Proceedings of the

SYMPOSIUM ON RECENT ADVANCES IN GEOTECHNICAL CENTRIFUGE MODELING

A symposium on Recent Advances in Geotechnical Centrifuge Modeling was held on July 18-20, 1984 at the University of California at Davis. The symposium was sponsored by the National Science Foundation's Geotechnical Engineering Program and the Center for Geotechnical Modeling at the University of California at Davis.

The symposium offered an opportunity for a meeting of the International Committee on Centrifuges of the International Society for Soil Mechanics and Foundation Engineering. The U.S. participants also met to discuss the advancement of the centrifuge modeling technique in the U.S. A request is being transmitted to the American Society of Civil Engineers to establish a subcommittee on centrifuges within the Geotechnical Engineering Division.

THE L.C.P.C. CENTRIFUGE

J.-F. CORTE Head Geotechnical and Soil Mechanics Division * 2
Laboratoire Central des Ponts et Chaussées (France)

Centrifugal testing for geotechnical studies has been practised in France at the Laboratoire Central des Ponts et Chaussées (L.C.P.C.) since 1975. However the experimentations had to be run on the facilities of the Commissariat à l'Energie Atomique (C.E.A.) which were designed for defense applications. In 1980 a proposal to build a new large centrifuge, entirely devoted to geotechnical studies, was accepted and the L.C.P.C. centrifuge should be in operation by the end of 1984.

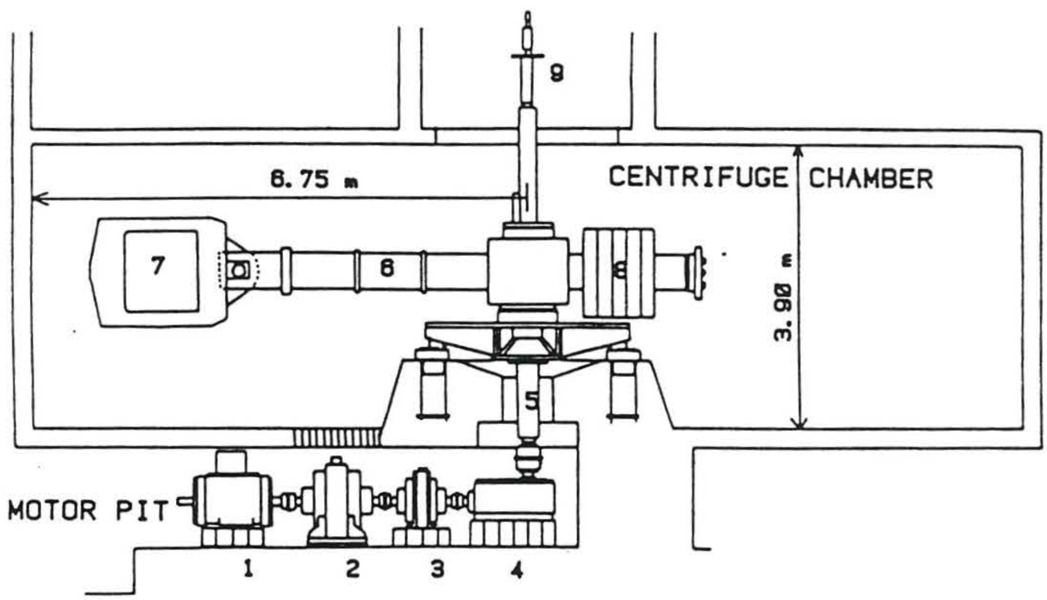
The main characteristics which define the capacity of this machine are summarized in Table 1.

distance to platform surface		5.50 m
maximum acceleration at 5m radius		200 G
maximum payload	at 100 G	2 000 kg
" "	at 200 G	> 500 kg
maximum package dimensions	length	1.40 m
	width	1.10 m
	height	1.50 m
run up time to 100 G		180 s

Table 1. L.C.P.C. Centrifuge capacity

THE CENTRIFUGE

The centrifuge was designed by ACUTRONIC Corporation from the specifications defined by L.C.P.C. for performance and operation of the machine. The design of the mechanical parts aimed at avoiding complex states of stresses for a good understanding of all the efforts in the most highly strained regions. Moreover to limit the uncertainties in ageing brought by the manufacturing process, all parts are free from welding except the platform and the bearing support. Figure 1 shows a general view of the centrifuge and its drive unit.



1. AC MOTOR
2. EDDY CURRENT CLUTCH
3. EDDY CURRENT BRAKE
4. GEAR BOX
5. DRIVING SHAFT
6. ROTOR ARM
7. COUNTERWEIGHTS
8. SWINGING BASKET
9. SLIPRING STACK

Figure 1. L.C.P.C. Centrifuge. Machine and drive unit

The swinging basket

Its design had to conciliate antagonistic objectives : low mass, high rigidity and large openings allowing easy access to the model package and photographic observation of the rear face of the model in flight. (Figure 2). Finite element analyses were made to improve the design.

The platform has a honeycomb welded structure ; its stiffness limits the deflection to less than 1 mm under maximum load. The swing arms are machined from steel plates 100 mm thick.

In order to reduce aerodynamic forces, the swinging basket is covered with fairings designed from model tests with a small centrifuge at a 1/19 scale.

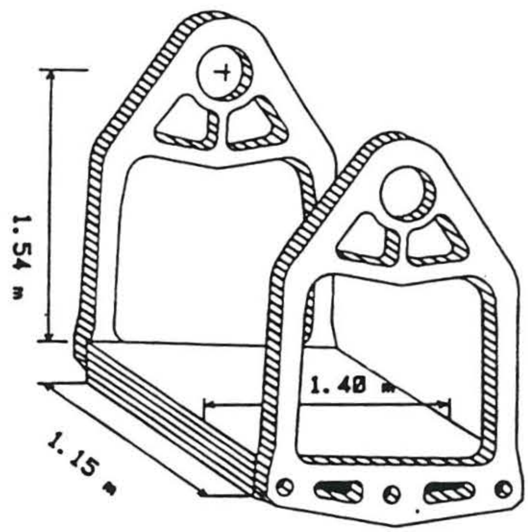


Figure 2. Swinging basket without its fairings

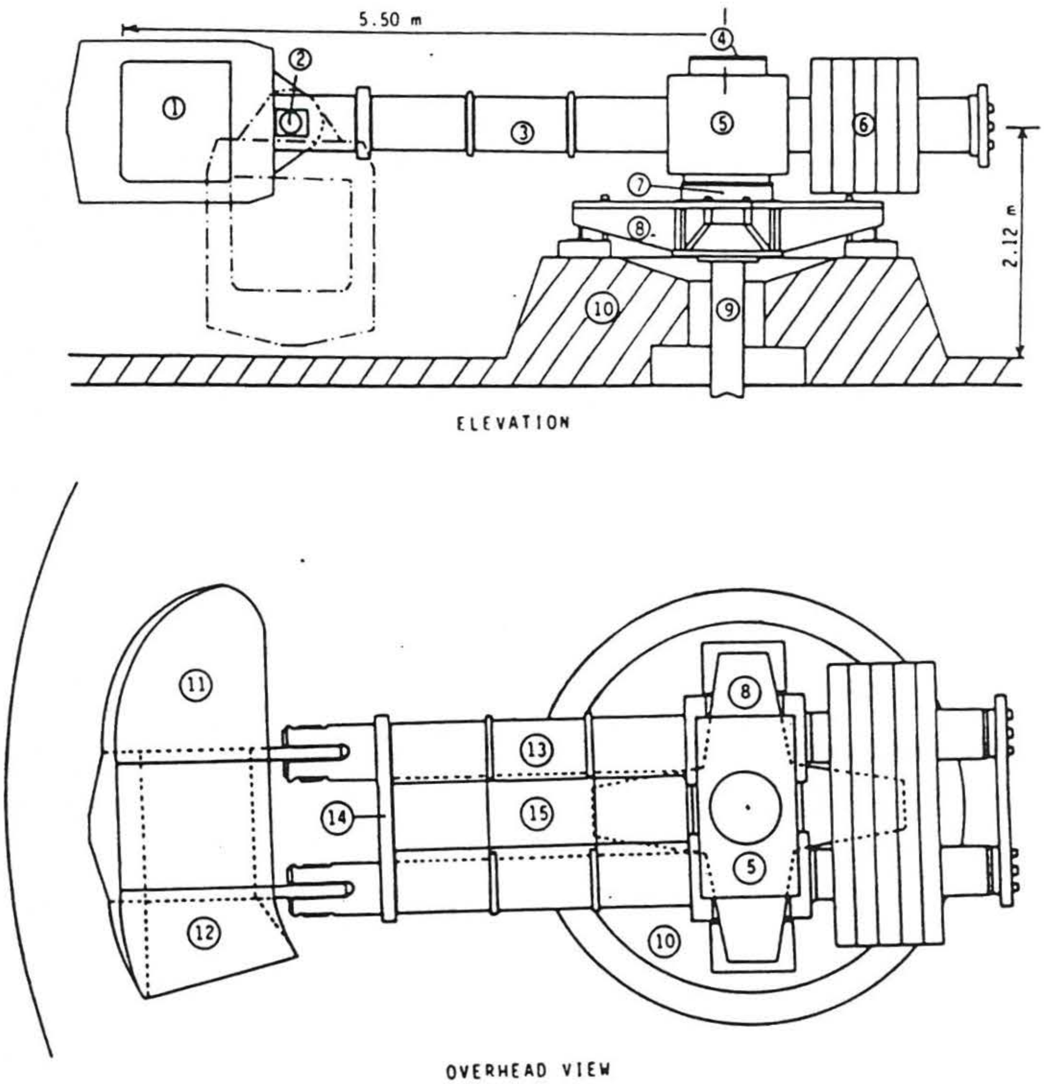
<u>The rotor and its support</u>

The rotor arm is dissymetrical to reduce power requirements (Figure 3). It is made from two cylindrical solid blanks of steel (0.50 m in diameter, 6.50 m long, mass 6800 kg).

On the basket side the bars are bored to reduce their weight and are machined to support the sperical bearing of the swinging basket. The opposite portion is threaded for the displacement of the counterweights.

These two cylinders are fixed to the central box by four compression rings. The rotor is connected to the vertical driving shaft by a diaphragm.

The counterweights are made of five cast iron plates of 3500 kg each. The balance is adjusted by displacement along the threaded portion of the arm.



1. Swinging basket
2. Spherical bearing
3. Rotor arm
4. Diaphragm
5. Central driving box
6. Counterweight
7. Bearing shaft
8. Support
9. Driving shaft
10. Concrete base
11. Basket front shroud
12. Basket rear shroud
13. Arm tube
14. Brace
15. Hinged lid cover

Figure 3. Elevation and overhead drawings of the L.C.P.C. Centrifuge

The hollow bearing shaft carries three roller bearings. The radial forces act on two barrel-shaped roller bearings placed symmetrically with respect to the medium plane of the rotor. The gravity load is carried by a third taper roller bearing placed underneath. The bearing shaft is welded to a four-arm base.

To drive unit

The drive system consists of four elements : a constant speed electric motor, an eddy current clutch, an eddy current brake and a gear box. This solution has been selected mainly because it generates a minimum of electric interferences.

The A.C. motor has two speeds for better efficiency and lower running costs. Its characteristics are given in table 2.

number of poles	4	6	
rotating speed at full load	1 480	985	rpm
nominal power	410	170	kW
efficiency at full load	94	94,8	%
nominal torque	2 645	1 650	Nm
maximum torque	4 760	5 110	Nm

Table 2. Characteristics of the dual speed motor

DATA ACQUISITION SYSTEM, OBSERVATION AND OPERATION ON THE MODEL

Data acquisition

Different lines are provided to transfer data exchanges between the model mounted on the swinging platform and the control room, via sliprings. Two different configurations are available (Figure 4).

In the first case, a 100 channel H.B.M. acquisition chain is fixed on the rotor near the central shaft. Analog signals from the transducers placed on the model are sampled, digitized and stored. The results are then transmitted to the computer in the control room via a IEEE 488 line with HP-IB extender via only one high frequency slipring. The acquisition frequency is about 20 channels/s.

In the second configuration the analog signals transit directly via the 100 low noise sliprings to analog recorders in the control room. The twenty coaxial lines have a bandwidth of more than 10 Mg Hz, and the eighty two-conductors armored lines can transmit signals of 1 Mg Hz.

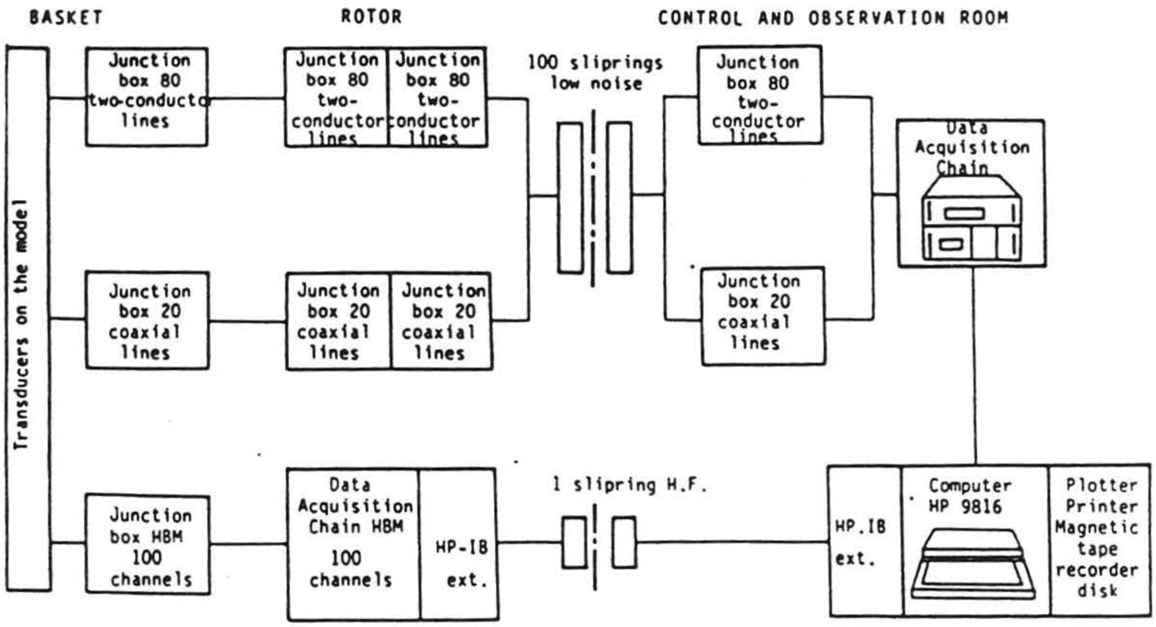


Figure 4. Organization of the data acquisition system

Observation of the model

Three television cameras are used : two survey the centrifuge chamber, the third one is fixed on the rotor arm and gives a continuous overhead view of the model.

The rear face of the model can also be photographed in flight from a small room adjacent to the centrifuge chamber.

Operations on the model

Various tools and equipments to load foundations, to build embankments or to excavate in flight are presently under study.

Electric energy is supplied to equipments mounted on the model or on the rotor arm by five power sliprings (3 phases, 1 neutral, 1 earth). Six rotary joints (two high pressure 20 MPa, four low pressure 1 MPa) are also available for the command of hydraulic or pneumatic devices.

Figure 5 shows the general arrangement of the service lines.

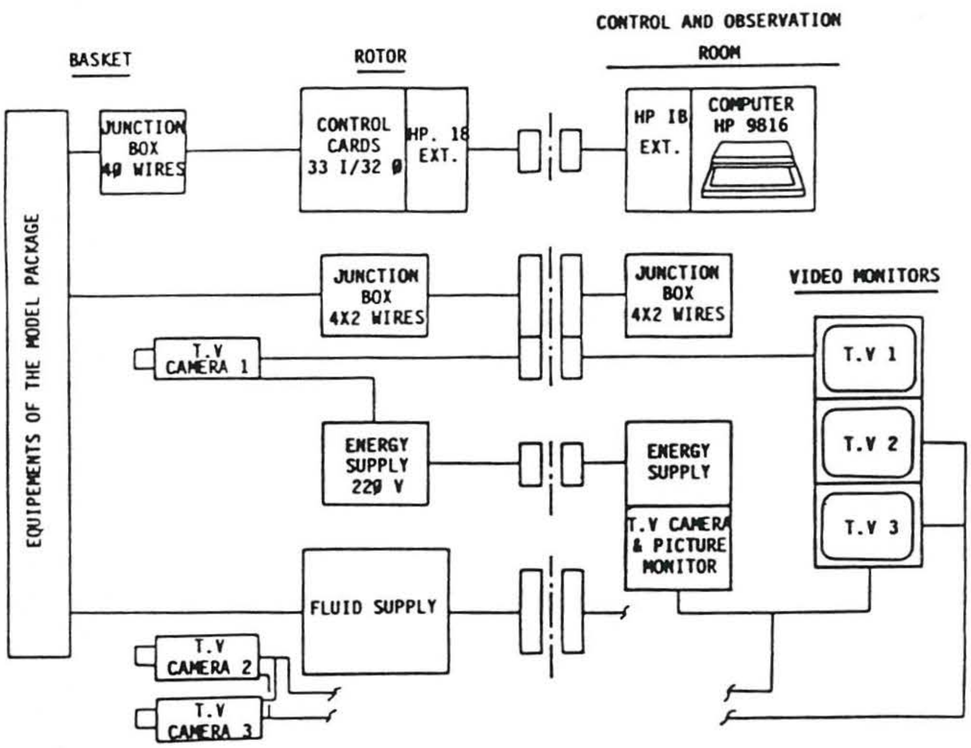


Figure 5. Service lines for observation an operations on the model in flight

THE CENTRIFUGE BUILDING.

The centrifuge is built on the Nantes Center site of the L.C.P.C. in a special building shown by Figure 6. For a convenient use all the facilities have been placed together : from the soil preparation laboratory to the centrifuge chamber ; these rooms are also at the same level. The centrifuge chamber which houses the rotor is 13.5 m in diameter and almost 4 m high. For safety, the reinforced concrete wall is surrounded by an embankment 6 m thick.

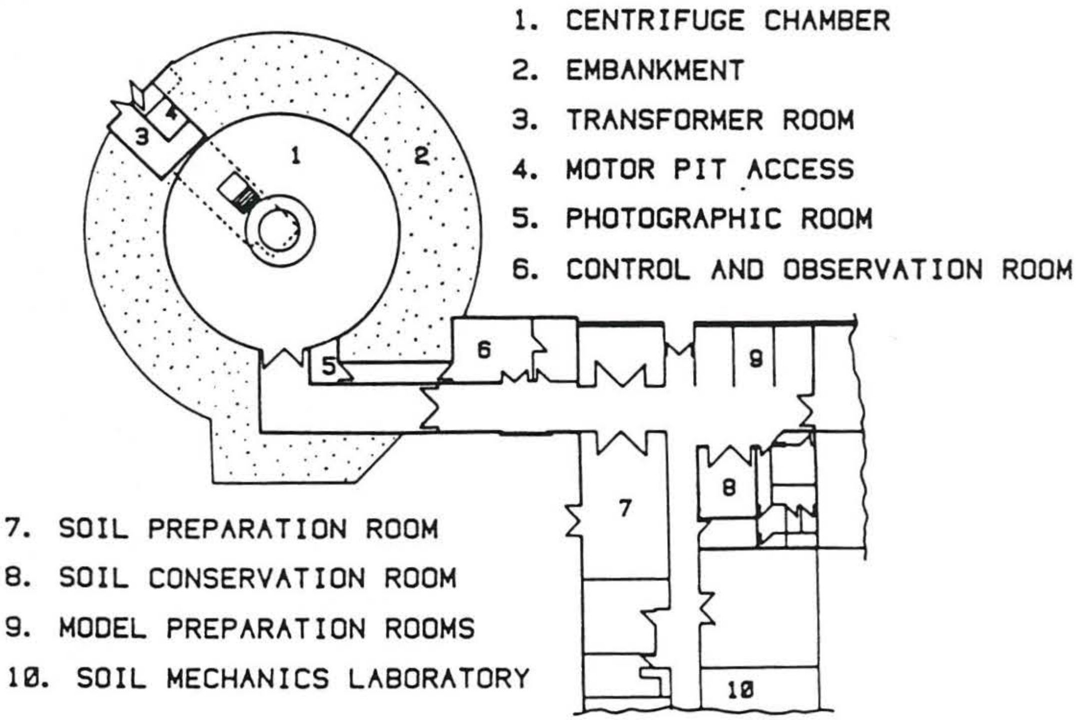


Figure 6. L.C.P.C. centrifuge facilities