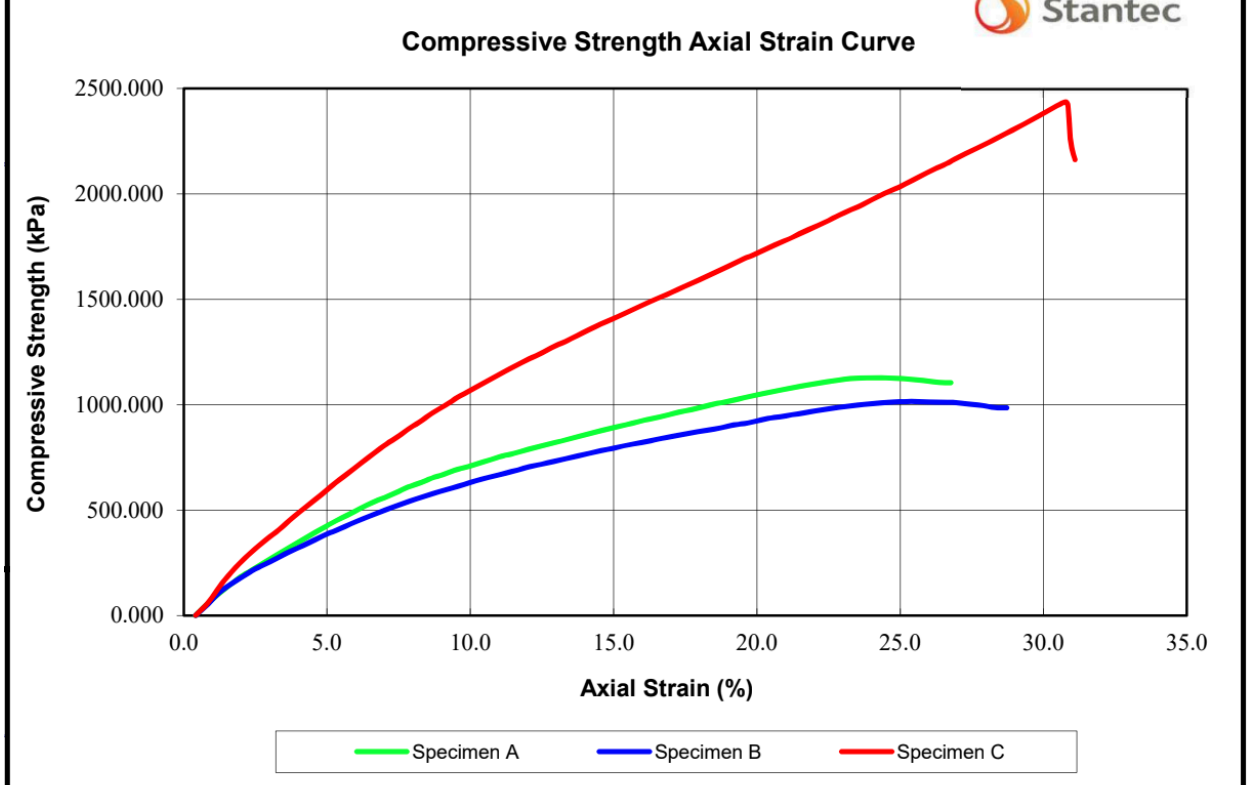


WIND PRESSURE SIDES

* FOR COMPRESSION & TENSION ALL THE VALUES HAVE PASSED THE ALLOWABLE LIMITS
* DEFLECTION VALUES WERE WRITTEN ON THE TABLE ABOVE
* EXCEPT 50'-0" HIGH WALL, REST OF THE WALL'S STRESS, STARIN AND SHEAR VALUES ARE BELOW THE ALLOWABLE LIMITS (WITH PROPER POST-TENSIONING WORK)
* IF WE USE PROPER POST-TENSIONING SYSTEM AT THE CERTAIN DISTANCES (FROM FOUNDATION TO TOP OF THE WALL), WE WILL BE ABLE TO USE JBF WALL SYSTEM AT 250 MPH WIND SPEED

Hemp-Lime Compression Strength - September 2017 - Stantec

Stantec Consulting Ltd.
Compressive Strength Report



Before Test	Specimen A	Specimen B	Specimen C	
Water Content (%)	-	-	-	
Dry Density (g/cm3)	0.354	0.372	0.425	
Saturation (%)	-	-	-	
Void Ratio	-	-	-	
Diameter (mm)	151.3	151.8	151.5	
Height (mm)	283.3	280.3	280.6	
Test Data	**A**	**B**	**C**	
Compressive Strength (MPa)	1.13	1.01	2.44	

Hygrothermal Performance Assessment - November 2016 - JSS

Under the applied assumptions, boundary conditions, and input data, the hygrothermal performance assessment for the Super SSR Modular Block Wall System comes to the conclusion that this system works without any additional vapor retarder. Furthermore, the following recommendation regarding sensitive input data should be followed:

- For location with high driving rain loads, the water absorption coefficient of the exterior plaster +paint according to (ASTM C1794) should stay below 1.410-6 lb/(in2 s) (0.001 kg/(m2s)). If this cannot be guaranteed, a solar absorptivity of the exterior paint of at least 0.5 is required.
- For cold climate zones, the water vapor permeance of the exterior plaster + paint should be higher than 3.5 perm (sd value lower than 0.93 m).

Hygrothermal Report - August 2016 - BCIT

Density:

The measured dry density of HempLime is 360 ± 24 kg/m3. It is determined from physical dimensions and oven dry mass measurements of nine specimens.

Thermal Conductivity:

The thermal conductivity of HempLime is carried out according to ASTM Standard C518: “Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus“ using four - 30 cm X 30 cm specimens. The measurements are done at a temperature difference of 20o C and a mean temperature of 24o C. Table 1 shows the average thermal conductivity and resistance values of the four HempLime specimens. To help establish the measurements ranges, the difference between the maximum and the minimum measured values are also presented in the table.

Table 1. Thermal conductivity of HempLime specimens

Specimen Thickness mm	Mean temperature °C	Hot Plate Temperature °C	Cold Plate Temperature °C	Thermal Conductivity W/(m·K)	Thermal Resistance m²·K/W
53.87 ± 1.89	24.00 ± 0.03	34.00 ± 0.03	14.00 ± 0.02	0.084 ± 0.004	0.640 ± 0.031

Heat Capacity:

The heat capacity of HempLime is determined using a LaseComp Fox heat flow meter and WinTherm32 software for analysis and determination of transient heat transfer through the specimens.

Based on four samples measurements, the average volumetric and specific heat capacities of HempLime are:

Volumetric heat capacity: 426,706 ± 21 J/(m3·K)

Specific Heat Capacity: 1185 ± 21 J/(kg·K)

Sorption Isotherm:

The equilibrium moisture contents of HempLime at 30%, 50%, 70%, 80%, 90% and 95% relative humidity are determined according to ASTM Standard C1498: “Standard Test Method for Hygroscopic Sorption Isotherms of Building Materials”. For each test point, three specimens with dimensions of 51 mm X 51 mm are used. The measurements are carried out in controlled climatic chambers that are maintained at a constant temperature of 23o C and the desired relative humidity set point. A water immersion test is used to determine the capillary saturation moisture contents of the samples. Table 2 shows the measured equilibrium moisture contents of HempLime specimens at different relative humidities.

Table 2. Equilibrium moisture contents of HempLime

RH, %	Moisture Content, kg/m^3
30	12.44 ± 0.44
50	18.06 ± 0.68
70	27.18 ± 1.76
80	37.07 ± 1.43
90	52.54 ± 2.34
95	77.72 ± 19.72
100	591.17 ± 17.91

Water Vapor Permeability:

The water vapor permeability of HempLime is determined according to ASTM Standard E-96: “Standard Test Methods for Water Vapor Transmission of Materials”. Using climatic chambers, wet cups and dry cups, the water vapor transmission rates of HempLime are determined. The climatic chambers are set at 50%, 70% and 90% relative humidity and 23o C temperature. The dry (0%) and wet (100%) relative humidity conditions in the test caps are provided by CaCl2 descant and distilled water, respectively. For each test, three circular specimens of 12.37 cm in diameter are used as replica. The average water vapor permeability values of HempLime at different mean sample relative humidities are shown in Table 3.

Table 3: Vapor permeability of HempLime at different relative humidities

Sample Mean RH (%)	Chamber RH (%)	Cup RH (%)	Permeability kg/(s·m·Pa)
25	50	0	3.0 E-11
35	70	0	3.1 E-11
45	90	0	3.7 E-11
75	50	100	5.3 E-11
85	70	100	6.8 E-11
95	90	100	1.38 E-10

Water Absorption Coefficient:

The water absorption coefficient of HempLime is determined according to ASTM Standard C1794: “Standard Test Methods for Determination of the Water Absorption Coefficient by Partial Immersion”. Three test specimens, 100 mm X 100 mm each, were used for the measurements. Water is maintained at 23±0.5°C. The measured water absorption coefficient of HempLime is 0.0711 ± 0.0004 kg/(m2·s1/2).

Porosity:

The porosity of HempLime samples are obtained by determining the full saturation weight of the samples following the water immersion test procedure and by measuring the suspended weight of the samples in water. The later measurement is used to define the volume of the samples. Based on these measurements of three replica samples, the porosity of HempLime is found to be 68 ± 0.5%.

Joint, Screw and Compression - July 7, 2017 - Acuren

Overview: Acuren Group Inc. conducted 3-point bend, screw, and compression tests on fiber glass reinforced plastic (FRP) components for Just Biofiber Structural Solutions Corp. The testing evaluated joint and body strength across black and green FRP materials, providing insights into material performance under load.

Bend Testing Results:

- **Joint Testing (Black FRP):** Load capacity ranged from 14.6 kN to 23.1 kN, with higher loads indicating better joint strength.
- **Body Testing (Black FRP):** Maximum loads ranged from 9.5 kN to 18.8 kN.
- **Body Testing (Green FRP):** Higher loads were achieved, ranging from 18.5 kN to 24.3 kN, suggesting greater material resilience.

Screw Testing Results:

- **Joint Testing (Green FRP):** Max load: 4.7 kN.
- **Body Testing (Black FRP):** Max load: 1.3 kN.
- **Body Testing (Green FRP):** Loads ranged from 1.7 kN to 2.9 kN, showing modest improvements over black FRP.

Compression Testing Results:

- **Joint Compression:** Load capacity ranged from 23.23 kN to 29.09 kN.
- **Body Compression:** Loads reached up to 44.03 kN, demonstrating high material strength.

Key Findings:

- Green FRP generally outperformed black FRP in body strength and screw retention.
- Compression strength was a standout metric, especially in body tests.
- Joint strength showed variability, emphasizing the need for precise manufacturing controls.

Conclusion: The results highlight the robust performance of FRP materials, especially green formulations, for structural applications. Recommendations include optimizing joint design and exploring alternative fasteners to enhance screw load capacity.

Noise Barrier Review - April 26, 2019 - BKL

The results of the two sound absorption tests for the hemp-block wall without and with plaster-coat, as described above, are given in Figure 5 and 6 (pages 9 & 10). The Noise Reduction Coefficient (NRC) and Sound Absorption Average (SAA) derived for the two test configurations were:

		NRC / SAA
Test 18-03-B1	Sound Absorption of Hemp-Block Wall with Scratch-Coat	0.55 / 0.53
Test 18-03-B2	Sound Absorption of Hemp-Block Wall with Plaster-Coat	0.10 / 0.09

The full reports are available upon request.