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INGENIERIA Y SISTEMAS, S.A.

STRUCTURAL DYNAMIC TESTING LABORATORY

Structural Dynamic Testing Laboratory

Aries Ingeniería y Sistemas, S.A. (Aries) provides complete **Structural Dynamic Testing Laboratories** to perform quasi-static, pseudo-dynamic, and dynamic tests in order to fully understand the failure mechanisms and collapse process of structures. The laboratory is typically comprised of a test bench and strong floor equipped with reaction wall and mass. The various types of test benches are: load frames, servo-hydraulic systems, and shaking tables, so the laboratory can provide quasi-static, pseudo-dynamic, and dynamic testing. Smaller laboratories in structural and geotechnical engineering can be integrated in the Structural Dynamic Testing Laboratory and can be used for research and instruction.

Quasi-Static Test: In the quasi-static test, the specimen is subjected to a predefined history of loads or displacements. It is done at a reduced velocity compared to the expected velocity when subjected to, for example, an earthquake. The objectives is to know the stiffness and other structural parameters.

Pseudo-Dynamic Test: Structural displacements due to external loading are calculated computationally using a stepwise integration procedure and applied quasi-statically to the test specimen. The resulting resistance forces are measured and fed back to the computational model as part of the input for the next calculation step.

Dynamic Test: In this test, the loads are applied continuously on the structure. The dynamic test is used for fatigue or real time hybrid testing, as well as other applications as the **Shaking Table,** a device for shaking structural models or building components with a wide range of simulated ground motions, including reproductions of recorded earthquakes. The shaking table can be used to test the structural response to verify seismic performance.

Civil Work definition: **Aries Ingeniería y Sistemas** provides civil works definition for any need, from the reaction wall, reaction mass, or strong floor to the complete laboratory.

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STRUCTURAL DYNAMIC TESTING LABORATORY

1. QUASI-STATIC & PSEUDO-DYNAMIC

2. DYNAMIC: SHAKING TABLE

- 2.1. GENERAL
- 2.2. PERFORMANCE
- 2.3. SYSTEM SIZING
- 2.4. CONTROL SYSTEM

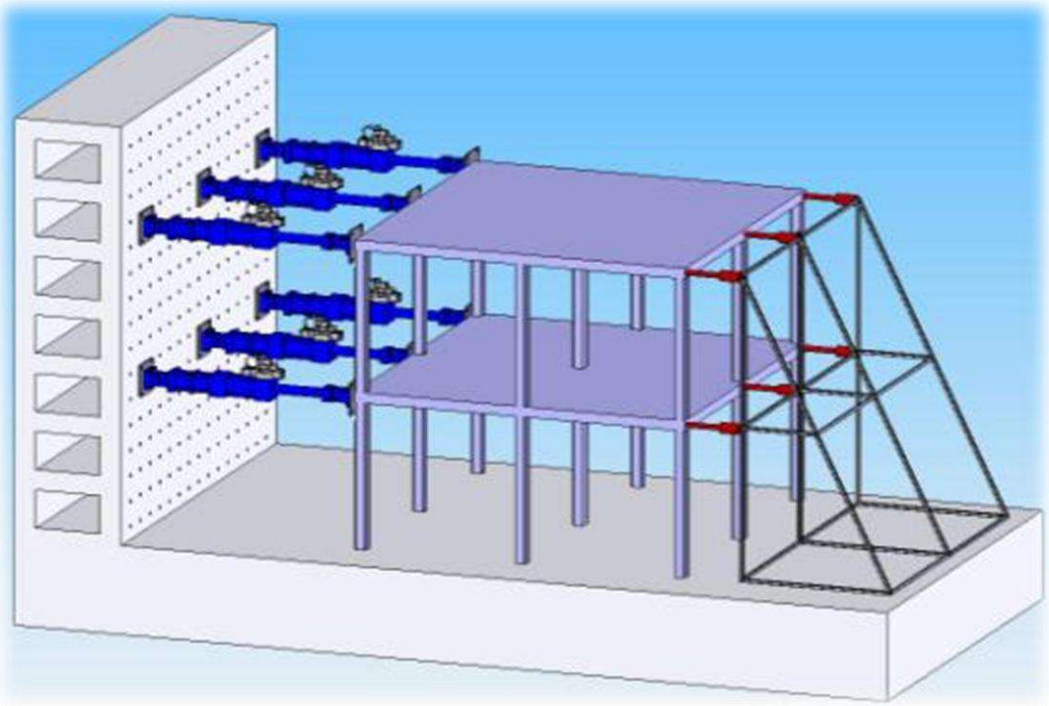
3. CIVIL WORK

4. CONCLUSION

5. CONTACT

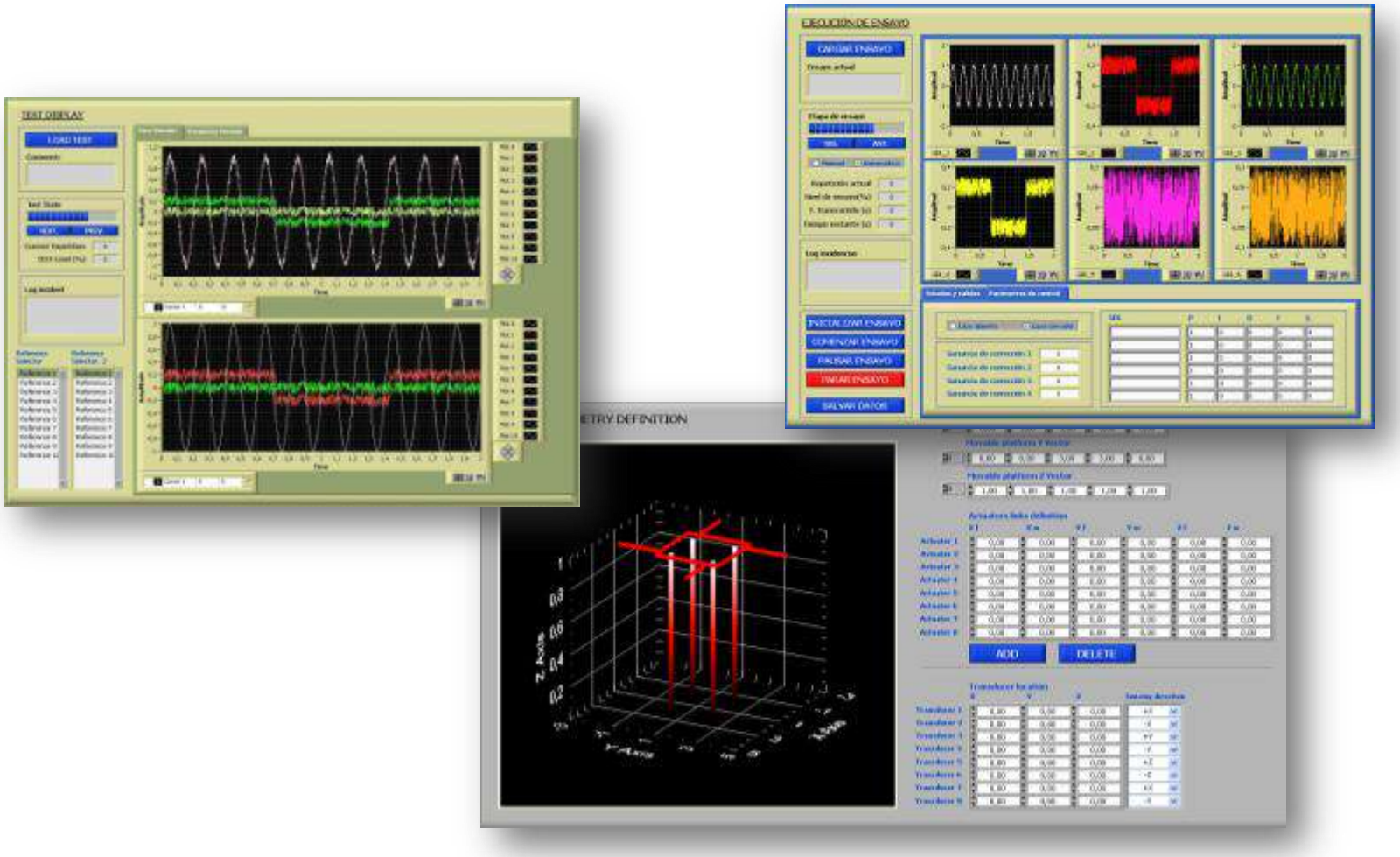
- **SYSTEM COMPONENTS**

A large strong floor area to which large scale or full-sized specimens and structural assemblages can be attached for quasi-static and dynamic testing. A number of reaction frames or reaction walls are also needed for providing lateral support. Reaction frames may be used with a steel portal frame to provide more versatility.



1. Quasi-static & Pseudo-dynamic

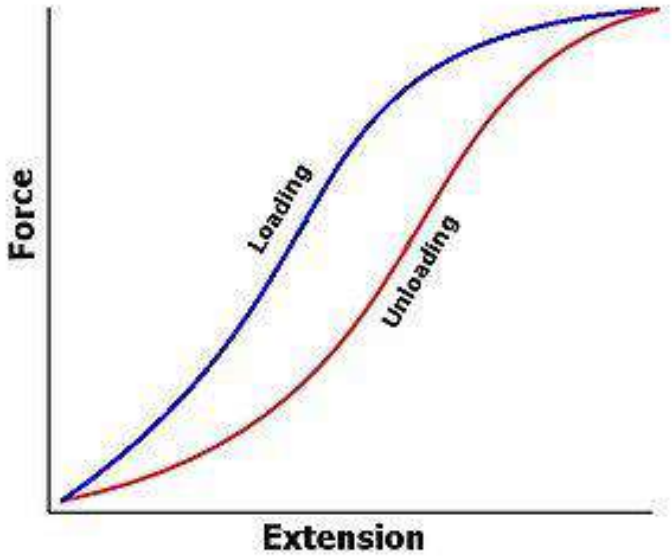
- **CONTROL SYSTEM**



- **QUASI-STATIC**

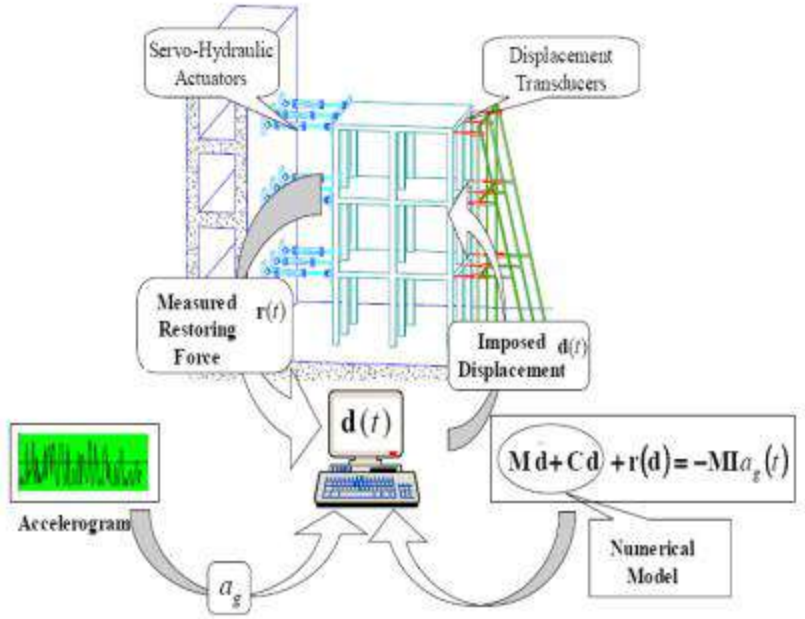
A predefined force or displacement record is applied on specific places of the tested structure at a reduced velocity.

For common materials such as steel or concrete, carrying out the test at reduced speed does not considerably change the structure behaviour, therefore allowing better control of the imposed displacements and more accurate measurements.



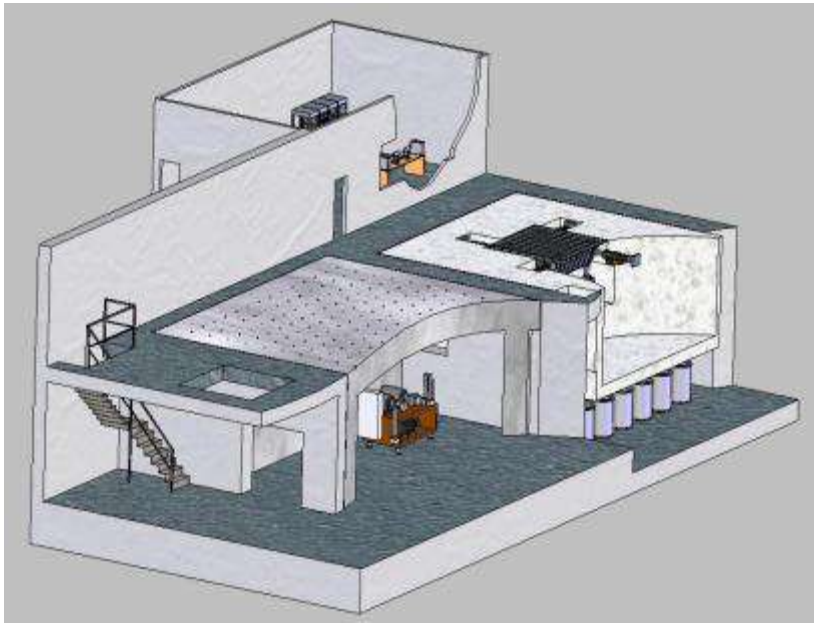
- **PSEUDO-DYNAMIC**

Pseudo-dynamic testing is a particular type of quasi-static test in which small displacements are imposed on several parts of the specimen to be tested.
The displacements applied to the structure are unknown before the test is performed. Instead, they are calculated taking into account experimentally-measured restoring forces while the test itself is being carried out by means of a step-by-step integration method which is implemented in the main control computer software.
The pseudo-dynamic method, which allows for subjecting the structure to the real deformations, combines the advantages of shaking table and quasi-static tests. It allows for true structure seismic response, as would occur in a shaking table test, but is able to test larger specimens with more accurate measurements than the quasi-static tests.

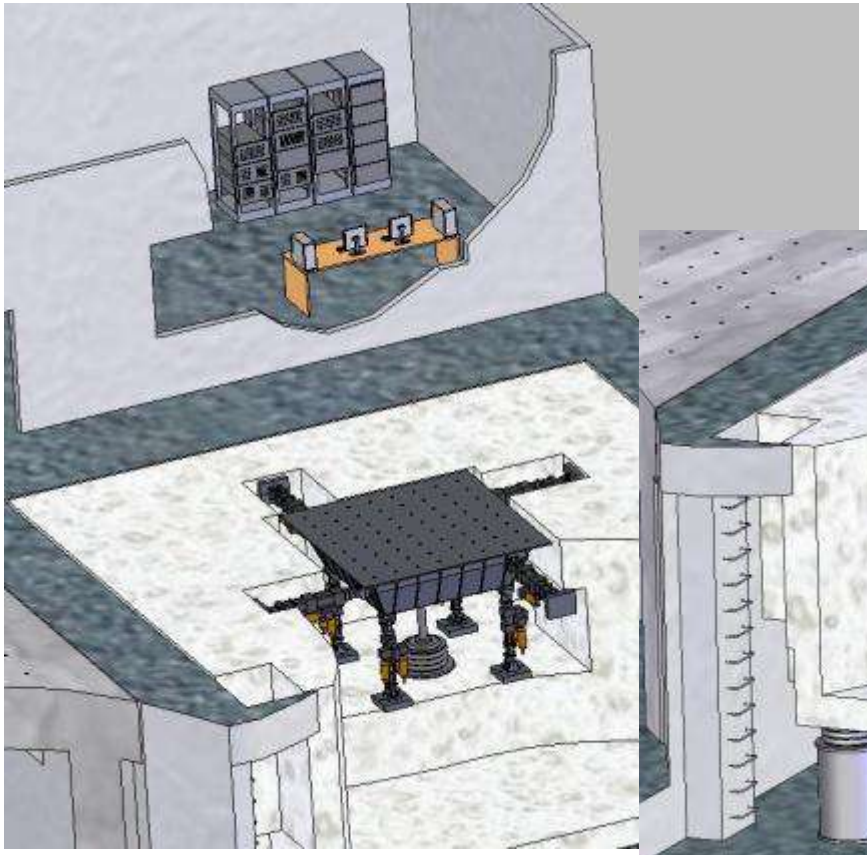


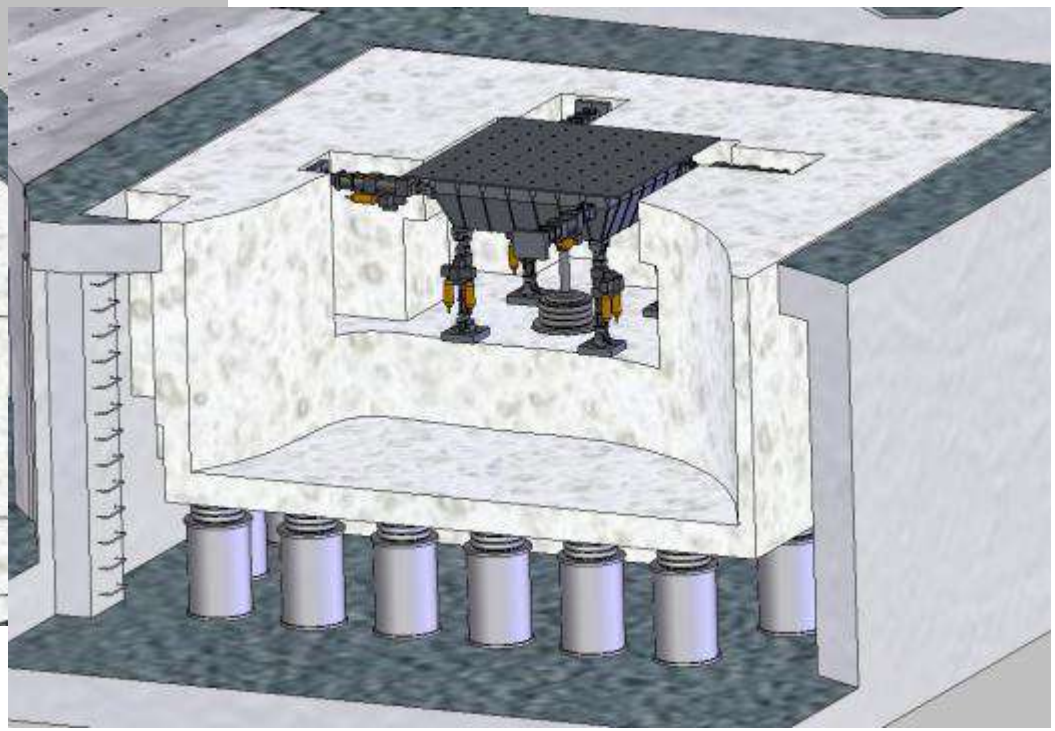
- **SHAKING TABLE**

A shaking table can provide the dynamic stroke necessary to replicate full-scale displacements, velocities, and accelerations at the upper levels of multi-story buildings during earthquake shaking. The structure can be experimentally evaluated under full-scale floor motions to understand, quantify, and control the seismic response.

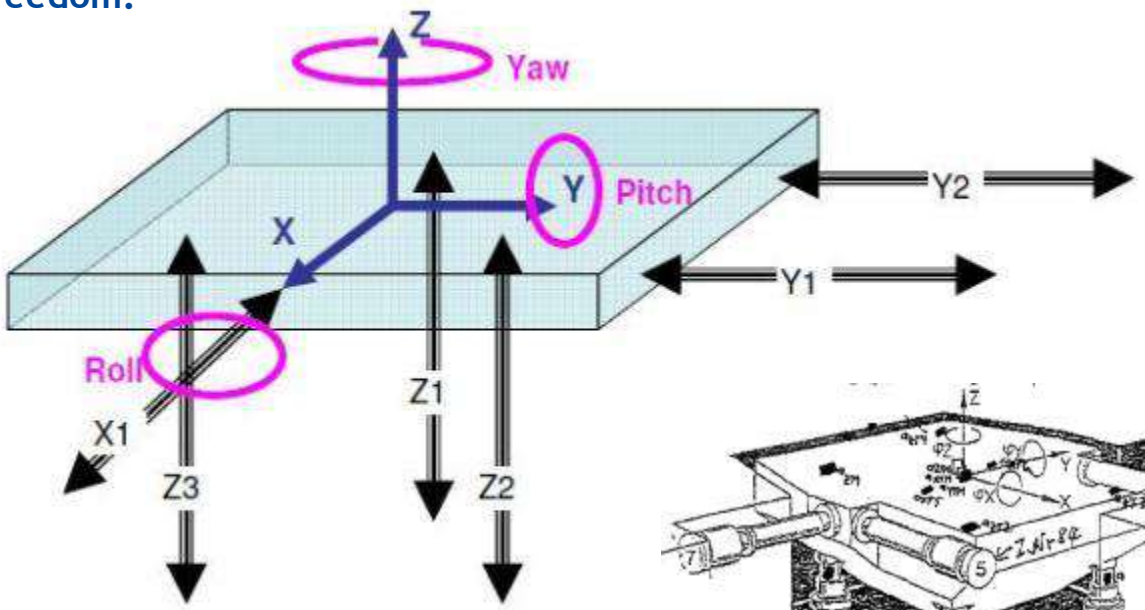


2.1 General

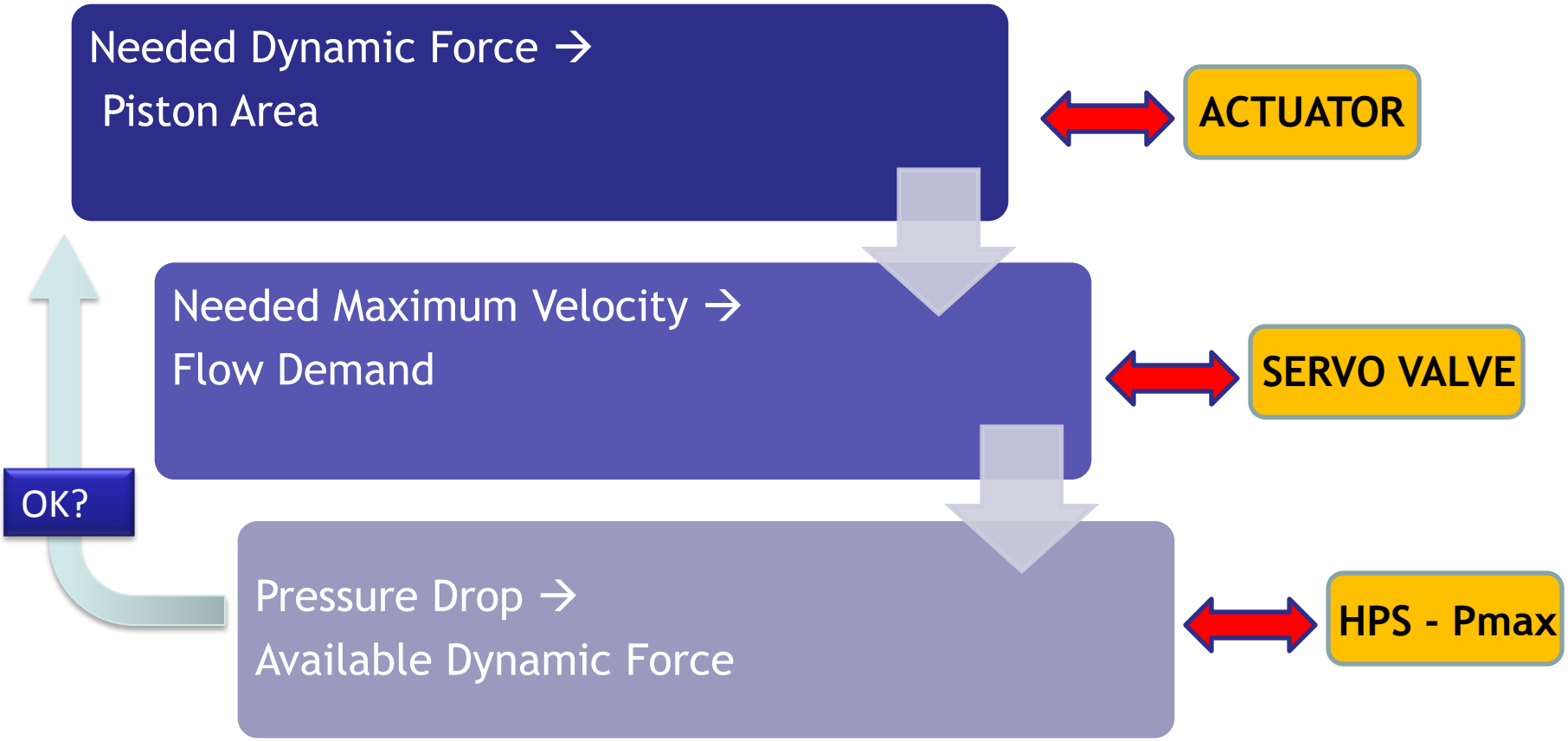




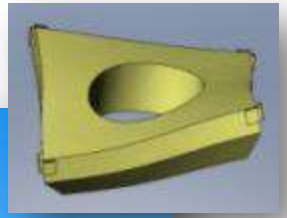
- **Payload:** Weight, dimensions.
- **System Performance:** Displacement, Velocity, Acceleration.
- **Degrees of Freedom.**

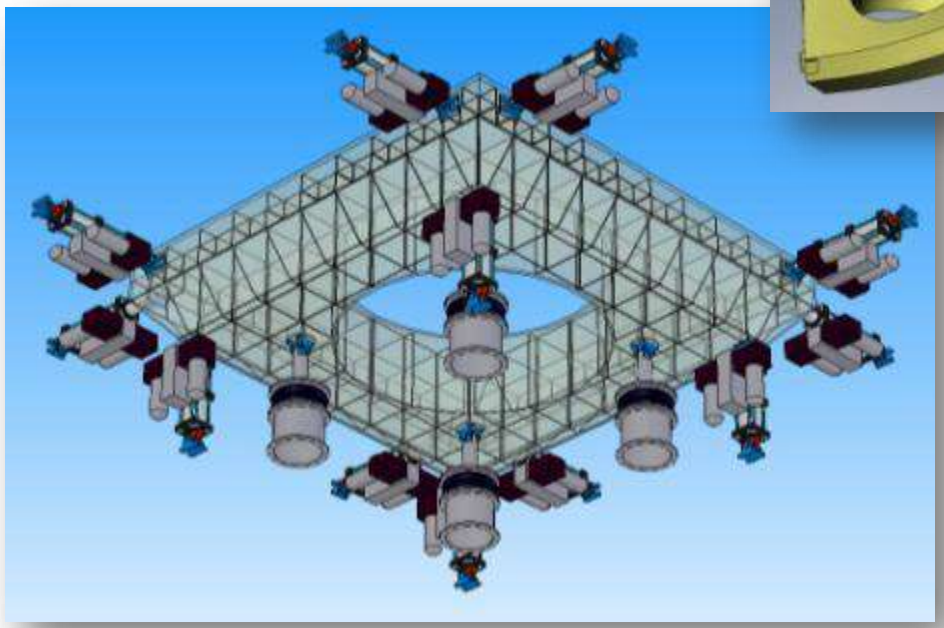


2.3.1 HYDRAULIC

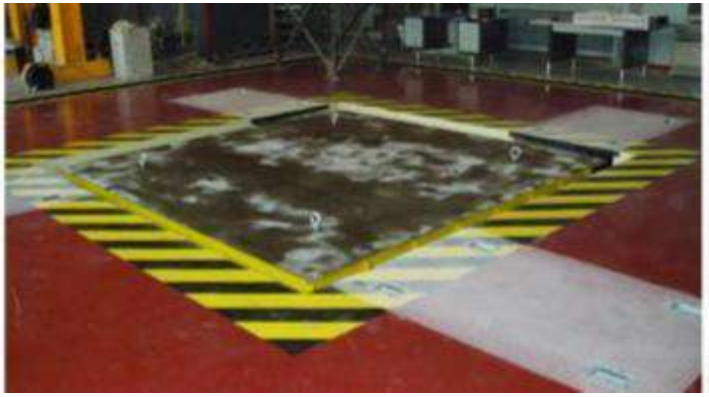


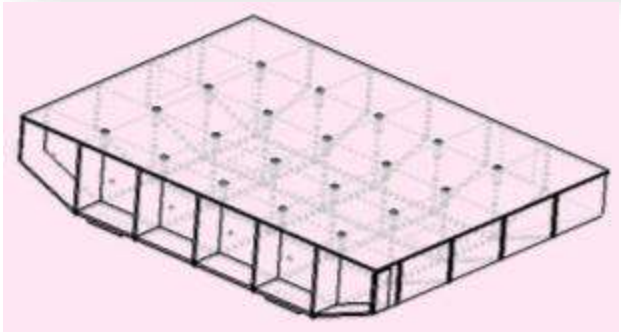
2.3.2 TABLE





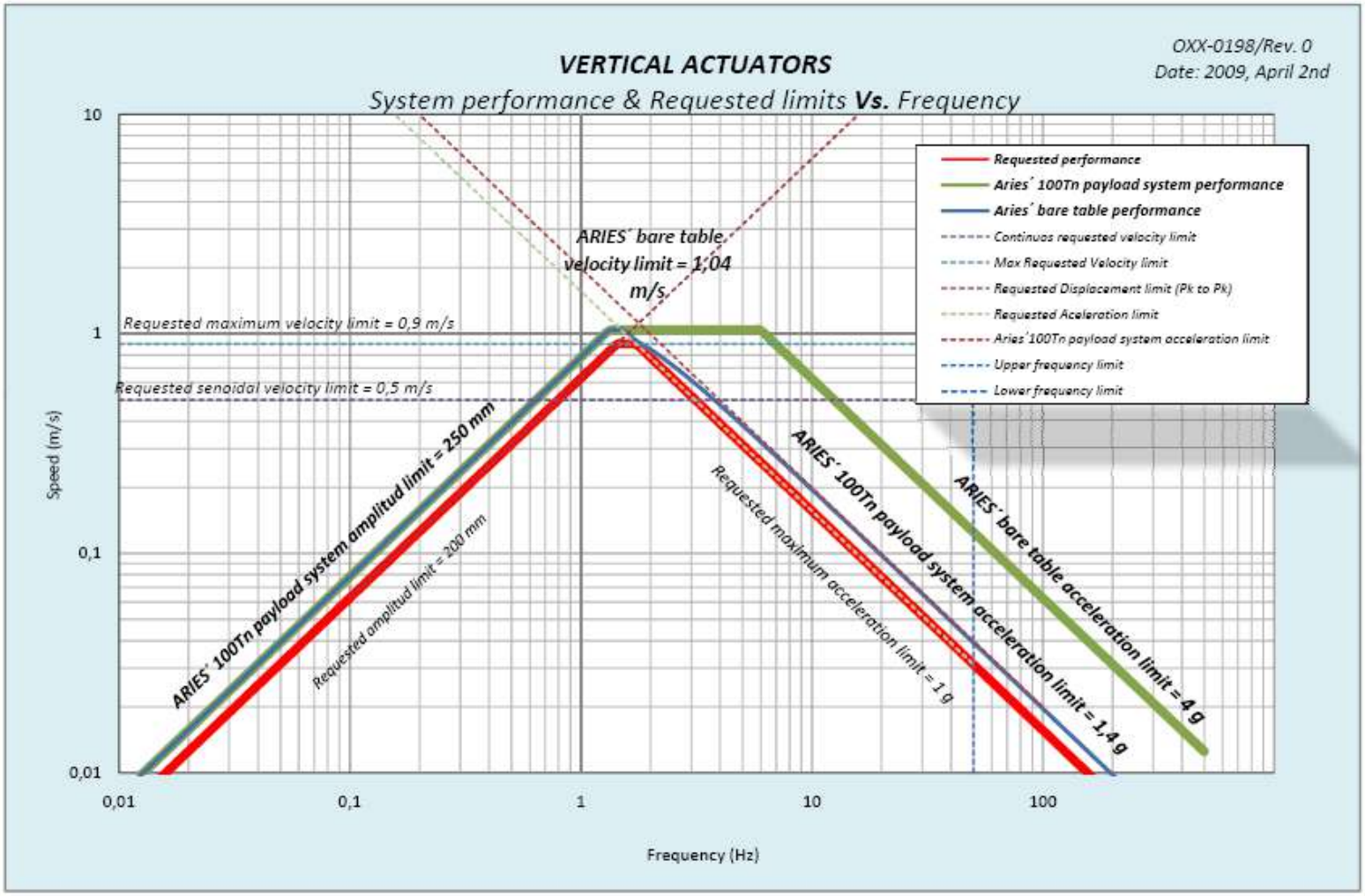
- Designed using sophisticated FEA analysis.
- Maximized bending and torsional stiffness to weight ratio.



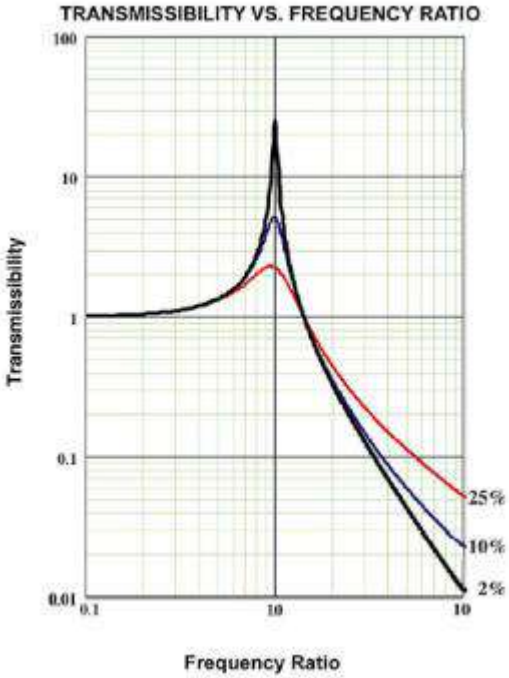


- Aluminum or steel.
- Grid of threaded inserts on upper surface.
- Natural Frequency: 1st vibration mode well over the desired operating frequency.

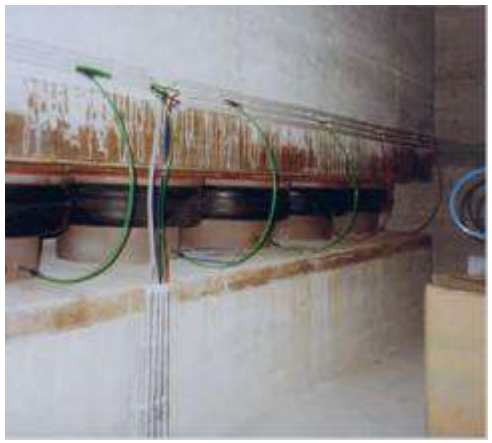
2.3.3 ACTUATOR PERFORMANCE

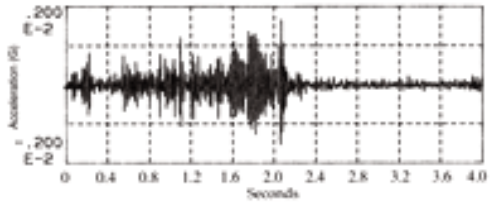


2.3.4 VIBRATION ISOLATION

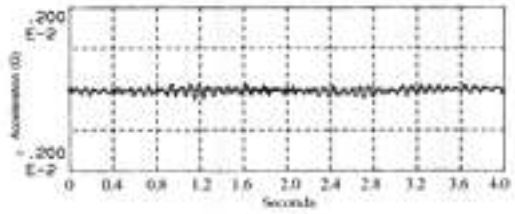


$$Fn = \frac{1}{2p}\sqrt{\frac{k}{M}}$$





Transmitted before isolation



Transmitted after isolation

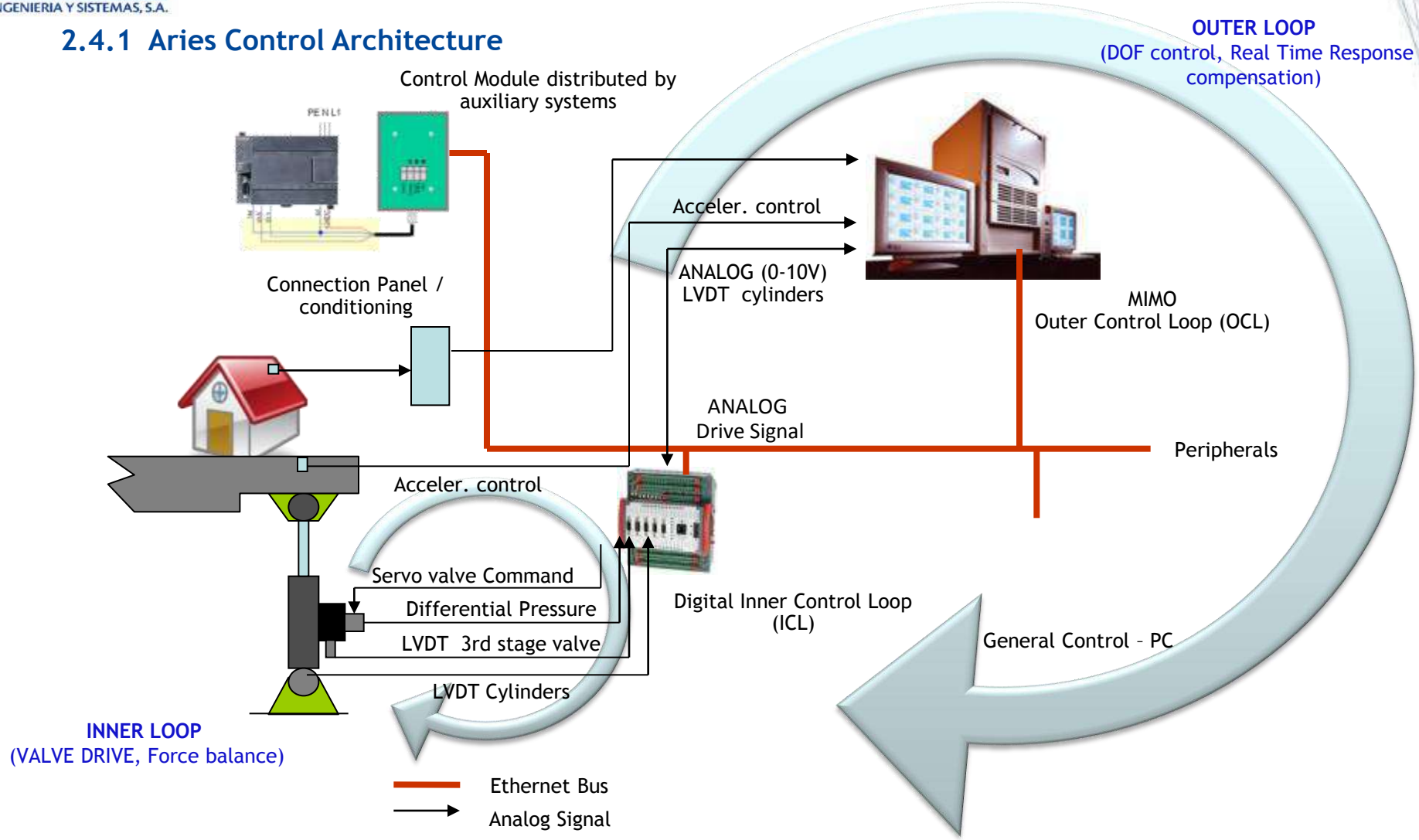
2.4.1 Aries Control Architecture

2.4.2 INNER LOOP CONTROL (CLI)

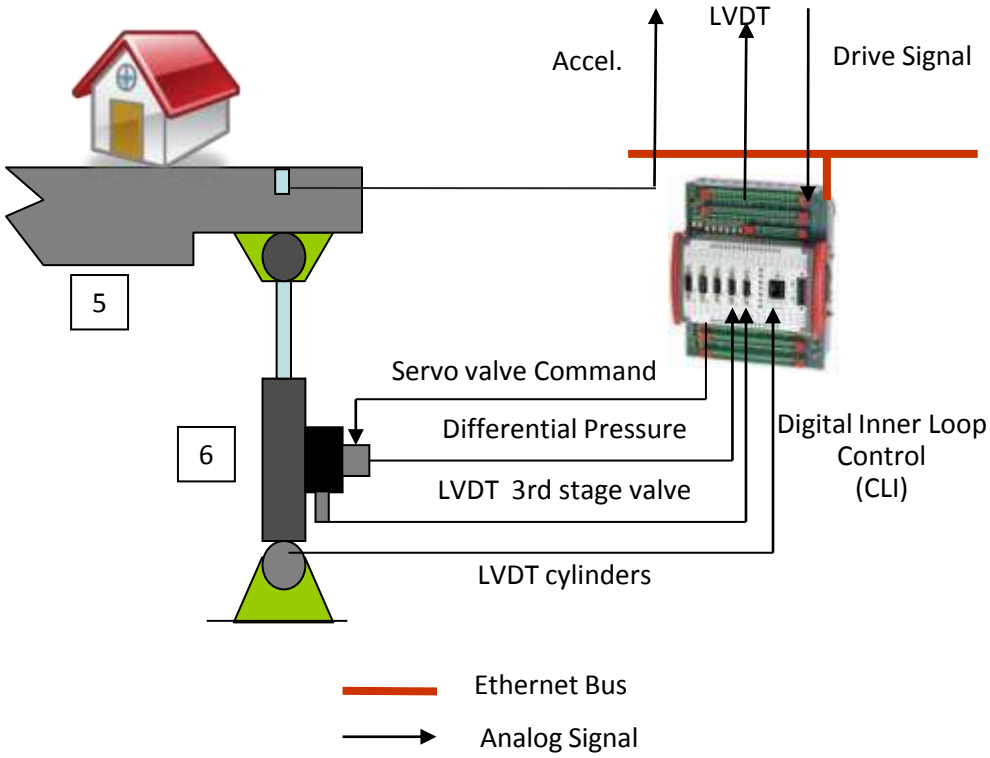
2.4.3 OUTER LOOP CONTROL (CLE)

2.4.4 Control Compensation Strategies

2.4.1 Aries Control Architecture



2.4.2 INNER LOOP CONTROL (CLI)



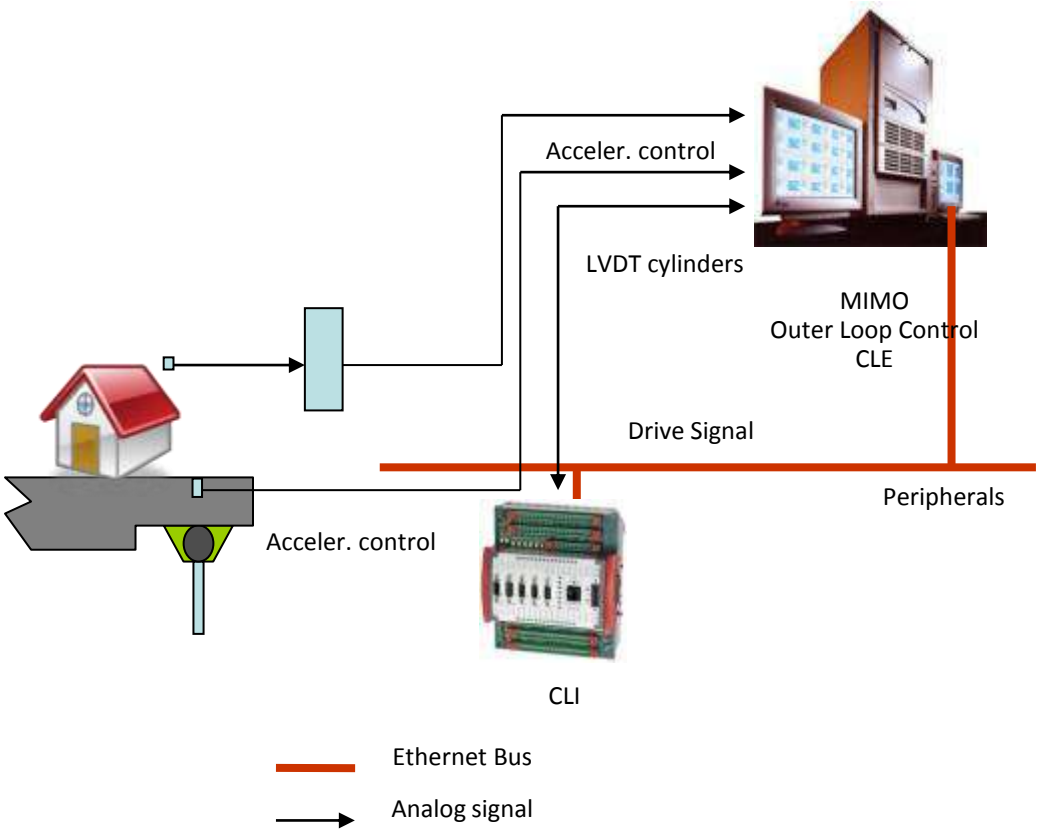
- Main Tasks by cylinder:

➢ Cylinders Individual Movement Control.
➢ Signals conditioning.
➢ ΔP Stabilization.
➢ Force balance compensation.
➢ Dither Generation.
➢ PIDF loop with LVDT 3rd stage, if necessary.
➢ Command Signal generation to the servo.

- Characteristics:

➢ Complete digital Control loop and programmable software.
➢ Dedicated Real TIME controllers.
➢ Ethernet communication with Desktop PC control.

2.4.3 OUTER LOOP CONTROL (CLE)



- Main Tasks:

- **MIMO** (rectangular).
- Multivariable Control.
- Control in degrees of freedom.
- Geometrical Compensations.
- System response based compensation.
- Updates the system's Impedance Matrix in each loop.
- Spectral Analyzer.

2.4.4 Control Compensation Strategies

• **Multi Variable Control** (Displacement , pseudo-velocity, acceleration):

To improve system response measurement based on frequency.

• **Cross-coupling Compensations** (System Impedance Matrix).

To take in to account the influence on 1 DOF over non-direct affected cylinders.

• **Force Balance** (through individual Delta P measurement):

To control internal table tensions caused by hyperstatic conditions of the system.

• **Feed Forward advanced close loop algorithm:**

To improve frequency response and system stability.

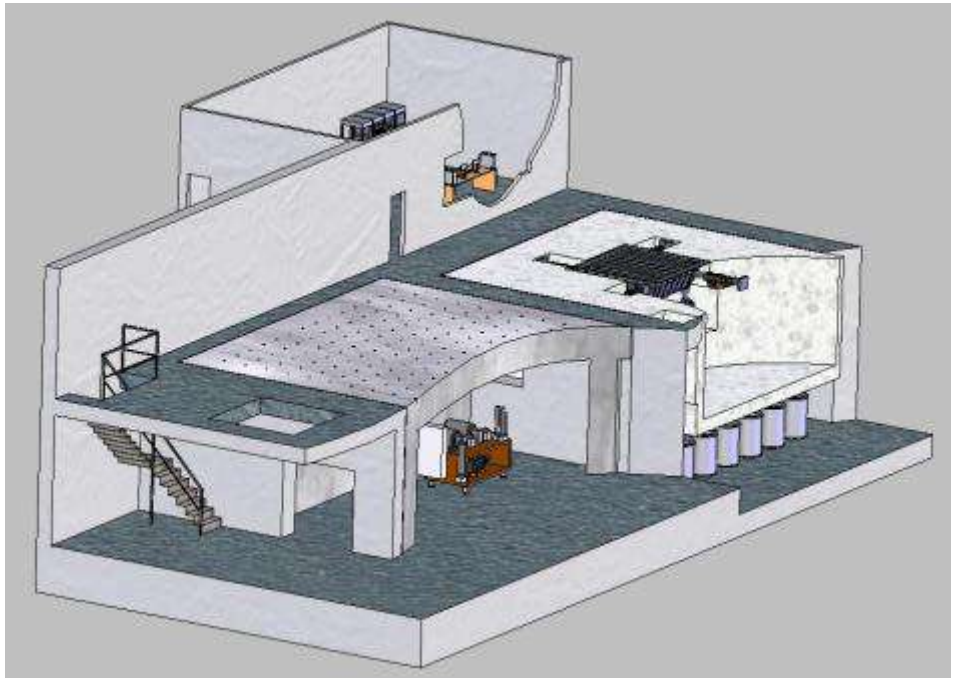
• **Overturning Moments Compensation** through system impedance matrix.

Aries Ingeniería y Sistemas provides complete civil work definitions needed for building a full Structural Dynamic Testing Laboratory.

Civil works are typically comprised of a reaction wall, reaction mass, and strong floor.

The isolation system is needed in order to reduce vibrations and transmitted loads to the rest of building.

Aries Ingeniería y Sistemas can also provide the layout of the complete Laboratory.



4. Conclusion

- Aries Ingeniería y Sistemas has extensive experience in advanced test systems, having supplied to more than 25 countries worldwide.

- By adapting to client needs, Aries Ingeniería y Sistemas offers a flexible solution to tailor-made engineering.

- The structural dynamic testing laboratories are state-of-the-art systems with real-time controls.

- Each laboratory can be upgraded (mechanical, hydraulic, control systems), ensuring a long-lasting cost efficiency.

- The structural dynamic testing laboratories update the system's Impedance Matrix during every loop.

- Civil work definition can be included.

- Aries Ingeniería y Sistemas provides training, maintenance, and operation support.

5. Contact

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