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# CENTER FOR TRANSPORTATION INFRASTRUCTURE AND SAFETY

## **Acquisition of Specialized Testing Equipment for Advanced Cement-Based Materials**

by

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**NUTC  
RE299**

**A National University Transportation Center  
at Missouri University of Science and Technology**

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16. Abstract This equipment purchase will enabled the development, manufacturing, and implementation of advanced and sustainable materials for transportation infrastructure, with emphasis on concrete. The developments of “green” technologies that can lead to cost savings are of prime interest. This included projects dealing with the performance of self-consolidating concrete (SCC) in cast-in-place bridge superstructure and substructure elements, use of high volume fly ash concrete (HVFAC) in infrastructure applications, the performance of roller compacted concrete (RCC) for rigid concrete pavement for highways, rural roads, and airfield pavements, as well as the feasibility of using high contents of reclaimed asphalt pavement and reclaimed asphalt roofing shingles in flexible pavement mixtures. The common denominator of these technologies is savings of construction duration and cost and reduction in the carbon footprint of construction materials and activities.			
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## **Acquisition of Specialized Testing Equipment for Advanced Cement-based Materials**

**Project Objective:** This equipment purchase will enabled the development, manufacturing, and implementation of advanced and sustainable materials for transportation infrastructure, with emphasis on concrete. The developments of “green” technologies that can lead to cost savings are of prime interest. This included projects dealing with the performance of self-consolidating concrete (SCC) in cast-in-place bridge superstructure and substructure elements, use of high volume fly ash concrete (HVFAC) in infrastructure applications, the performance of roller compacted concrete (RCC) for rigid concrete pavement for highways, rural roads, and airfield pavements, as well as the feasibility of using high contents of reclaimed asphalt pavement and reclaimed asphalt roofing shingles in flexible pavement mixtures. The common denominator of these technologies is savings of construction duration and cost and reduction in the carbon footprint of construction materials and activities.

A summary of the equipment purchased is listed on the following pages.

### **Benefits of the purchased equipment to CTIS Research:**

The advanced infrastructure materials that will be investigated with the purchased set of equipment will allow the delivery of low cost, environmentally friendly, sustainable materials that can ensure safe and fast construction and rehabilitation of transportation infrastructure and increase the service life of such structures. Research projects enabled by this equipment will advance the body of knowledge related to the US DOT strategic goals that are specific to the nation’s infrastructure as follows:

- State of Good Repair
  - Improve structural integrity, reliability, and sustainability of the transportation system.
  - Develop performance-based specifications and quality management tools in infrastructure construction and rehabilitation.
  - Advance scientific understanding and state-of-the-art of practice employed in corrosion prevention and maintenance.
  - Improve fundamental understanding of bond so that innovative material systems can be designed to deliver more durable and sustainable solutions.
  - Improve structural health monitoring capabilities.
  
- Economic Competitiveness
  - Develop material science and fundamental understanding of sustainable construction materials.
  - Validate short- and long-term performance of construction materials in field environments.
  - Promote standardization and code approval of products and design protocols.
  
- Environmental Sustainability
  - Foster new technologies which promote sustainable infrastructure.

<b>ADVANCED CONSTRUCTION MATERIALS LABORATORY EQUIPMENT LIST</b>		
<b>MIXING</b>		
Twin mixer concrete batch plant	Concrete Mixer System - 1125	R74454
	Concrete Mixer System - 375	R74456
Enrich Intensive mixer (150-L output)	Concrete mixer	R74430
Hobart mixer (20L capacity)	Mortar/paste mixer	R74500
<b>RHEOMETERS / WORKABILITY</b>		
ConTec 5 Rheometer	Concrete and mortar	R74409
ConTec 6 Rheometer	Micro-mortar	R74410
Anton-Paar MCR 302 Rheometer	Cement paste	R74401
Fann Viscometer 35	Cement paste	R74469
ICAR portable rheometer	Concrete	R74406
<b>ENVIRONMENTAL CHAMBERS</b>		
De-Icing Salt Scaling Chamber (ASTM C672)		R74453
Alkali-Silica Reaction Chamber (ASTM C1293)		R75001
Freeze-thaw chambers (ASTM C666-A)		R74474 / R74411
<b>TESTING FRAMES</b>		
MTS 315.04 Test Assembly	1 million lb. (4,600 kN) in compression ½ million lb. (2,300 kN) in tension	R74457
Instron 5965 Universal Testing System	5 kN load frame	R74405
<b>NON-DESTRUCTIVE TESTING</b>		
ConCure ZoneCure System	Wireless concrete maturity system	R74397
Impact Echo with Freedom Data PC	Nondestructive testing	R74394
MicroIICI-8 Acoustic Emission System	Acoustic emission	R74421
Resipod	Electrical resistivity	R74393
RSV-150 Remote Sensing Vibrometer	Laser vibrometer	R74419
<b>MATERIAL CHARACTERIZATION</b>		
Pycnometer (Ultrapyc 1200e)	True volume/density of solids	R74396
Blaine Air Permeability	Surface fineness measurement	R74395
Gyratory Compactor ICT-100R	Packing density measurement of aggregates and workability of low slump concrete	R74407
Mercury Intrusion Porosimetry (MIP)	Pore-size distribution	R74420
Rapid Air-Void Analyzer (ASTM C 457)	Air-void measure for hardened concrete	R74485
AVA - Air Void Analyzer	Air-void measurement for fresh concrete	R74408
Creep frames	Creep cells for high-strength concrete	R75035-42 R75049-55
<b>CALORIMETERS</b>		
Calmetrix I-Cal 8000	8-cell Isothermal Calorimeter	R74404
Calmetrix F-Cal 4000	4-cell semi-adiabatic calorimeter	
Calmetrix P-Cal 1000	Portable Calorimeter	
<b>MISCELLANEOUS</b>		
Geneq Concrete Cylinder End Grinder	Concrete sample preparation	R74422
Dust Collector	Industrial strength, portable dust collector	R75015 /R75029

## **CONCRETE WET BATCHING PLANT**

A concrete batching plant was sent out for bid after preparation of a detailed Request for Proposal with the specifications of the system. The delivered system includes the following components:

### **TWIN MOBILMAT MIXER RESEARCH MIXING AND BATCHING PLANT**

MobilMat Mo 375-1125/3-3+1-PCS fully automatic computer control for 1000 concrete recipes according to PSK12-093/4.

The base machine consists of the following structural components:

#### **A) Mixer Platform**

Modern rigid wide flange support structure with spacious service platform surrounding the mixer, columns and heavy cross bracing as well as floor plate for securing to site foundation. Concrete discharge height 1500 mm (5 ft).

#### **Large platforms**

Mounted at mixer level on both sides, with slip resistant bulb plate floor and safety railings.

#### **Staircase to the mixer platform**

with stable steps 700 mm (28 in) wide and railings on both sides.

Installed in the machine platform is:

#### **Planetary High Shear Countercurrent Mixer HPGM 1125**

Mixing pan with 1 hydraulically operated discharge gate with 2 proximity limit switches for indicating "open-closed" position, hydraulic system with drive motor, hydraulic pump, 4/3 way-valve, pressure gauge with regulator and cylinder, drive by electric motor with thermistor, hydraulic torque converter. Reduction gear and planetary drive, mixing stars with mixing arms and mixing shovels, mixer cover with large cleaning flaps incl. safety limit switches and additional inspection port with safety fence, aggregate inlet with mechanically operated dust flap, cement inlet and water inlet with distribution plate. Mixer floor with 2 X moisture probe holes-one for HydroMat Probe, one "blind" hole for future air entraining measuring probe.

#### **Mixer side wall lining**

with exchangeable and reversible wear-resistant lining plates, material thickness of 12 mm.

#### **Protections for mixer arms out of Polyurethane**

#### **Manually operated back-up hydraulic pump**

for emergency opening of mixer discharge gate.

#### **Supervising device for rotation and temperature**

for planetary drive and torque converter, including evaluator installed in control system.

#### **Air Bag**

Airproof dust bag to compensate the air volume displacement when charging the mixer, i.e. for dust free hatching.

### **Concrete discharge cone- Hydraulic actuated**

Out of steel plate, with wear-plate liner and rubber collar, mounted to the mixer discharge gate, for concrete discharge.

### **Skip hoist**

Skip bucket with bottom discharge gate and steep incline side walls for fast and complete discharge. The four skiphoist wheels have permanently lubricated bearings. Hoist winch with gear motor 11 kW (15 HP), single layer cable drum with machined cable grooves for guidance of the hoist cable, 0.4 m/sec skip hoist travel speed, upper skip hoist track with security safety bolt to prevent skip hoist travel during transport and maintenance, slack cable switch, limit switches for filling position, wait position, discharge position and skip "too high" stop position.

### **Precision Electro-mechanical cement weigher**

Weighing range of 500 kg (1,100 lbs), weigher with three load cells and digital scale indicator installed in the control system, weigh-bin with four cement inlets, pneumatic vibrator for quick and complete discharge of weighbin, flexible vent hose to the mixer, pneumatically operated weigh-bin discharge gate 250 mm (or 10 in.) with limit switch for indicating "closed", flexible connection to the mixer.

### **Precision Electro-mechanical water weigher**

Weighing range 300 kg (660 lbs), weigher with one load cell and digital scale indicator installed in the control system, weigh-bin, 1.5 in. water supply line with pneumatically operated ball valve, pneumatically operated weigh-bin discharge gate 150 mm (6 in.) with limit switch for indicating "closed", flexible connection to the water adding pipe line on the mixer.

### **"HYDROMAT" Water Metering Computer**

Automatically controls the concrete water/cement ratio by monitoring 1 wear resistant microwave moisture probe which is built into the mixer floor. The target water/cement ratio and actual cement weight are entered into the computer. The "HYDROMAT" accurately determines necessary water.

### **Mixer service control panel- mounted at mixer platform level**

Mixer service control panel for cleaning and maintaining the mixer with lock-out selector switch "operation-maintenance" including Emergency stop switch with lock-out key and All-pole disconnect switch for mixer and hydraulic pump.

### **Installation for compressed air plumbing- factory installed**

For electro-pneumatic operation of aggregate hatching gates, discharge gate of cement weighbin and ball valve of water dosification unit, with maintenance unit (oil- and water-separator, pressure regulator, pressure gauge, pressure monitor switch), coupling for spray guns etc., including electro-magnetic valves and air pipes.

### **B) 375 Mixer Platform - designed for bolted flange connection to mixer platform of HPGM 1125**

#### **Large platforms**

mounted at mixer level on both sides, with bulb plate floor and safety railings.

#### **Staircase to the mixer platform**

with stable steps 700 mm (28 in.) wide and railings on both sides.

Installed in the machine platform is:

#### **Planetary High Shear Countercurrent Mixer HPGM 375**

Mixing pan with a hydraulically operated discharge gate with two proximity limit switches for indicating "open-closed" position, hydraulic system with drive motor, hydraulic pump, 4/3 way-valve, pressure gauge with regulator and cylinder, drive by electric motor with thermistor, reduction gear and planetary drive, mixing stars with mixing arms and mixing shovels, mixer cover with large cleaning flaps incl. safety limit switches and additional inspection port with safety fence, aggregate inlet with mechanically operated dust flap, cement inlet and water inlet with distribution plate.

#### **Mixer side wall lining**

with exchangeable and reversible wear-resistant lining plates, material thickness of 12 mm.

#### **Protections for mixer arms out of Polyurethane**

#### **Manually operated back-up hydraulic pump**

for emergency opening of mixer discharge gate.

#### **Air Bag**

Airproof dust bag to compensate the air volume displacement when charging the mixer, i.e. for dust free hatching.

#### **Concrete discharge cone**

Out of steel plate, with wear-plate liner and rubber collar, mounted to the mixer discharge gate, for concrete discharge.

#### **Skip hoist**

Skip bucket with bottom discharge gate and steep incline side walls for fast and complete discharge. The four skiphoist wheels have permanently lubricated bearings. Hoist winch with gear motor 4 kW (5.5 HP), single layer cable drum with machined cable grooves for guidance of the hoist cable, 0.4 m/sec skip hoist travel speed, upper skip hoist track with security safety bolt to prevent skip hoist travel during transport and maintenance, slack cable switch, limit switches for filling position, wait position, discharge position and skip "too high" stop position.

#### **Skip hoist aggregate weigher- weighing range 600 kg (1,325 lbs)**

With load-cells and cabling to terminal box enclosure, including frame and supporting construction - scale indicator with digital display.

#### **Precision Electro-mechanical cement weigher**

Weighing range 150 kg (330 lbs), weigher with three load cells and digital scale indicator installed in the control system, weigh-bin with 4 cement inlets, pneumatic vibrator for quick and complete discharge of weighbin, flexible vent hose to the mixer, pneumatically operated weigh-bin discharge gate 250 mm (10 in.) with limit switch for indicating "closed", flexible connection to the mixer.

#### **Precision Electro-mechanical water weigher**

Weighing range 100 kg (220 lbs), weigher with one load cell and digital scale indicator installed in the control system, weigh-bin, 1 1/2 " water supply line with pneumatically operated ball valve, pneumatically operated weigh-bin discharge gate 150 mm (6 in.) with limit switch for indicating "closed", flexible connection to the water adding pipe line on the mixer.



### **"HYDROMAT" Water Metering Computer- special version for two (2) separate probes**

Automatically controls the concrete water/cement ratio by monitoring 1 wear resistant Microwave & Radar moisture probe which is built into the mixer floor. The target water/cement ratio and actual cement weight are entered into the computer. The "HYDROMAT" accurately determines necessary water.

### **Mixer service control panel- mounted at mixer platform level**

Mixer service control panel for cleaning and maintaining the mixer with lock-out selector switch, "operation-maintenance" including Emergency stop switch with lock-out key and All-pole disconnect switch for mixer and hydraulic pump.

### **Installation for compressed air plumbing-factory installed**

for electro-pneumatic operation of aggregate batching gates, discharge gate of cement weighbin and ball valve of water dosification unit, with maintenance unit (oil- and water separator, pressure regulator, pressure gauge, pressure monitor switch), coupling for spray guns etc., including electro-magnetic valves and air pipes.

### **Manual control system (incl. MCC)**

Motor Control Center for later integration into the Mo 1125 batch plant. For integration the PC software and the PLC software has to be modified. The hardware will be integrated without major modifications.

### **Reversing belt - for distribution of aggregates**

Conveyor length	3.600 mm (12')
Conveyor belt width	800 mm (32")
Conveyor speed	1.62 m/sec. ( 320 fpm)
Electric motor drive	2 x 3 kW (2x4 HP)

Conveyor frame work in rigid execution, gear motor, rubber-coated head drum, spring-type belt scraper, tail drum with spindle tensioners, 3 part troughing idlers - 400 mm distance, return idlers with guide rollers, belting EP 315/3, 4:2 mm, V-type lower belt scraper, loading skirt, safety grate protection on troughing idlers and tail drum, emergency stop pull cable on both sides of conveyor with switch.

### **Transfer belt**

Conveyor length	6.400 mm (20')
Conveyor belt width	800 mm (32")
Conveyor speed	1.62 m/sec. (320 fpm)
Electric motor drive	4 kW (5.5 HP)

Conveyor frame work in rigid execution, gear motor, rubber-coated head drum, spring-type belt scraper, tail drum with spindle tensioners, 3 part troughing idlers - 400 mm distance, return idlers with guide rollers, belting EP 315/3, 4:2 mm, V-type lower belt scraper, loading skirt, safety grate protection on troughing idlers and tail drum, emergency stop pull cable on both sides of conveyor with switch.

### **C) Skip Hoist Track**

Fabricated from rigid channel steel, reinforced execution with steel safety panelling closing the back, including fasteners.

### **D) Galvanized Safeguards Panels**

Installed between the skip hoist and the row-type silo with integrated safety stop/ switch mounted on the access door.

### **E) Row-type bin 3-25-WBSOO for aggregate storage and weighing**

Aggregate is charged into the bins by front end loader.

Storage volume approx.	25 m <sup>3</sup> (33CY)
Number of bins:	6
Loading width each bin approx.	2.450 mm (8'-0.5")
Loading height approx.	3.490 mm (11'-504")
Row-type silo width approx.	2.920 mm (9'-7")

Storage bins in totally welded construction with 2 electro-pneumatic segmental hatching gates - gate opening width is adjustable, 1 vibrator mounted on bin # 2 discharge cone, collapsible bin side walls – hinged for transport - and partition walls with lock pins for speedy erection.

Weigh belt- suspended from bin structure

Conveyor belt width	800 mm
Conveyor speed approx.	0.90 m/sec. (180 ft/min.)
Electric motor direct drive	5.5 kW (7.5 HP)

Conveyor frame work in rigid execution, gear motor, rubber-coated head drum, tail drum with spindle tensioners, 3 part troughing idlers - 400 mm distance, return idlers with guide rollers, belting EP 315/3, 4:2mm, adjustable belt skirting, belt wiper on underside, loading skirt, safety grate protection on troughing idlers and tail drum, emergency stop pull cable on both sides of conveyor with switch.

Electro-mechanical aggregate weigher, weighing range 2000 kg (4400 lbs), with load cells and securing device for transport.

### **F) 1 Exchangeable bin (1.5 m<sup>3</sup>)**

including extension of the row-type silo support structure and the weighbelt: Including pneumatically operated flap.

### **G) Cement distribution**

- **4 Cement incline screw conveyors**
  - **4 Cement horizontal distribution screws with pneum. butterfly gates**
  - **4 Support stands with cone for cement charge hopper for Super Sacks**
- including connection flange for screw conveyor, closed loop for no dusting.

### **H) Electric Equipment and Control**, consisting of:

- Cabling- complete for connecting all field devices between all motors, limit switches, valves and control desk, acc. To ULICSA American Standard .

The standard electric cabling allows set-up of the control table at a max. distance of 10 m (33 ft) from the front machine supports.

- Fully automatic control, PCS-Pro" consisting of:

- Control panel

with operational graphic for manual control, main disconnect switch, ammeter for mixer motor, digital scale indicators (OK 850 and OK 860) for the weighers and the Siemens S7 PLC is housed in a control panel enclosure and will be installed in a control room at ground level provided by customer.

PC, monitor and keyboard to be installed at customer's desk.

- Program software:

- 1000 Concrete recipes - Programming capacity:
- 12 aggregates per recipe 6 out of 12
- 5 cement sorts per recipe 3 out of 5

- 3 water sorts per recipe 3 out of 3
- 4 admixtures per recipe 4 out of 4
- with raw material statistic
- 50 text memories

### **Special voltage and frequency for MCC**

### **PCS-Control according to CSA/UL standards**

### **All field cabling for plant incl. according to CSA/ UL standards**

### **Uninterruptable Power Supply Unit (UPS) for the PC**

### **Mixer motor with variable speed frequency drive for HPGM 1125**

**Control for 1 admixture metering system (Scale Type)**  
impulse meter type incl. DK 860 indicator or weigher with DK 850 indicator.

### **Control extensions for each further admixture pump**

Admixture addition user definable:

- with aggregate
- with final water
- after water addition

### **HYDROTESTER Automatic measuring probe for sand moisture**

Mounted under the hatching gate. For Automatic sand/water correction with abrasion-resistant moisture probe installed in active flow area of the aggregate weigh-hopper, moisture indicator range 0 - 20% integrated in control panel with connection cable between probe and indicator unit.

### **Mounting bracket for Hydrotester**

### **Cement Screw Conveyor- (30') long (incline)**

conveying length 30', inclination max 50 degrees, AC direct drive gear motor unit, 1 inlet, cleaning flap, connection parts to cement hopper and cement weigher and all-pole disconnect switch for electrical lock-out of cement screw conveyor in case of maintenance or repair works.

### **Super sack rack for charging cement to cement screw**

Including removable super sack support rack, support stand with 19" diam. feed collar inlet sized for super sack spout, 12" tall with 4 Cuft charge hopper.

### **Automatic Mixer Cleaning System for HPGM 1125 and HPGM 375**

### **Additional hand wand for cleaning system (At mixer & ground level)**

### **Amixture dispenser scale ( measuring by weight) Budget**

Assumes 3 admixtures metering at a time, system built for HPGM 1125 mixer for 6 admixtures. Exact specification to be determined after technical clarification typical recipe.

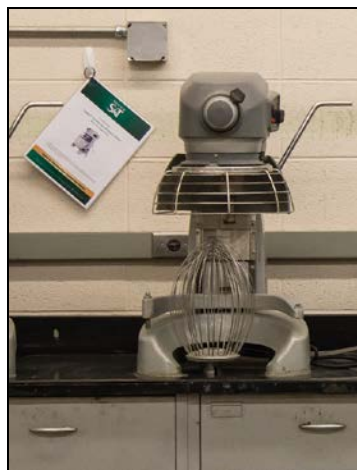


## MIXERS

- Concrete
  - Eirich Intensive mixer with 150-L output – the Eirich intensive mixer is best known for optimum mixing technology. The Eirich intensive mixer separates the transportation of the mix from the actual mixing process. This results in numerous process design advantages. The mixing pan can be arranged either horizontally or at an optimized angle of inclination to suit the particular requirements.



- Mortar
  - Hobart mortar/paste mixer (20 Liter capacity) - ASTM-compliant mixers for mixing hydraulic cement pastes and mortars of plastic consistency. Mixer includes Bowl Positioning Adapter, a stainless steel bowl and 1 flat, stainless steel beater for mixing heavy materials. Mixer operates on principle of planetary action—beater reaches every part of the batch, rotating on its axis in opposite directions as it moves around the bowl. Thoroughly blends, mixes and aerates all ingredients for consistent, predictable finished batches.



## RHEOMETERS

- Contec viscometer for Concrete (Viscometer 5) - for mortar and concrete ( $D_{max} \leq 25$  mm)



- Contec viscometer for Micro-mortar (Viscometer 6) - for mortar and paste ( $D_{max} \leq 5$  mm)



- Rheometer for paste (Modular compact rheometer (MCR) 302) - modular compact rheometer, allows integration of a wide range of temperature devices and application specific accessories. The EC motor technique, the low friction bearing and the patented normal force sensor have been optimized enabling any type or combination of rheological tests, both in rotational and oscillatory mode.



- Fann Viscometer 35 - Fann Viscometer 35 is a true Couette coaxial cylinder rotational viscometer. In this viscometer, the test fluid is contained in the annular space or shear gap between the cylinders. Rotation of the outer cylinder at known velocities is accomplished through precision gearing. The viscous drag exerted by the fluid creates a torque on the inner cylinder or bob. This torque is transmitted to a precision spring where its deflection is measured and then related to the test conditions and instrument constants.



- ICAR rheometer - rugged, portable instrument for measuring fundamental flow (rheological) properties of fresh concrete. This instrument is used to: characterize the influence of new materials on concrete rheology, optimize mixture proportions so that the resulting concrete flows readily but is resistant to segregation (especially important for self-consolidating concrete) and allows on-site quality control.



## ENVIRONMENTAL CHAMBERS

- Alkali – Silica Reaction chamber
  - ASTM C1293
  - Temperature: 38°C to 60°C
  - Temperature sensor accuracy:  $\pm 0.2^{\circ}\text{C}$
- De-icing Salt Scaling chamber
  - ASTM C 672
  - Temperature: -18 to 23°C
  - Cycle: one cycle per day



- Freezing and thawing chambers
  - ASTM C 666A
  - Specimen: 1 Reference + 16 prisms (75 x 75 x 355 mm)
  - Dimension: 0.9 x 2.2 x 1.1 m
  - Temperature: -18 to 4°C
  - Cycle: 6 cycles per day





## TESTING FRAMES

- The MTS Rock and Concrete Test System
  - MTS Model 315 Load Frame Assembly
    - 4.600 kN (1.000 Kip) compression.
    - 2.300 kN (500 Kip) tension.
    - 100 mm (4.0 in.) stroke.
    - Test space height with adapter plates: Max. 1160 mm (45.7 in.). Min. 1060 mm (41.7 in.)
    - Test space width. 686 mm (27 in.)
    - Stiffness  $10.5 \times 10^9$  N/m ( $6.0 \times 10^7$  lb/in.)
  - FlexTest 60 Digital Control System
    - Versatile, easy-to-use servo-controller for general testing applications. It provides real-time closed-loop control with transducer conditioning and function generation to drive various types of servo-actuators. The FlexTest 60 controller can support up to 8 control channels and up to 6 test stations, with support for up to 6 ft/low/high hydraulic service manifolds, or up to 2 off/low/high and 2 proportional I ISMs.
  - Uniaxial Compression Test Package
    - For high force compression testing where the loads exceed 1,000 kN (220 Kip) the load arc measured using a differential pressure transducer. This method will provide load measurement accuracy within approximately  $\pm 0.5\%$  for forces larger than 1,000 kN (220 Kip). Due to actuator friction, force measurement using this method becomes less accurate at lower forces.
    - For low force compression testing (forces less than 1000 kN (220 Kip) a load cell is used for improved load measurement and control resolution. ASTM standard test methods may require the improved force measurement accuracy that is provided by the appropriate force transducer.
  - MTS 505.30 Silentflo Pumping System

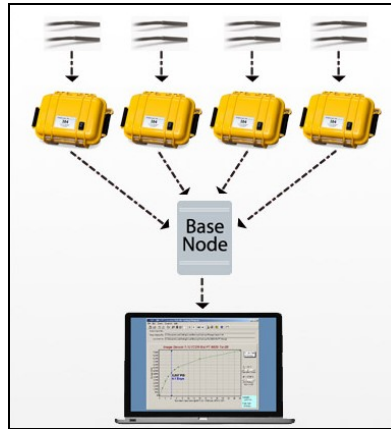


- Instron 5965 Test System –Dual column table top electromechanical testing system including:
  - Capacity 5 kN (500 kg, 1125 lb)
  - Integrated digital closed-loop control and data acquisition electronics including crosshead extension and load measurement channels
  - Test control panel with two softkeys, results display, start, stop and return functions, programmable function keys, test status indicators, variable speed jog and specimen protection.
  - Testing speed range: 0.001 to 3000 mm/min (0.00004 in/min to 120 in/min).
  - Crosshead return speed: 3200 mm/min (128 in/min)
  - Base adapter: Type D female fitting (0.5 in clevis pin)



## NON-DESTRUCTIVE TESTERS

- ConCure ZoneCure System (maturity monitoring) - a system to measure the temperatures, temperature differences and maturity values during hardening of a structure at critical locations. ZoneCure allows strength estimation at an early age as well, provided the strength-maturity relationship for the concrete mixture used in the structure has been established and programmed into the software.

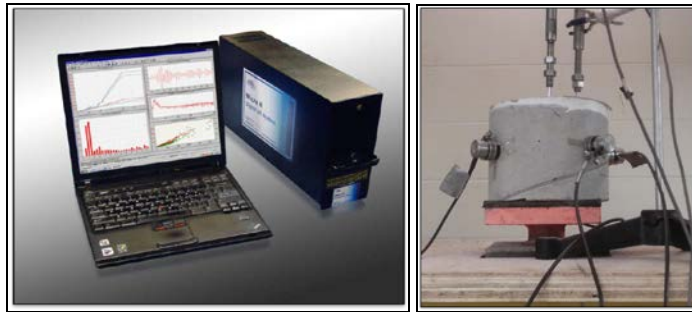


- Impact Echo - system is designed to determine the condition and thickness of concrete, wood, stone, and masonry structural members when voids, honeycomb, and/or cracks are suspected. IE investigations can also be performed to predict the strength of early age concrete if the member thickness is known. Lastly, the IE method will provide information on the depth of a flaw or defect, in addition to mapping its lateral location and extent. An advantage of the IE is that only one side of the structure needs to be accessible for testing. With Freedom data PC - provides stress-wave based NDT condition evaluation of concrete, masonry, asphalt, wood and other construction materials, as well as seismic testing of soil and rock. This platform provides complete data processing capability for all test methods.



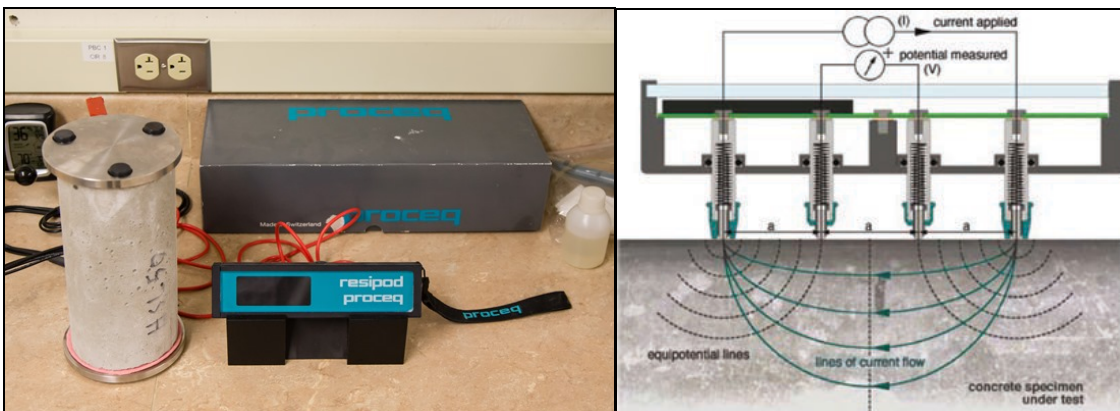
- Micro II PCI-8 Acoustic Emission System – 8 channel digital data acquisition acoustic emission system that resides on a full-size PCI card. Through the high performance PCI bus and Direct Memory Access (DMA) architecture, significant AE data transfer speeds can be attained (up to 132 Mb/sec.), assuring a wide bandwidth bus for multi-channel AE data acquisition and waveform transfer. Digital acquisition circuitry virtually eliminates drift, thereby achieving high accuracy and reliability.
  - Low power consumption.
  - 8 digital (16-bit A/D) complete AE channels on one full-size PCI card.
  - PCI-bus provides AE data transfer rates of up to 132 Mb/sec to a PC computer.

- 4 High Pass, 4 Low Pass filter selections for each channel, totally under software control.
- Up to 2 parametrics on each PCI-8 board with update rates up to 10,000 readings/second (when attached to hit data).
- Designed with multiple FPGA's and ASIC IC's, to provide extreme high performance and minimize components and cost.
- Hit LED drivers are built within the PCI-8 board so that AE activity LED's can be attached directly.
- Built-in AE feature extraction provides high speed transient data analysis at high hit rates.
- Built in waveform processing with DMA & Bus Mastering transfer for high speed transfer of waveforms on all 8 AE channels.
- Digital signal processing circuitry virtually eliminates drift, thereby achieving high accuracy and reliability.



- **Resipod** - Resipod is a fully integrated 4-point Wenner probe, designed to measure the electrical resistivity of concrete in a completely non-destructive test. It is the most accurate instrument available, extremely fast and stable and packaged in a robust, waterproof housing designed to operate in a demanding site environment. The Resipod is the successor of the classic CNS Farnell Resistivity Meter.

Surface resistivity measurement provides extremely useful information about the state of a concrete structure. Not only has it been proven to be directly linked to the likelihood of corrosion and the corrosion rate, recent studies have shown that there is a direct correlation between resistivity and chloride diffusion rate and even to determination of early compressive strength. This makes it one of the most versatile NDT methods for concrete.



- RSV-150 Remote Sensing Vibrometer – The RSV-150 Remote Sensing Vibrometer is designed for point-and-shoot condition monitoring and testing the dynamics of structures from a distance. Its advanced laser Doppler interferometer technology saves time by avoiding contact sensor installation and is readily applied to any vibration measurement task. The RSV-150 offers a full solution for vibration analysis:
  - Interferometric optical sensor equipped with long range lens, an in-line video camera and additional green pilot laser for targeting.
  - Controller to convert the sensor signals into easily acquired voltage outputs for velocity and displacement.
  - Rigid tripod system for precise targeting on remote objects.



## MATERIAL CHARACTERIZATION

- Ultracyc 1200e Pycnometer - This equipment is used to determine true density and density of powder materials. This pycnometer is specifically designed to measure the true volume of solid materials by employing Archimedes' principle of fluid displacement and gas expansion (Boyle's Law). The versatility of this equipment is important because the required volume for density determination depends on the fineness of the powder. The density is one of the basic physical characterization of powder materials.



- Blaine Air Permeability - Fineness measurement apparatus: This apparatus is to determine Blaine fineness of powder materials. The Blaine of powder materials has significant influence on workability and rheology of cementitious materials, including concrete. The Blaine is one of the basic physical characterization of powder materials.



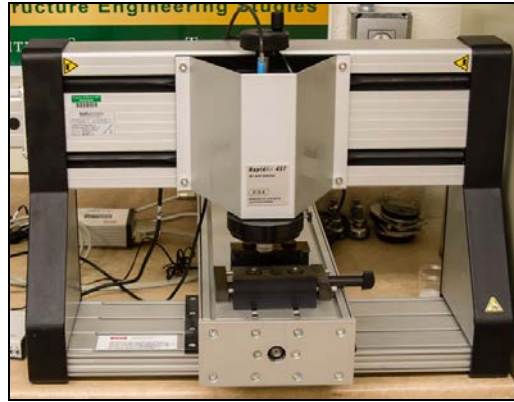
- Gyratory compactor ICT-100R - this piece of equipment is used to test compactability of aggregate and low workable concrete. This model is the most complete equipped version for all kind of laboratory compacting work (research, mix design, specimen preparation etc.).



- Mercury intrusion porosimeter (MIP) - Non-wetting fluid (mercury) Intrusion device, by pressure, for pore size distribution determining in solid porous sample. Mercury intrusion pressure is raised automatically, up to 220 MPa, and intruded volume into sample is related with porosity determination. The measuring range of pores is between 7 nm and 0.4 mm.



- Rapid air-void analyzer (ASTM C 457) - an automated measuring system for analyzing the air content, and distribution in hardened concrete, which is of importance when evaluating the freeze-thaw resistance of concrete. The system can replace the manual tests performed as described in the ASTM designation C 457. It is comprised of a computerized control unit (PC) with a 20" LCD color monitor, a digital color camera, and a microscope objective mounted on a moving stage, and a user-friendly analysis software operating in MS-Windows environment.



- AVA (Air Void Analyzer) is used to measure the air-void parameters (spacing factor and specific surface) of samples of fresh air-entrained concrete. Samples are taken after concrete has been placed in the structure and consolidated. It provides timely information to reveal problems with the air-void system.



- Creep Frames – these are fabricated pieces of specialized equipment to test the creep measurement of high-strength concrete. A total of 15 pieces were fabricated.





## CALORIMETERS

- Calmetrix I-Cal 8000 - I-Cal 8000 is an 8-cell Isothermal Calorimeter designed to test cement paste, mortar or even real concrete in compliance with ASTM C1679 ("Standard Practice for Measuring Hydration Kinetics of Hydraulic Cementitious Mixtures Using Isothermal Calorimetry"). Precision sensors measure the heat flow generated by the early hydration reaction of cement as the ambient temperature around the samples is controlled by Calmetrix's CalCommander software interface.



- Calmetrix F-Cal 4000 Semi-Adiabatic Calorimeter - F-Cal 4000 is a portable calorimeter with four sample channels that emulates the curing conditions of concrete flatwork. It is ideal for quick testing of concrete in field conditions. F-Cal units are portable, yet rugged enough to be carried in the back of a pick-up truck, or left on site in a Concrete plant for testing in real conditions. F-Cal 4000 enables testing of up to four cement, mortar or concrete simultaneously, in standard 4"x8" (100 mm x 200 mm) cylinders or in any container of equal or smaller size. Calmetrix's proprietary CalCommander software for data retrieval and analysis lets users to select one of the F-Cal's cells as a temperature reference cell.



- Calmetrix P-Cal 1000 - The P-Cal is a high performance semi-adiabatic calorimeter with high efficiency insulation to achieve close to adiabatic conditions. The P-Cal is the only high performance semi-adiabatic calorimeter that is so portable it can easily be carried in concrete delivery trucks or other field applications. Don't be fooled by its size: the quality of the insulation gives the P-Cal 1000 laboratory-level quality, with precise and replicable measurements.

P-Cal 1000 can be used to test concrete, mortar or paste in a standard 4"x8" (100 mm x 200 mm) cylinder or any standard container that fits inside. P-Cal measures changes in temperature, a proxy for heat released as cement is hydrating. Because of its ultra-high performance insulation, It closely mimics the conditions encountered in the core of mass concrete applications.



## GENERAL PURPOSE LABORATORY EQUIPMENT

- Geneq Automatic Concrete Cylinder End Grinder - automatic grinder grinds specimen ends plane and parallel. This unit can grind three (3) 4" x 8" (100 mm x 200mm) test cylinders or two (2) 6" x 12" (150 mm x 300 mm) test cylinders simultaneously, has adaptor for 4" x 8" (100 mm x 200 mm) test cylinders.



- Model PFC12 Portable Fume collector - 1200 CFM - Model PFC12 Portable Fume collector features a 1200 CFM fully portable base unit with a 6" x 10' Z-Max fume arm with hood standard. 12 & 14 powder-coated steel construction with on/off switch & 20' cord. 5" swivel casters with brakes on front, 10" rear wheels. External dust tray. The motor is a 1.5 HP direct drive high efficiency motor with manual thermal overload mated with high efficiency direct drive non-sparking composite BI wheel. 250 sf flame retardant 80/20 cell poly cartridge filter. Tool-less filter service and maintenance.



## **Upgraded Equipment –**

The Environmental Chamber and Dynamic Cyclic Load Frame in the Engineering Research Laboratory and was also upgraded. This will enable the increase in the ranges of temperature (from 0 to 120 °F) and relative humidity of 40% to 100% that will enable greater capabilities of testing the performance of construction materials for infrastructure applications.

### **Functions/uses of the equipment:**

The individual functions/uses of each piece of equipment are defined in the descriptions above. As a whole, the combination of these equipment will allow the complete study of advanced cement-based materials, starting in the lab and ending with validation/implementation the field.

Starting at the microscale, the following pieces of equipment will be used for material characterization and optimization of mix designs. This includes the testing of the physical characteristics of cement-based materials, asphalt binder, and concrete, as well as rheological characteristics, physio-chemical properties, hydration kinetics of these materials.

On a macro-scale, a number of key equipment will be required to produce high performance concrete materials and evaluate their characteristics under different loading and environmental conditions. These equipment include environmental chambers which enable the testing of transportation infrastructure materials, components and systems under real exposure conditions. This equipment will allow CTIS researchers to address the need for in-situ data to drive rapid development of sustainable solutions to the marketplace.

In the laboratory, the following pieces of equipment will be used to test the structural performance of these materials in order to determine their behaviors under service conditions and under extreme loading conditions.

The final step in the overall study of these advanced materials, the following pieces of equipment will be implemented in field conditions to monitor their short-term and long-term response. Structural health monitoring of these structures will also be carried out.