THE EARTHQUAKE ENGINEERING RESEARCH LABORATORY FACILITIES OF CGS (ALGERIA)

1. INTRODUCTION

The earthquake engineering laboratory at National Earthquake Engineering Applied Research Center, CGS was completed at the end of 2010. The laboratory facilities are specifically designed in order to test civil engineering structures and components up to collapse or ultimate limit states. Its primary mission is to study and check the seismic performance of the civil engineering structures and other industrial equipments.

The research activities will include:

- The development of experimental research in the field of earthquake engineering
- Dynamic qualification test of industrial equipment
- Conduct a collaborative research project with national and international institutions

Ultimately, the goal of the laboratory is to improve our understanding of earthquakes and their effects in order to make a significant contribution to the important issue of seismic safety in Algeria and around the world.

2. LABORATORY FACILITIES

The Laboratory is located at SEBALLA 10 Km west of Algiers. The main testing equipments of this laboratory comprise, the 32×13 square meter strong reaction floor, 15 meters high by 13 meter wide reaction wall, 6.1×6.1 meter square tri-axial shaking table, an advanced hydraulic distribution system, a series of high performance actuators, two high-capacity bridge cranes and 128-channel data acquisition system.

The main view of the laboratory is shown in Figure 2.1 and Figure 2.2 illustrates the configuration of the internal space of the laboratory.

Figure 2.1. Main view of the laboratory

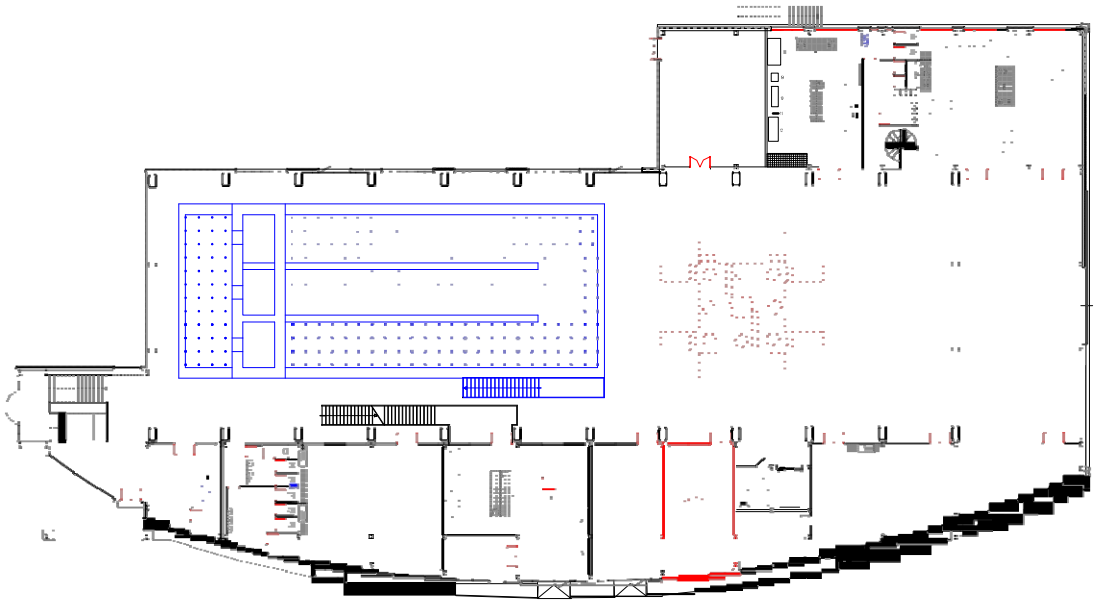


Figure 2.2. Ground floor level of the laboratory

3. PSEUDO-DYNAMIC TESTING FACILITY

The Pseudo-dynamic testing facility of the laboratory, shown in Figure 3.1, will offer the possibility to perform a seismic tests on a full or reduced scale specimens, by using various experimental methods, such as traditional quasi-static tests, cyclic loading tests and pseudodynamic tests with substructuring techniques, as well techniques for modal assessment and system identification. Here after, a brief description of the key components of the pseudo-dynamic testing facility are introduced.

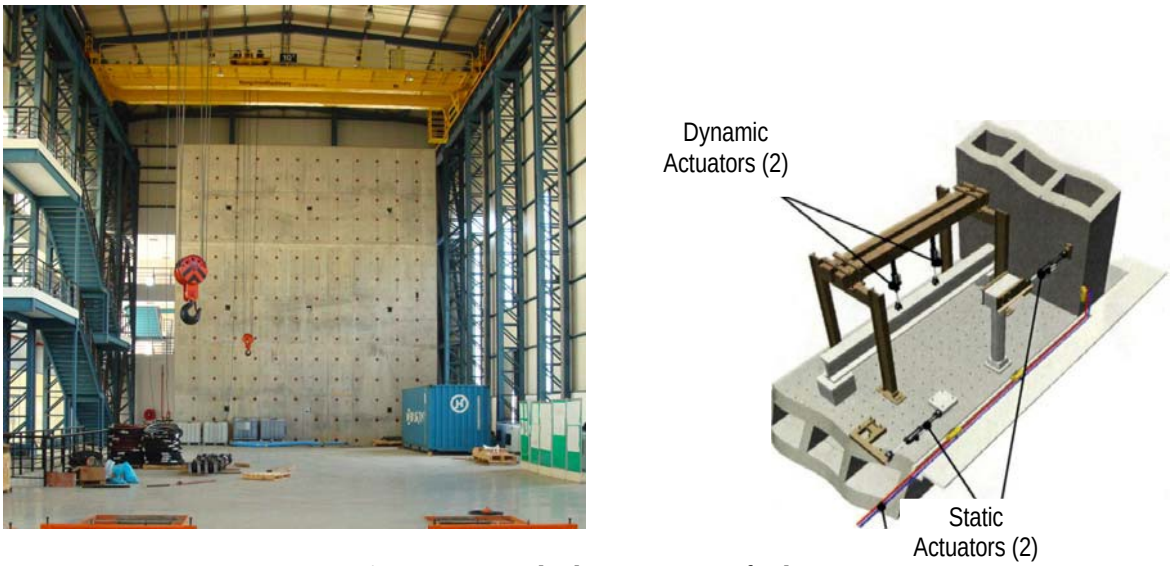


Figure 3.1. Pseudo-dynamic testing facility

3.1. Strong Floor

The strong floor consists of a 1m thick reinforced and post-tensioned concrete slab with 13 × 32 square meter of usable test area. It features tie-down holes that are spaced each 1 m x 1 m having a capacity of axial force of 500 kN.

3.2. Reaction Wall

The reaction wall consists of a 15 m high by 13 m wide reinforced and post-tensioned concrete wall. It features tie-down holes that are spaced each 1 m x 1 m. The maximum load capacities of reaction wall is 120 MN.m bending moment and 12 MN base shear force. The specified concrete compressive strength for the reaction wall and strong floor is 40 MPa.

3.3. Hydraulic Actuators

There are 04 hydraulic actuators, 2 for dynamic and 2 for static loadings. The capacities of these actuators are listed in Table 3.1. All of the actuators are double acting, push and pull.

Table 3.1. Actuator capacities

Actuator MTS model	Quantity	Stroke (mm)	Force (kN)	Servovalve (LPM)	Rating
244.41S	02	508	±550	1500	Dynamic
244.41	02	1016	±550	57	Static

3.4. Controller

MTS FlexTest™GT Controller: The FlexTest™GT Control System is powerful and flexible digital controller for general testing application and includes specific application software for Civil Engineering applications. The current configuration allows up to 4 actuators and 4 independent test stations to run simultaneously. This means that any of the four actuators may be assigned to either controller and operated separately or together.

4. SHAKING TABLE FACILITY

The CGS shaking table consists of 6.1m x6.1m steel platform of 40 tons weight which has six degrees of freedom controlled by twelve actuators. Its primary function is to replicate in the laboratory a real earthquake motion inputs, an artificial ground motions and a wide range of vibration signals to simulate induced vibration, to a specimen having a maximal weight of 60 tons. The system is capable of simulating earthquake events and other ground vibration with displacements of ±150 mm and ±250mm in the horizontal directions and ±100mm in the vertical direction. Accelerations of ±1.0 g for horizontal directions and ±0.8 g for vertical direction are possible with maximum test specimens of 60 tons. Figure 4.1 shows a view of the shaking table and its components.

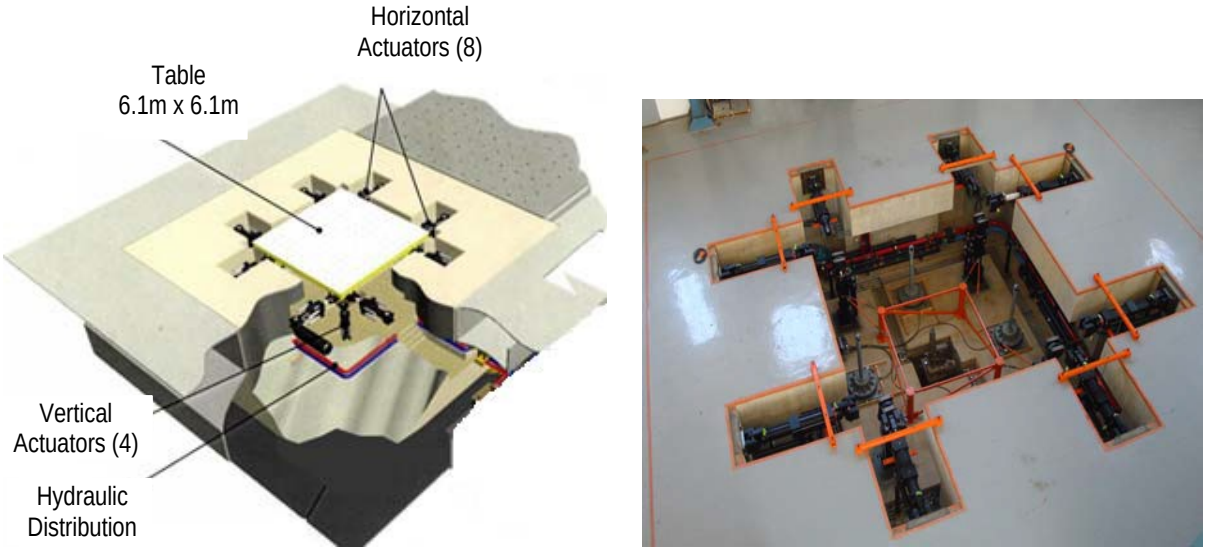
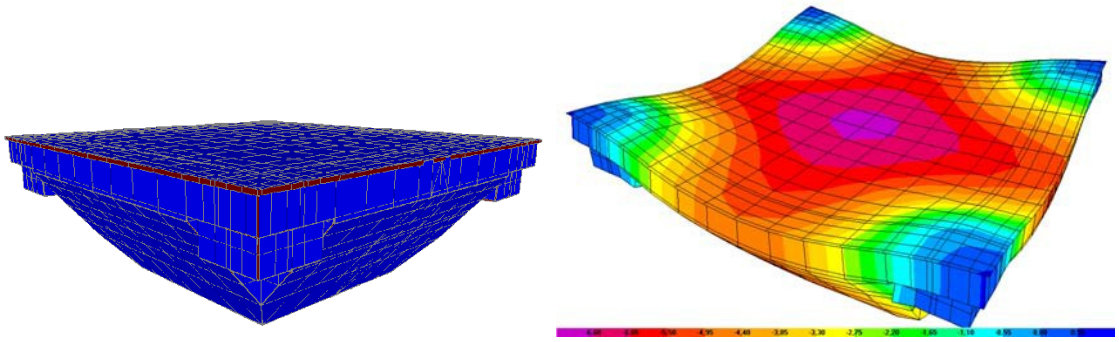


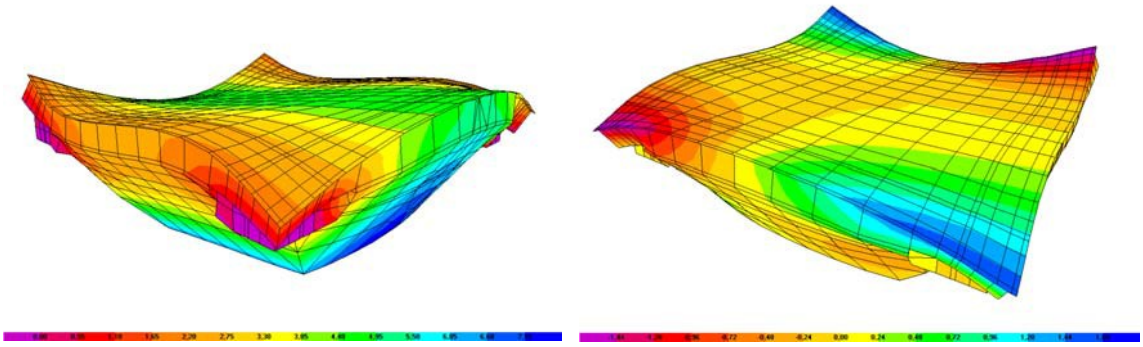
Figure 4.1. CGS Shaking Table

The shake table platform, or platen, represents a structural steel box of variable depth up to 2.2m. The platen is fabricated in two pieces and will be assembled on-site using field welding. A computational model of the platen is developed using a finite element analysis package SAP2000 in order to verify its stiffness requirements and to ensure the table design has a vibrational first mode well above the desired operating frequency range of the system. Figure 4.2 below shows a schematic of the platen and its first three modes of vibration.



(a) Platen (b) Mode 1: freq = 98,27 Hz (vertical mode**)**

Figure 4.2. Analytical model and mode shapes of the platform (continue)



(c) Mode 2: freq = 126,69Hz (X direction mode) (d) Mode 3: freq = 127,26Hz (Y direction mode)

Figure 4.2. Analytical model and mode shapes of the platform

4.1. Technical parameters

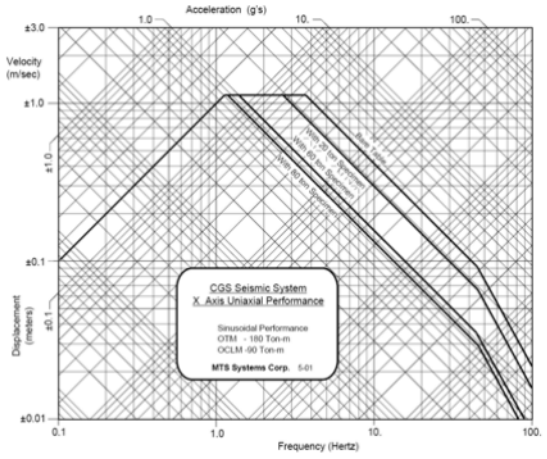
The main specification of the shaking table is given in Table 4.1.

Table 4.1. Main Specification of the shaking table

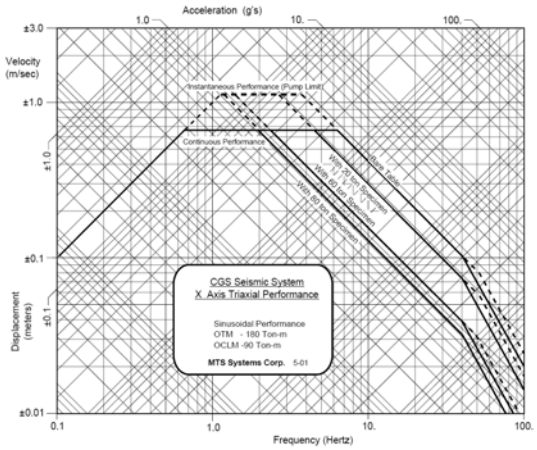
DOF	06		
Table Size (m)	6.1 × 6.1		
Specimen Mass (Ton)	60		
Shaking Direction	X-Horizontal	Y-Horizontal	Z-Vertical
Acceleration (g)	±1.0	±1.0	±0.8
Velocity (m/sec)	±1.1	±1.1	±1.0
Displacement (m)	±0.25	±0.15	±0.10
OTM (Ton-m)	180		
OCLM (Ton-m)	90		
Freq. Range (Hz)	0.1-50		

4.2. Performance envelopes of the shaking table

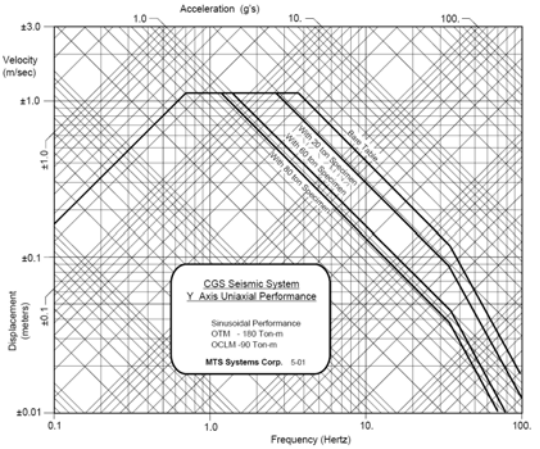
The performance envelopes of the shaking table in a tripartite plot for a bare table condition and a table loaded with 20 ton flexible payload as well as a table loaded with a 60 ton rigid payload are shown in Figure 4.3 for X, Y and Z axis, respectively.



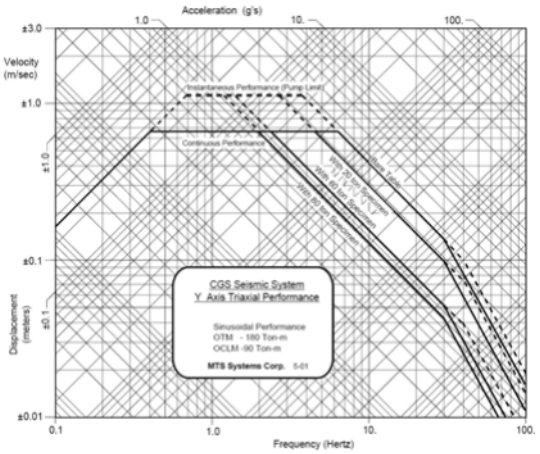
(a) X axis uniaxial performance



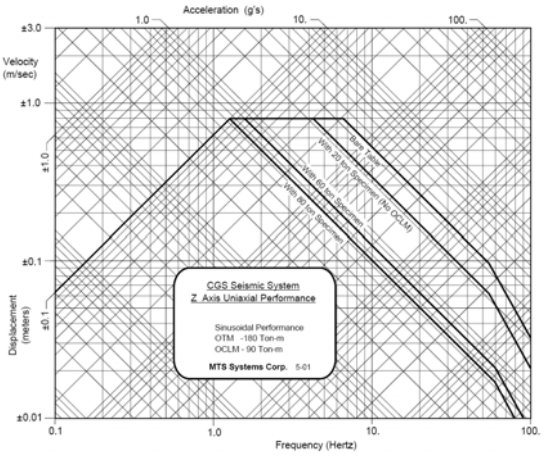
(b) X axis triaxial performance



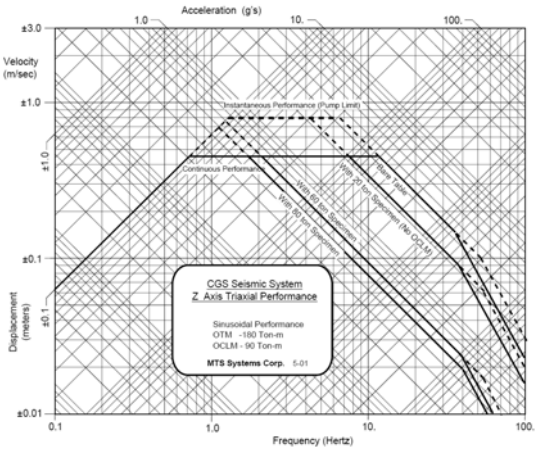
(c) Y axis uniaxial performance



(d) Y axis triaxial performance



(e) Z axis uniaxial performance



(f) Z axis triaxial performance

Figure 4.3. Performance envelopes of the shaking table

4.3. Controller and software

4.3.1. MTS 469D Digital Control System:

MTS 469D Digital Control system commands the shaking table's movement. The controller provides for closed loop control of motion in translation and rotation about the 3 principal axes. The controller is designed so that each of these 6 degrees of freedom can be programmed individually and run

concurrently. Earthquake acceleration records are used in programming the command signal to the shaking table.

4.3.2. STEX3 Digital Computer Subsystem:
STEX3 supplements the real time MTS 469D Digital Controller by providing additional table programming capabilities. Tests can be programmed for data acquisition only, system frequency response measurement, and the execution of time history and compensated test waveforms. The STEX3 software is designed to provide advanced capabilities in the following areas:

- Set up and configuration of seismic tests
- Execution of tests and acquisition of system and specimen data
- Synthesis of earthquakes from Power Spectra Density, PSD, and response spectra
- Analysis and processing of acquired data
- Modeling of the system response
- Execution of iterative, compensated testing for high accuracy results

Ability to transfer, archives, and maintain complete test histories

5. OTHER FACILITIES

5.1. Hydraulic power supply

The hydraulic power supplies the laboratory equipment consists of 6 high pressure pumps that can deliver a total of 4200 liters per minute at 20.5 MPa and (8× 45 liters) accumulators distributed in the pit for peak demands.

Figure 5.1. View of the hydraulic power supply

5.2. Data acquisition

The data acquisition system consists of 128 channels of Conditioned inputs (DC conditioner), expandable. The system is portable and can be easily moved with the STEX computer to the structural area during testing. Maximum sampling rate per channel simultaneously is 2000 data samples per second. The main features of the acquisition system are:

- Signal input panel for easy hookup
- Programmable differential amplifier
- Programmable anti – aliasing filter
- Programmable excitation
- Auto zero and balance
- 16 bit conversion accuracy
- Data storage for up to 512 kB per channel

5.3. Bridge Cranes:

Two overhead bridge cranes span the laboratory. One crane has 32 ton capacity and the other has 10 tons capacity. The cranes have a clear height of 16.5m and travel in the longitudinal and transverse directions. They are remotely controlled and can operate in unison or independently of each other.

5.4. Fabrication and Staging Area

One thousand two hundred square meters (1200m^2) fabrication, staging, and storage area is adjacent to the building. This area will be used for fabricating the specimens that will be tested either on the shaking table or on the strong floor and the reaction wall. After testing the damaged specimens will be removed outside using a 7 ton forklifts.