TU DELFT GEOTECHNICAL CENTRIFUGE
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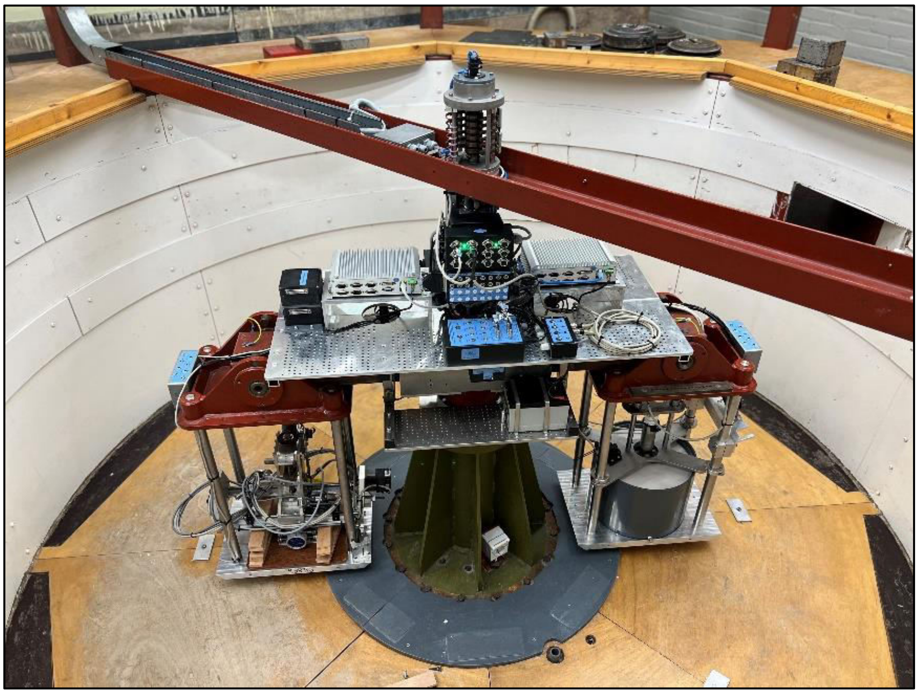
Owner: Delft University of Technology, Department of Geoscience and Engineering, Geo-Engineering section
Location: Delft, Netherlands

SUMMARY

The research laboratories at the Geo-Engineering section at TU Delft include a small-size, 9.0 g-ton geotechnical centrifuge with a 1.22-meter radius arm and symmetrical platforms swinging carriers. After it became fully operational in 1990, the geotechnical centrifuge has been continuously upgraded to adapt to state-of-the-art research activities. Past and current investigations of geotechnical structures and phenomena using this equipment include slope stability, levees, soil-structure interaction under static and cyclic loading, tunnelling, excavations, and shallow and deep foundation systems.



TU Delft Geotechnical Centrifuge (TU Delft 2023)

GENERAL SPECIFICATIONS

The geotechnical centrifuge at TU Delft was designed and built between 1988 and 1990 by Dr.ir. H.G.B. Allersma (Allersma, Centrifuge 94, 1994). The **arm assembly** consists of a beam with a length of 1.50 m, connected to the central axis's main shaft and to two swinging carriers at both ends. The **swinging carriers** allow mounting models with a base area of 0.3 by 0.4 m^2 and a height of up to 0.45 m. The **effective radius** between the central axis and the floor of the carriers is 1.22 m.

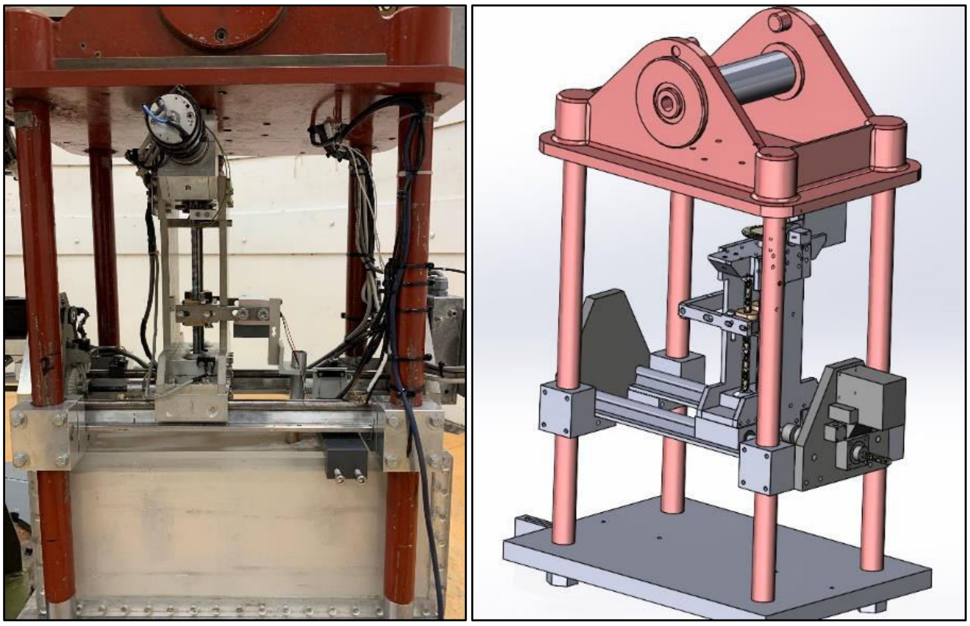
The **driving system** includes an 18 kW electric motor that allows a speed range capacity of up to 450 RPM, which translates to a maximum increment in the simulated gravitational acceleration of 300g. A **maximum payload** of 30 kg is allowed at 300g (centrifuge rated at approximately 9.0 g-ton).

Control and data communication is performed with an Ethernet Capsule Slip Ring with a maximum operating speed of 250 RPM, coupled to an onboard wireless router and the original eight-slip-ring system included in the original assembly. The complete system includes 46 communication channels operating at a maximum data logging frequency of 200 kHz.

CUSTOMIZED MODELLING TOOLS

Two-dimensional Loading System

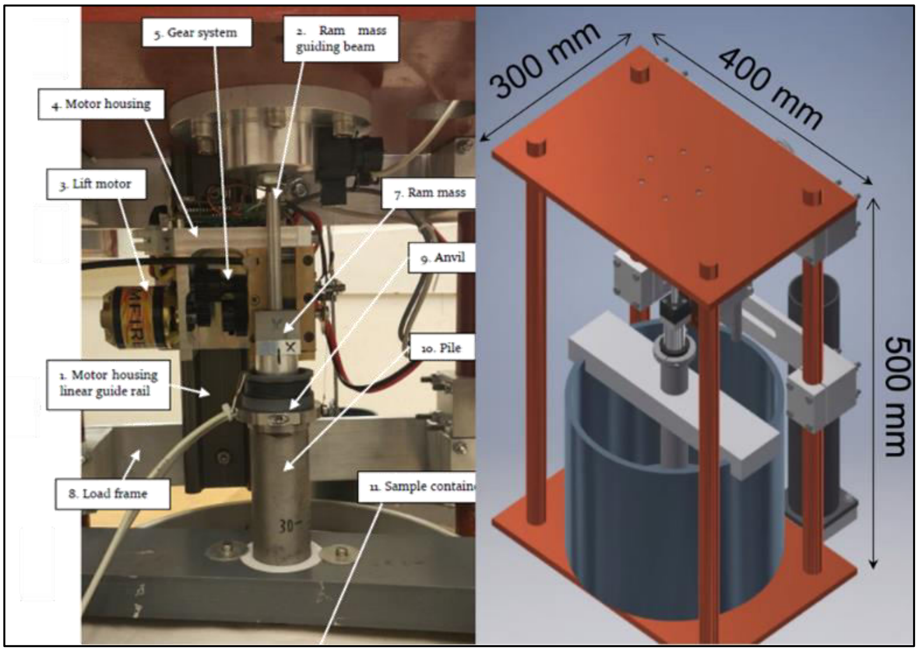
This equipment allows in-flight lateral and horizontal loading to small-scale deep foundation models. The system includes a customized actuator with vertical and lateral movement working under both load- and displacement-controlled conditions (Li et al., Geotechnical Testing Journal 43.5, 2020). With adequate sensing instruments on the foundation element, this equipment has been used to investigate the behaviour of monopiles under different loading conditions and for different bearing soils (e.g., Li et al., Canadian Geotechnical Journal 58.11, 2021).



General setup and sketch for TU Delft two-dimensional loading system (Chortis et al., Ocean Engineering 197, 2020)

Impact-Driving Simulator

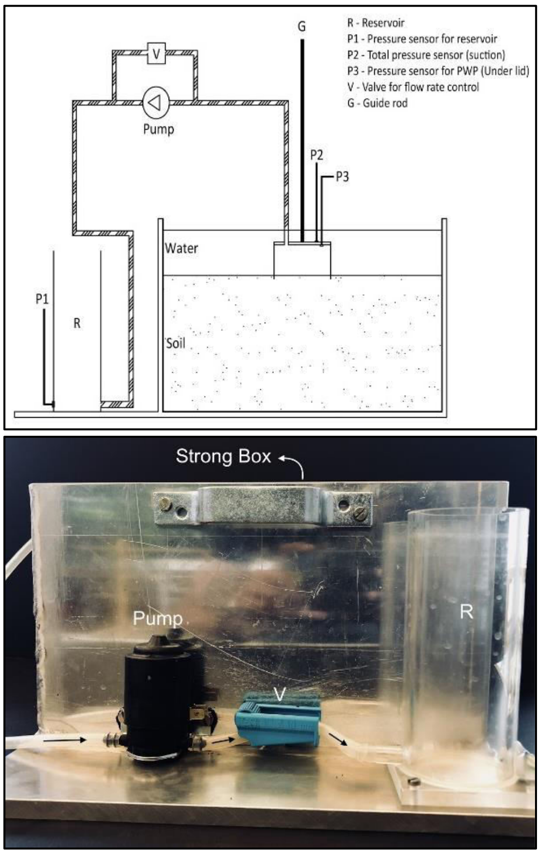
The impact-driving simulator induces impact frequencies and energy levels in small-scale centrifuge models similar to those observed in the field (van Zeben et al., Physical Modelling in Geotechnics, vol. 1, 2018). This device has been utilized to investigate the pore pressure evolution experienced during the installation of open-ended piles in offshore applications and the efficiency of the installation method compared to other installation alternatives (Askarinejad et al., ECPMG 2020). Current developments have upgraded the impact-driving actuator to achieve greater impact loads and allows the study of alternative installation methods (Quinten et al., ICPMG 2022).



General setup and sketch for TU Delft in-flight impact-driving system (van Zeben, M.Sc. Thesis, TU Delft, 2019)

Suction Caisson Installer

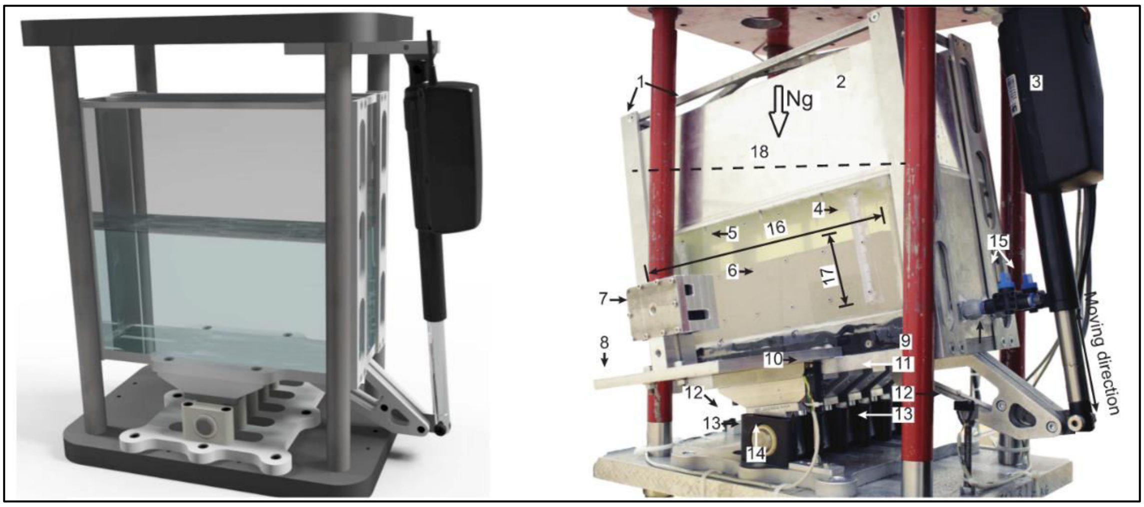
This system allows modelling the installation of suction piles in centrifuge while monitoring the loading response of the pile and the undrained soil response (Yuen et al., ECPMG 2020). The setup comprises a customized strongbox made of aluminium and a pump and solenoid valve, which control the installation mechanism.



Sketch and general setup for TU Delft suction caisson installer (Yuen et al., ECPMG 2020)

Tilting Table

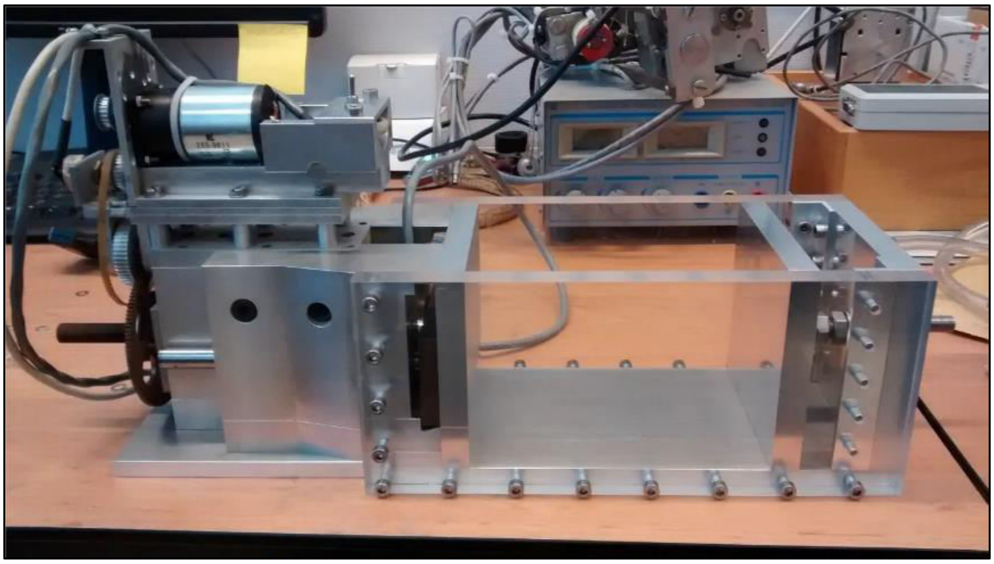
This equipment comprises a base plate supporting the small-scale model and an actuator assembly that allows a controlled, in-flight, single-plane rotation of the model (Zhang and Askarinejad, Landslides 16.10, 2019). The general device was initially designed to model static liquefaction in marine environments and their interaction with buried pipelines, but other applications are possible, including slope stability and mass movement investigation.



Sketch and general setup for TU Delft centrifuge tilting table (Zhang and Askarinejad, Landslides 16.10, 2019)

Retaining Wall Simulator

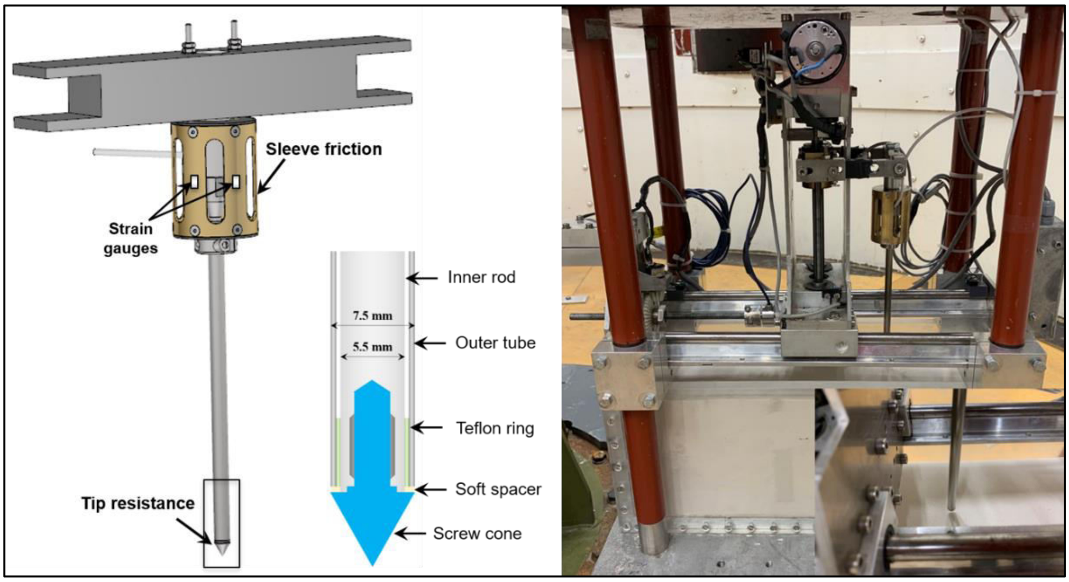
The retaining wall simulator allows modelling active and passive stresses in small-scale centrifuge models. The device was designed and built to investigate the overlapping of the passive zones phenomenon (Hopman, Ph.D. Thesis, TU Delft, 2016).



General setup for TU Delft retaining wall simulator (Hopman, Ph.D. Thesis, TU Delft, 2016)

Centrifuge Mini-CPT Assembly

The newly developed mini-CPT adapts to small-scale modelling the well-known and widely utilized in geotechnical engineering practice Cone Penetration Tests (CPT). This equipment is currently used to obtain qc profiles of centrifuge specimens used on deep foundation investigations (Wang et al., Cone Penetration Testing 2022).



Sketch and general setup for TU Delft mini-CPT (Wang et al., Cone Penetration Testing 2022)

0.25 m-radius Centrifuge

TU Delft also has a secondary centrifuge device with a 0.25-meter radius arm and is currently used for clay samples preparations.

TU Delft 0.25 m-radius geotechnical centrifuge (TU Delft 2023)