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| Tesing facility at BCRC  December 7, 2021 | Overview  The Bronco Construction Research Center (BCRS) is hosted by the Engineering & Applied Sciences College of Western Michigan University. The BCRC contains Structural Testing and Civil Engineering Materials Testing laboratories with a fabrication shop. This is a supplement document shows descriptions and specifications of the testing laboratories. |

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# Structural Testing Laboratory

The Structural Testing Laboratory has a footage area of 3172 ft2 with a concrete firm floor. The laboratory is provided with research testing equipment that can simulate natural hazard effects on buildings represented by seismic and wind loading conditions. The dynamic roofing facility at BCRC is exclusively equipped with one of the unique wind uplift simulators in the US academies. The dynamic wind uplift table (24ft × 12 ft) is intended to evaluate the wind resistance of roof structures under design pressure up to 300 psf. The structural lab is also served by a load frame testing system containing a hydraulic pumping unit and hardline hydraulic system capable of delivering hydraulic fluid at 3,000 psi (21 Mpa) to any of the 6-valve manifold assemblies and two actuators (horizontal and vertical). The sections below list more descriptions and details of the testing facility.

## ***Dynamic Wind Uplift Table***

The Dynamic Wind Uplift Table (DWUT) is primarily designed to execute the standard test method for the dynamic wind uplift resistance of membrane-roofing systems developed under the Canadian Standards Association (CSA A123.21:20) based on wind-tunnel studies of full-scale roof assemblies. The DWUT consists of a bottom frame of adjustable height upon which the roof specimen and a removable top chamber are installed (see Figure 1a). The design allows for installing and evaluating attachment systems for roofing conditions. The bottom frame and top chamber are 7,315 mm (288 in.) long, 3,658 mm (144 in.) wide, and 800 mm (32 in.) high. The top chamber is equipped with six windows for viewing and with a gust simulator, which consists of a flap valve connected to a stepping motor through a timing belt arrangement (see Figure 1b).

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| (a) | (b) |

Figure : Dynamic Wind Uplift Table: (a) Wind chamber and frame; (b) Gust simulator

Pressure suction as high as 14.4 kPa (300 psf) over the roof assembly is produced by a 74.4-kW (100 hp) fan with a flow rate of 5000 L/s (10594.4 ft3 /min). Around all the edges, the DWUT has Snap-on buckles to lock the top chamber together with the bottom frame to form an airtight system. A computer, using feedback signals, controls the operation of the DWUT. The computer regulates the fan speed to maintain the required pressure in the chamber. Operation of the flap valve simulates the wind gusts in the form of uniform cyclic pressure loading over the roofing system’s surface. Closing the flap valve allows pressure to build in the chamber while opening the valve bleeds the pressure. Also, the test facility has instrumentation for measuring the specimen’s responses, including pressure, force, and displacement sensors.

The items of the DWUT are listed below and labeled accordingly to Figure 2:

* Top Chamber, Bottom Frame with 12 by 24 ft in size that structurally strong with four lifting mechanisms for the top chamber to a maximum height of 10 ft from the ground. (Items #1 and #2)
* Fan system (Blower and Inverter) that can simulate a minimum of 300 psf suction (Item #3)
* Gust simulator (Flap and Servo Motor) that can reproduce the CSA A123.21 wind gusts (Item #4)
* Sensors and Data acquisition system necessary to measure the system performance as per CSA A123.21 (Item #5)
* Control system that runs the CSA A123.21 test protocol via executable software (item #6)

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Figure : Overall Layout of hardware and control system of the DWUT

## ***Load Frame Testing System***

The load frame testing system was designed and fabricated to carry the dead and reaction loads of the attached actuators (see Figure 3). Hydraulic power supply with the pipe distribution system is sized for 150 GPM and portal frame rated for 500 kN vertical loading. Facility work includes 162-ton reaction mass. Mounting Swivel Base: rated at ± 35 kips (150 kN) dynamic compression. +50 kip (112 kN) static compression. +90°-80° pivot, ± 17° tilt. Rod End Swivel: rated at ± 35 kips (150 kN) dynamic compression. +50 kip (112 kN) static compression. +90°-80° pivot, ± 17° tilt. High-strength stud kit installed. Servo Valve: Rated at 16.5 GPM at 1000 PSID (70 Bar).

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Figure : Load frame testing: (a) Vertical actuator of 110 kips; (b) steel frames; (c) lateral actuator of 22 kips

**Specifications**

* Lateral Dynamic Hydraulic Linear Actuator:

(22kip/100kN) [Fatigue Rated]

2.75 Inch (69.85 mm) heat treated alloy piston rod

Force ± 22,260lb (99kN) @ 3000 psid (210 bar)

7.42 in2 equal area (47.87 cm2)

Manifold: Integral dual servo valve manifold with Moog 761 series valve pattern.

Load Cell: 25 kips (125 kN) nominal fatigue rating, 300% overload capacity.

Servo Valve: Moog G761-3005 valve rated at 16.5 GPM (62.4 IPM) @1000 psid (70 bar)

Shore Western Model: 912D-7.42-10-4-2348

* Vertical Dynamic Hydraulic Linear Actuator (110 kip/500kN)

Force ± 115,000lb (513 kN) @ 3000 psid (210 bar)

38.48 (in2) equal area (248 cm2)

Stroke: 10 in (254mm) ± 5 in

Mounting: Swivel Base rated at ± 110-kip (500kN) dynamic, + 150 kip (670kN) static compression, +30-90° swivel ± 6° tilt

Rod End: Swivel; Rod End rated at 110-kip (500 kN) dynamic, +150 kip (670 kN) static compression, +30-90° swivel ± 6° tilt

Manifold: Integral dual servo valve manifold with Moog 761 series valve pattern.

Load Cell: 110 kip (500kN) nominal calibrated rating. 300% overload capacity.

Servo Valve: Moog G761-3005 valve rated at 16.5 GPM (62.4 IPM) @1000 psid (70 bar)

Shore Western Model: 914D-38.48-10-4-2348

# Construction Materials Testing Laboratory

Construction Materials Testing laboratory primarily involves testing materials according to ASTM standards or customized small-scale experiments. These include construction materials (e.g., steel, concrete, wood), connections (e.g., mechanical or adhered connections), and highly flexible material (e.g., polymer and rubber -base). The laboratory recently was prepared with standard fixturing and measurement equipment to perform a wide range of ASTM standards on determining mechanical properties of adhesives, including shear strength, tear strength, tensile strength, elongation, and hardness. The Material Testing Laboratory houses two universal test machines, an environmental chamber, and a Stereo Microscope system (see Figure 4).

**Specification**

* 11.25 Kips (50 kN) Admet Model 2613 (eP2 Servo Control)

Tension Testing opening/Compression Testing Opening: 52”

Distances between columns/screws: 16.8”

Table Size:

Electro-Mechanical Unispace Tension and Compression (S/N: 351210A)

Testing Stroke: 46”

Testing Speed: .00002-20 IPM

Crosshead adjusting speed: 20 IPM

Weight: 375 lbs

10K (50 kN) Interface Load Cell S/N: 351210A

* 22 kips (100 kN) Capacity Instron, Model 1331, Two-Column Material Fatigue Testing Load frame

Instron 22 KIP Hydrostatic Bearing Actuator, Model A411-114, 4”

Stroke: 3,000 PSI, LVDT, S/N: 532

* Olympus Model SZS-STS, Stereo Microscope System with Adjustable Stand and Lumenera Software

Olympus SZ2-STS Mounting Arm

Infinity Camera Software (Infinity 1)

.5x Lens model: SZ-LGR66

Eye Piece: WHSZ10X-H/22

* Environmental chamber

capable of generating 100% relative humidity and a temperature range of -35 to +85 degrees C (-31 to 185 degrees F).

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| (a) | (b) | (c) |

Figure : material testing machine: (a) 11.25 kips electrical tension teste; (b) 22 kips hydraulic tension tester; (c) Microscopic

# Fabrication shop

A Fabrication shop of 4417 ft2 is operated with construction tools to build and assemble large-scale specimens of concrete, wood, and composite materials (see Figure 5). The fabrication shop has hanger doors access to the structural laboratory.

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Figure : Fabrication shop