Western Geotechnical Research Centre

Western Geotechnical Drum Centrifuge

The University of Western Ontario recently commissioned a Broadbent 2.2 m drum centrifuge for scaled physical modeling of geotechnical processes and structures. The new facility has been supported by a $5.4M grant from the Canada Foundation for Innovation Research Fund. The facility is located in a dedicated laboratory with a floor area of 300 m^2, which includes space for the drum centrifuge and a control room, model/instrumentation preparation and testing, storage, image analysis and data processing. The centrifuge consists of a 360-degree drum channel 0.4 m deep and 0.7 m wide, with a diameter of 2.2 m, able to hold up to 3.5 tonnes of soil. The drum is mounted via a central shaft on a pedestal, which is powered by a 35 kW motor that creates a hyper-gravity environment up to 249g. The 867 g-tonne machine has one of the largest 'scaled-model' soil environments in the world; an equivalent of 13.3M m^3 of soil, i.e. a soil body approximately 80 m deep, plan area of 0.08 km^2 and length of 0.7 km. If desired, smaller models can also be accommodated inside the drum channel using plane strain or axisymmetric boxes.

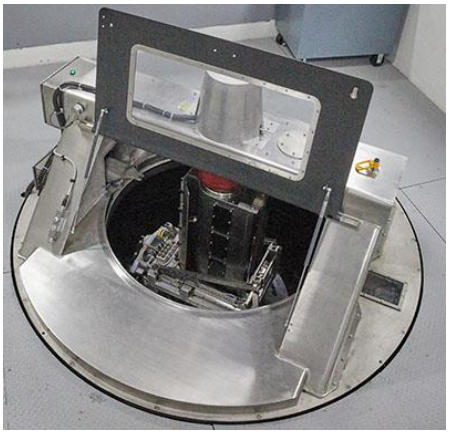
The tool-table system provides easy access to the spinning drum from a platform located on the central pedestal. This enables site investigation tools, structural loading or instrumentation to interact with the models via a three-axis robot. The robot can be used to apply various loading or displacement control profiles to soil bodies or structures, such as monotonic, periodic, successive step or multiple cycles. Twin high-speed data acquisition systems for the drum environment and the tool-table are capable of simultaneous interrogation of 64 channels of data with additional on-board digitization, network acquisition and control. Computer controlled two axis in-flight placement/pouring is used for preparation of soil layers with controlled density and strength. A profile actuator permits the creation, changing and monitoring of model soil surfaces in-flight.

A range of miniature instrumentation allows the measurement of stresses, forces and movements of soil sediments and structures in the models. This includes a high speed I-Scan pressure mapping system for accurately measuring and analyzing interface pressures between soils and structures. Visualization of the deformation of geotechnical structures and sediments during modeling events is achieved using an image system based on particle image velocimetry combined with close range photogrammetry and high-speed ruggedized video cameras. Miniature site investigation devices comprise of a piezocone penetrometer and a shear vane. Additional tools are available for T-bar and plate penetrometer testing.

A multi-channel ultrasonic in-flight interrogator has been created for geotomography of soil models, to evaluate spatial stiffness, saturation and packing states. This system enables up to 32 transducers (bender-extenders or dry point sensors) in 2D/3D arrays to be used to visualize elastic compression and shear wave velocity distributions. A two-dimensional earthquake shaker system is in development. A wide variety of motions will be possible with the shaker at up to 100g, including 1D and 2D acceleration time-histories comprised of periodic, aperiodic, random, or scaled earthquake signals. The drum earthquake actuator will be the only drum centrifuge mounted earthquake actuator in the world. The actuator will provide earthquake input motions for a payload of 1500 kg over a range of frequencies from 10 to 250 Hz. An active fluid wave flume paddle is also being developed to allow the investigation of scaled physical models of soil-structure-fluid interaction problems in the drum. Structures and sediment beds will be able to be subjected to properly scaled wave trains (up to 10 m wave heights at protoype scale) with minimal issues from reflected waves. Computer control of the paddle system will enable the formation of simple standing and progressive sinusoidal wave trains, multi-spectral seas and special solitary waves.

The new geotechnical drum centrifuge facility at Western is operated through a director (Dr. Tim Newson), manager (Dr Aly Ahmed) and two geotechnical technicians. Enquiries can be made using the contact information found below.

The drum centrifuge control room



Drum centrifuge and 3D robot

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