

## DUT Geotechnical Centrifuge Centre

Director: Prof. Dr. Zhongtao Wang

Manager: Wei Zhao

Contact: +86 138 4289 2776

Website: <http://civil.dlut.edu.cn/info/1011/1009.htm>

Owner: Institute of Geotechnical Engineering, DUT

Location: Dalian, PR China

### Introduction

Geotechnical centrifuge has become a widely used physical modelling tool in investigating geotechnical problems, re-establishing the prototype stress state in the scale soil sample by applying centrifugal acceleration. The DUT Geotechnical Centrifuge Centre encompasses a 1.4 m diameter (450 g-Tonne) drum centrifuge GT450/1.4 with twin concentric shafts, actuators, controller, tool table and two sets of data acquisition systems (DAS). The GT450/1.4 is also provided with many highly specialized devices and sensors, such as Druck pore pressure transducer (PPT), miniature compression/tension load cell (L/C), displacement transducer (LVDT) and laser sensor. Our facility and additional accessories are mainly used for investigation and teaching, and consulting services to the industry are also offered.

### Key Technical Specifications

Drum Centrifuge	
Manufacturer	Broadbent & G-max Company
Year established	2009
Radius to base of soil container	0.7 m
Capacity	450 gton
Channel dimensions	0.27 m x 0.35 m (H x W)
Major equipment	Test Specific Actuator, PIV Box, T-bar Penetrometer

### Drum Centrifuge

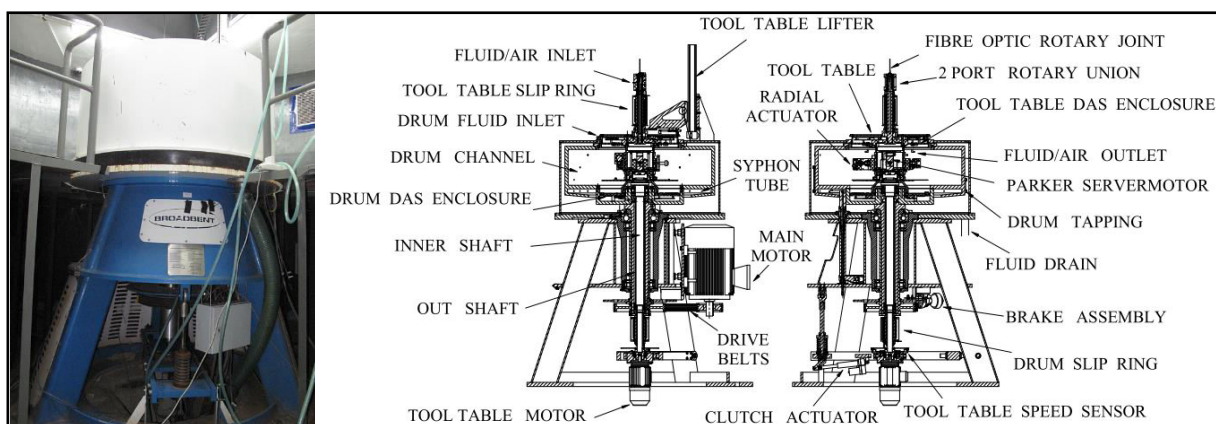
The DUT's drum centrifuge manufactured by Broadbent & G-max Company, has been installed at Dalian University of Technology in 2009, supplied as a 450 gton and 1.4 m diameter drum with twin concentric shafts. Control and data acquisition systems are provided in modular form, allowing a flexible choice of sampling and recording modes. The geo-centrifuge has a channel with a radial depth of 0.27 m and a height of 0.35 m for sample containment, and the maximum rotational speed is 875 rpm, equivalent to an acceleration of 600g at the bottom of the channel. Models can be installed directly inside the drum around the full circumference, and smaller models can be tested in suitable containers which are then mounted inside the drum channel. A key advantage of the drum centrifuge is that it is stronger in structure to keep better balance, and maintains a precise control of water depth through siphon at any operation speeds.

All safety related machine functions such as speed, vibration, automatic balancing, overload protection, access interlocks, and starting/stopping sequences are controlled by a dedicated centrifuge control system based on an industrial programmable logic controller (PLC). The PLC and the associated electrical components are installed in their own Control Panel Cubicle outside the centrifuge enclosure. A Local Control Panel is provided to display current status and to initiate normal operating functions such as starting, stopping and speed changing. Alternatively, these functions can be switched to operate by password from the Control Room PC. Five Emergency Stop pushbuttons are provided, which can be located as required both inside and outside the control room. A special air conditioning system is installed for temperature control to reduce measure

errors. A modified crane with frequency conversion is used to prevent mechanical components damage during lifting.

Twin concentric shafts allow the separate control of a central tool table with testing actuator independent of the outer channel containing models. The drum is mounted on the outer of the two shafts, which is rotated by a 55 kW 4-pole 400 V 3-phase 60 Hz motor via multiple V belts. The inner shaft is connected to the tool table on which specific test actuator can be mounted. Using a cone clutch, these shafts can be linked to rotate together, or can be operated independently. A 2.2 kW Parker servomotor fixed in the inner shaft allows the table to be indexed precisely relative to the inner shaft.

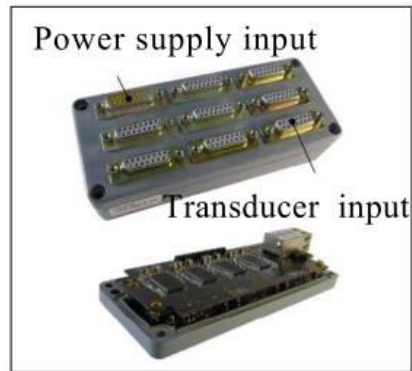
Two slip ring stack systems are mounted separately to interface the user to the Drum DAS and Tool Table. The latter one comprises three integrated sub systems including a single passage fibre optic rotary joint, two port 1 MPa hydraulic/gaseous rotary unions and 36 way 7.5 A electrical slip ring stack, manufactured from coin silver with silver graphite wiper brush tips. While the former one merely comprises a single over shaft mounted 44 way 7.5 A electrical slip ring stack.



The DUT's Drum Centrifuge GT450/1.4

### Data Acquisition Systems

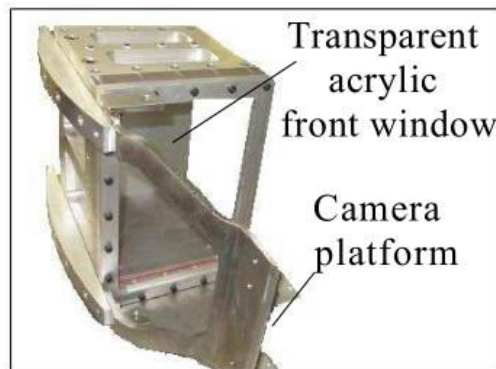
A wireless high-speed data acquisition system has been developed to provide an enhanced measurement system for experiments. The system has several novel features such as 16-bit resolution, a sampling rate up to 1 MHz associated with an automatic triggering of the data acquisition, combined with low-speed logging pre and post triggering. The system comprises a distributed network of up to 5 individual eight-channel logging units controlled via a wireless communication system. All features of each unit are mounted on a pair of custom-designed circuit boards removing the need for a dedicated acquisition card and an in-flight computer. The test data can be acquired and stored indefinitely through the units, which offer an Ethernet port and an independent IP address for communication via any TCP/IP protocol (including web browser) using wireless transmission to the centrifuge control room. The units are mechanically robust, being designed for operation at 350g.



Wireless data acquisition system

### PIV Box

Two PIV boxes, made of aluminium alloy frame with a transparent acrylic front window, are provided to improve the utility of the geotechnical centrifuge by increasing the detail and precision of deformation measurements. The box incorporates a small platform to mount a digital camera and lighting system to implement PIV measurements. Pentax waterproof camera W90 and Canon G10 digital camera are used to capture images. The camera G10 can be real-time controlled within the channel by the core 2 duo fan-less multimedia box via USB line.



PIV box

### T-bar Penetrometer

The T-bar consists of a 5 mm diameter bar with strain gauges located immediately above the cylindrical bar to measure the bearing pressure. The undrained shear strength is then calculated using a bearing capacity factor, which is usually adopted as 10.5. Besides of two T-bar penetrometers, there are also two Ball-bars, one Piezo ball, and three SCPTs in the laboratory for obtaining the soil strength and pore pressure.

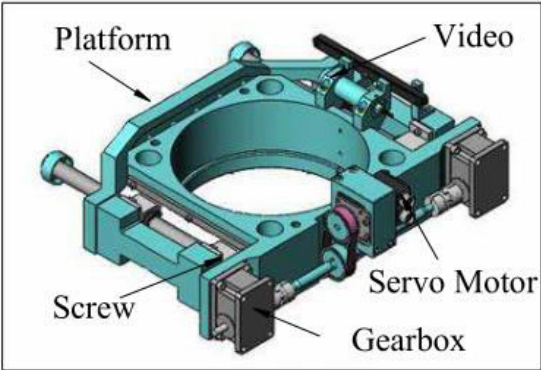


T-bar penetrometer

### Actuator

In order to apply vertical and horizontal loads to models, two actuators are developed. The first one with a stroke of 150mm is mounted on the tool table and linked to the centrifuge inner shaft. A new

actuator with 300mm stroke connected directly to the inner shaft has been introduced. Both actuators can perform radial and circumferential movement. Combined with the central shaft, they have circumferential axis movement with the maximum torque of 450 N.m. The radial loading platform with a minimum velocity of 0.001mm/s has a continuous load rate of 10 kN and is driven by lead screws powered by Parker 230V AC brushless servo motor fitted with 16:1 (old one) or 40:1 (new one) harmonic drive gearboxes. Each motor is anticipated to operate under velocity control through the PC using EASI-V programming language. Radial and circumferential movements can be pre-programmed to run monotonous, periodic, successive step or multiple cycles, which makes it feasible to simulate some construction process, such as pile driving and pulling. Load cells, displacement transducers, camera and any other useful equipment can be fixed on the actuator platform.



Test specific actuator

**Model Preparation Assembly**

Using a vacuum mixer, the slurry is mechanically stirred under vacuumed conditions to ensure a homogeneous mixture and minimize the segregation between clay and water. After mixing, soil deposition will be achieved by feeding dry sand or clay slurry through on-axis soil preparation assembly, which comprises of 8 ways slip ring stack, servomotor, nozzle, sleeve, funnel import and control cabinet. The assembly can be fixed on the drum casing. The nozzle put into the channel through the sleeve can rotate circumferentially together with the inner shaft or be moved vertically by the servomotor via the slip ring using the portable control cabinet. Flow of dry sand may be assisted by compressed air injection or changing a larger nozzle. A consolidation apparatus is fabricated to consolidate clay.



Vacuum mixer

Soil preparation assembly

Consolidation apparatus