Advanced Geotechnical Centrifuge Test Center

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Introduction

Geotechnical centrifuge is a professional equipment used to study complex geotechnical problems. Southwest Jiaotong University has been working on and developing the platform of centrifuge in the last 20 years. Now they have the Advanced Geotechnical Centrifuge Test Center with a maximum capacity of 150 g·t, and maximum centrifugal acceleration of 200 g. The test center has equipped with some advanced apparatus, including: a) high-speed cameram and image processing system for deformation analysis of model during the operation of centrifuge; b) a system used to simulate rainfall and changing of undergound water level. The maximum rainfall level of this system is 20 $L \cdot m^{-2} \cdot min^{-1}$, and the maximum water level is 200 mm; and c) a multi-axis robot system that can move to specific position (x, y, z) and posture (θ) under 100 g. This robot system can simulate some geotechnical construction processes, such as excavation, pile pulling, pit excavation, slope cutting etc. It can also be used to carried out penetration test. This centrifuge paltfrom can be used to study the performance of some geotechnical structures under complex situation.

Advanced Geotechnical Centrifuge Test Center.

Key Technical Spefications

Beam Centrifuge	
Manufacturer	China Academy of Engineering Physics
Year established	2001
Radius to base of soil container	2.7 m
Capacity	150 gton (1.5 tons @100g, max G-level: 200g)
Bucket area	1.2 m x 0.88 m
Major equipment	High-speed camera and image processing system (max G-level: 100g)

	Rainfall and underground water level change simulation system (capacity 1.5 tons @100g) Multi-axis robot system (capacity 1.5 tons @100g)

The beam centrifuge has an effective diameter of 5.4 m, and a maximum capacity of 150 gton. It can be accelerated up to 200g carrying a payload of 0.75 tons. One of the key advantage of the beam centrifuge is that the model can be installed without 90^{o} rotation (as in the drum centrifuge), thanks to the swing which rotates progressively with the increase of the g-level. As a result, the model base is always perpendicular to the acceleration vector. Each swing has a platform of 1.2 x 0.88 m, where the soil container is placed. The setup offers the possibility of a soil container of up to 1.2 m length, allowing testing large models corresponding to up to 240 m length (at the maximum g level).

The geotechnical beam centrifuge refurbished and installed at Southwest Jiaotong University.

The geotechnical beam centrifuge control system

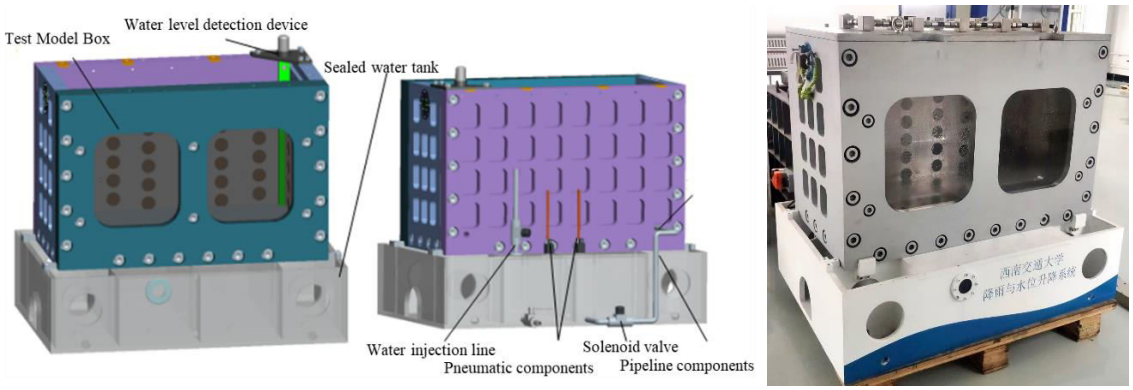
High-speed camera and image processing system

The system is primarily composed of an image acquisition system, image transmission system, and image storage and processing system. The image acquisition device (camera) is fixed near the

centrifuge model box and operates with the specimen under centrifugal force, enabling observation of the specimen inside the model box at up to 100 g acceleration. To prevent interference from centrifugal force, the external image acquisition card is fixed near the rotation center of the centrifuge. The image transmission system converts the Camera Link interface to a fiber interface through an external image acquisition card, and the fiber is connected to a storage computer in a remote control room via a fiber slip ring to record the images captured by the system. The image storage employs high-speed video storage software, which can instantaneously store digital images without compression directly to the PC hard disk or other storage media, and can record video data streams at the camera's maximum frame rate without dropping frames. The image processing system primarily uses TEMA software, which is an advanced offline image motion analysis software compatible with common image and video formats on the market, with strong operability and ease of use. The system's maximum tracking accuracy can reach 0.01 pixels.

Rainfall and underground water level change simulation system

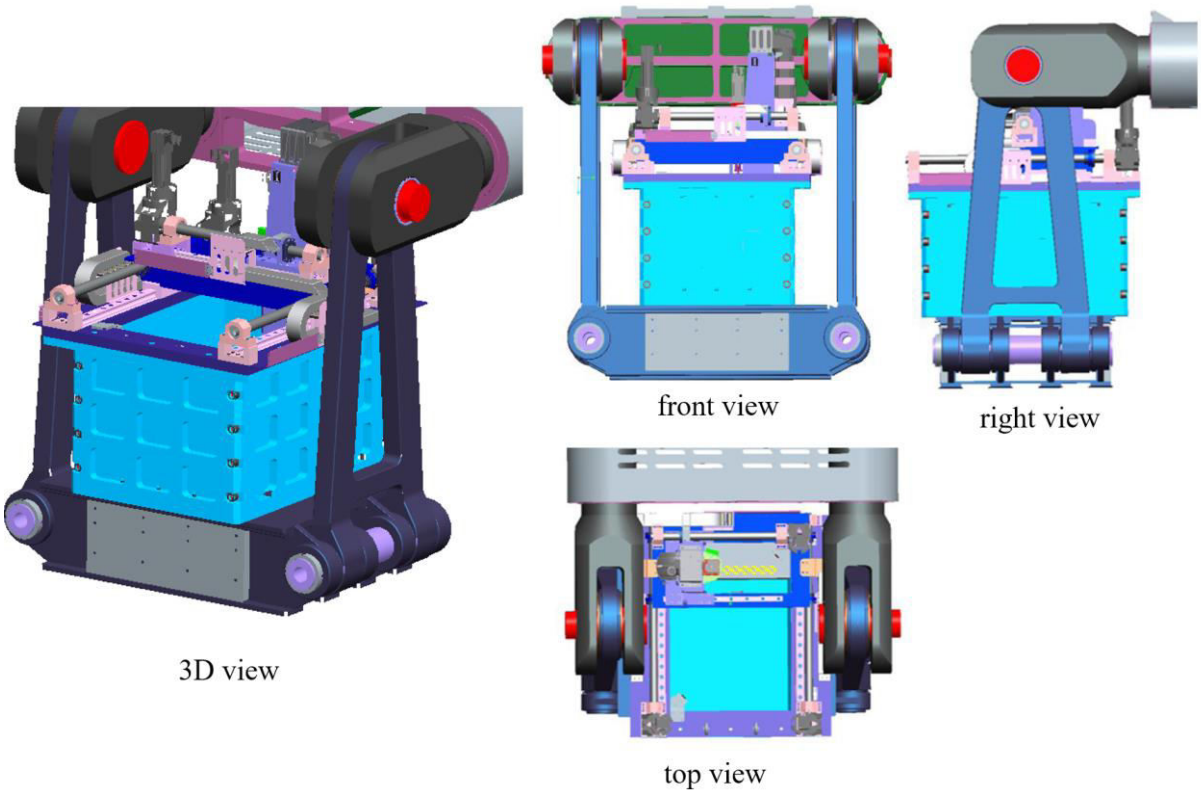
The rainfall and underground water level change simulation system can stably operate under a maximum centrifugal acceleration of 100g. The rainfall system is capable of simulating a maximum rainfall level of $20L \cdot m^{-2} \cdot min^{-1}$. The rain plate, which is made of aluminum alloy, is placed on the model box to support and secure the nozzles and water distribution devices, while also acting as a wind barrier to shield the raindrops inside the model box from the air flow generated by the centrifugal field. Changes in soil moisture caused by fluctuations in the underground water level can result in soil deformation and changes in soil strength characteristics, leading to slope instability, excessive settlement, or uplift deformation of foundations. To examine the force and deformation characteristics and instability mechanism of slopes and foundations under the effects of underground water level, the center is equipped with a water level fluctuation system that can achieve reciprocating fluctuation with a maximum water level fluctuation height of 200mm, enabling precise control of water level fluctuations. This system effectively supports research on the service performance of geotechnical structures such as embankments under the influence of rainfall and groundwater level fluctuations and provides technical support for revealing their failure mechanisms.



Schematic of the rainfall and underground water level change simulation system.

Multi-axis robot system

The multi-axis robots can carry out multiple actions on geotechnical models continuously, such as excavation and loading, without stopping the centrifuge, which simulates the actual construction process and provides technical support for investigating the impact of the construction process on the stress characteristics of geotechnical structures. The multi-axis robot system mainly comprises of a four-axis all-electric geotechnical centrifuge robot. It can move to a specified position (x, y, z) and posture (θ) during the operation of the 100g hypergravity centrifuge model test, realistically simulating actual soil construction processes, and executing various in-situ tests and displacement measurements, such as excavation, pile driving, pit excavation, slope cutting, etc., in a specific order on the test model.



Schematic of the Multi-axis robot system.