Tongji University Geotechnical Centrifuge Centre

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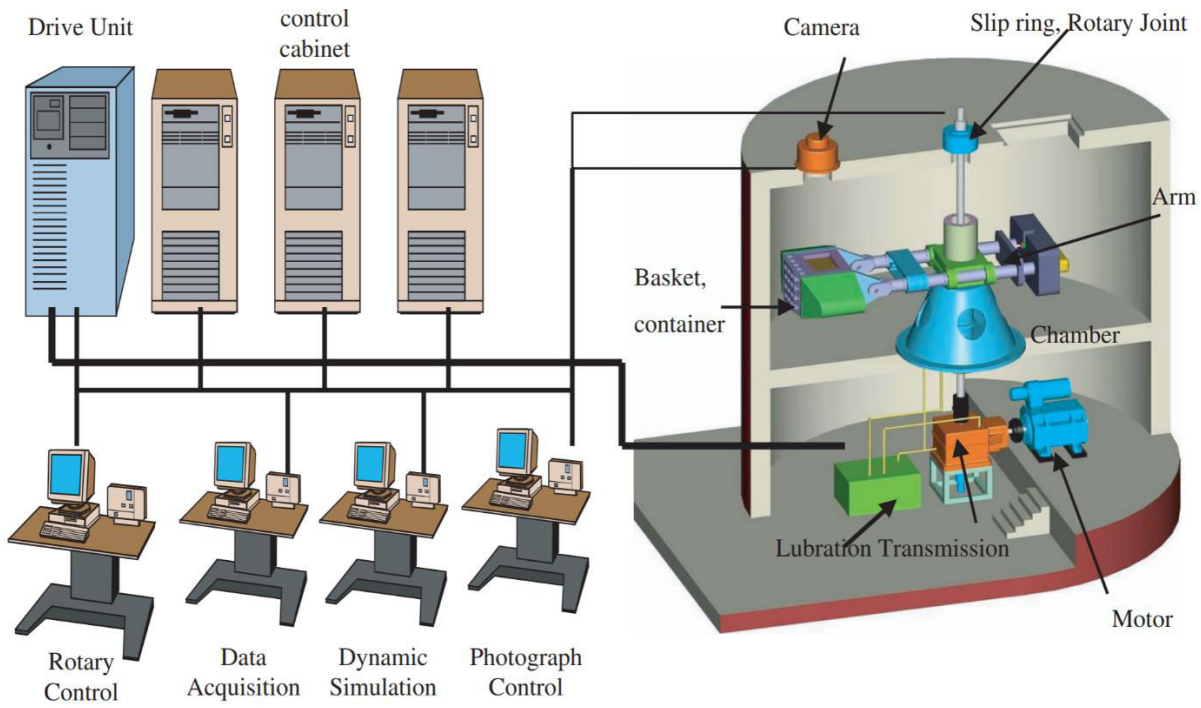
Location: Shanghai, China

Introduction

It is obvious that multiple gravity physical simulation can overcome the disadvantage that stress level in small-scale model is lower than the prototype level in 1g physical simulation. Especially, multiple gravity physical simulation is very appropriate to the problems of large scale and long duration in soft soils where nonlinearity is dominant. With that in mind, the Department of Geotechnical Engineering at Tongji University had developed and installed a geotechnical centrifuge facility with a capacity of 150 g*ton, an in-flight shaking table, a dynamic robot system, a variety of actuators, tool platforms, cooling systems, and measuring systems, and later it was incorporated into the platform of Key Laboratory of Geotechnical and Underground Engineering of the Ministry of Education, China. Our experimental infrastructure is predominantly used for scientific research and teaching purposes. In addition, we provide highly specialized consulting services for various geotechnical research topics arising from ongoing large-scale construction projects in Shanghai and areas beyond.



Layout of Tongji Centrifuge.

Key Technical Specifications

Beam Centrifuge	
Manufacturer	China Academy of Engineering Physics
Year established	2006
Effective radius	3 m
Capacity	150 gton (max G-level: 200g)
Performance	Maximum speed of rotation: 244 rpm
	Main motor: 250 kW
	Maximum acceleration: 200 g
	Maximum payload: 1.5 MN (when g = 100 g)
Bucket dimensions	1.6 m x 1.25 m x 2.17 m (L x W x H)
Rotary joints	Air passages 2: 1 Mpa
	Water passages 1: 2 Mpa
	Oil passages 2: 10 Mpa
Slip Rings	Signal line: 84
	Power line: 10 (380V, 10A; 220V, 5A)
	Video lines: 6
Data Acquisition	Static test: 40 channels
	Dynamic test: 32 channels
Cameras	Strobo-camera: 1
	CCD camera: 4
Major equipment	Earthquake simulator
	dynamic robot system
	Automated sand raining system

Beam Centrifuge

Targeting various geotechnical research topics arising from ongoing large-scale construction projects in Shanghai and surrounding areas, a geotechnical centrifuge facility had been developed and installed at Tongji University in Shanghai, China, and it has gradually transformed to a research centre of physical modelling covering theoretical and mechanism-oriented researches and industry practice-oriented ones serving all of the country and being very active in international collaboration. The centrifuge is a single basket beam type, composed of a control system, a drive system (including a reduction gearbox, a motor, etc.), a rotating system (including a basket, arm, arm support, etc.), and a static and dynamic data acquisition system. It is assisted by systems such as an automatic balancing system, an excavation system, an emergency shutdown system, and a vibration exciter system.

Single basket beam centrifuge developed and installed in Tongji.

With an effective radius of 3 m, the payload capacity is 150 g×ton, with a maximum acceleration of 200 g for static tests and 50 g for dynamic tests. Two kinds of model container have been designed, one is 0.7 x 0.7 x 0.9 m, the other is 0.5 x 0.5 x 0.8 m. The whole mass of the container and the model can reach 1500 kg when the acceleration is 100 g or 750 kg when the acceleration is 200 g. The platform space is 2.17 (H) × 1.6 (L) x 1.25 m(W), which can satisfy the needs of both static tests and dynamic tests. The height (in the radius direction when the basket is swung up) of 2.17 m can also allow an in-flight robot, such as a pile-driving robot to be installed onto the container.

Earthquake Simulator

An in-flight shaking table has been developed to provide the horizontal base motion. It can work under a maximum centrifuge acceleration of 50 g while the maximum shaking acceleration is about 20 g. The maximum displacement is ±6 mm with a load of 2.94 kN (including both model and container).

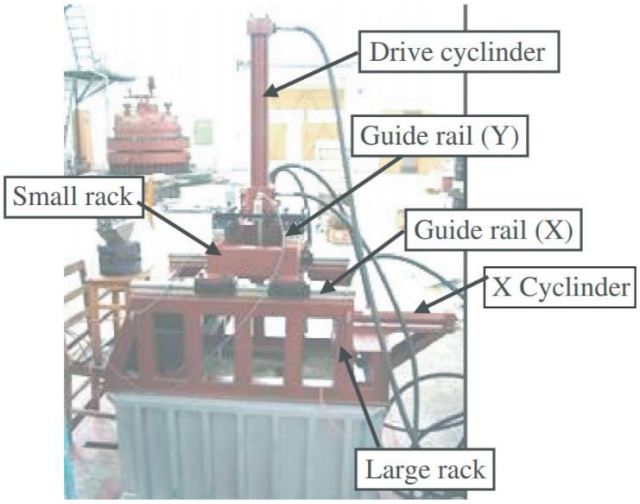
In-flight shaking table.

The shaking table utilizes a hydraulic actuator to vibrate the model container placed upon a slip table, which is installed together with the hydraulic cylinder, servo valve, connecting piece and accumulator in the bottom plate to make them a whole body. The under part of the slip table, the connecting parts and the basket work as the reaction mass. A single actuator is used to push the container and the special bottom structure ensures the sliding and guiding for the whole plate. The slip table and hydraulic cylinder are connected by a ball joint. An electro-hydraulic servo system is used to control the cylinder. Both the command and return signals are received by the main

controller and then amplified to drive the first stage servo valve and the second stage servo valve to push the hydraulic cylinder. The digital control system is responsible for the control of the acceleration of the system. An open loop system is adopted, the control manner being to reproduce the wave of the displacement and acceleration. The shaking table plate works in a way to control the displacement so that the real signal of the table matches the expected signal. The system reverse-transferring function is used to integrate the driving signal to get the expected signal.

Dynamic robot system

The dynamic robot system consists of a pile-driving, pile-pulling robot and an excavating robot to dig a hole or excavate a pit. A hydraulic servo control system is adopted, and a PC is used to control the movement of the robot, the pile penetration depth, the loading value and measurement and the whole system.



Pile-driving system.

The pile-driving system consists of a large rack, small rack, guide rail in the X direction, guide rail in the Y direction, X cylinder, Y cylinder and driving cylinder. The driving cylinder can accomplish a driving action after being set in any position within the range of the X and Y cylinders, which have strokes of 310 mm and 205 mm respectively. The stroke of driving cylinder is 460 mm. When pulling out piles, a sling dog is mounted on the end of the driving piston before operation which can pull the pile upward by moving the cylinder. Pile groups can also be pulled out by continuing the action while moving the X and Y cylinder. The largest pulling out distance is 400 mm.