Shaking Table_3D-Vision & REMOTE_control
at
ENEA C.R.Casaccia[1]

The main goal of the Virtual Laboratory DYSCO (structural DYnamic, numerical Simulation, qualification tests and vibration Control) is the realization of a network platform of remote shared experimental tests at the ENEA- Physical Technologies and new Materials laboratories of the Casaccia Research Center in Rome, Italy- for seismic, mechanical, aerospace and nuclear engineering.
The experimental facilities consist of two electrodynamics shakers and two high performance shaking tables for three axial mechanical and seismic tests of large structures.

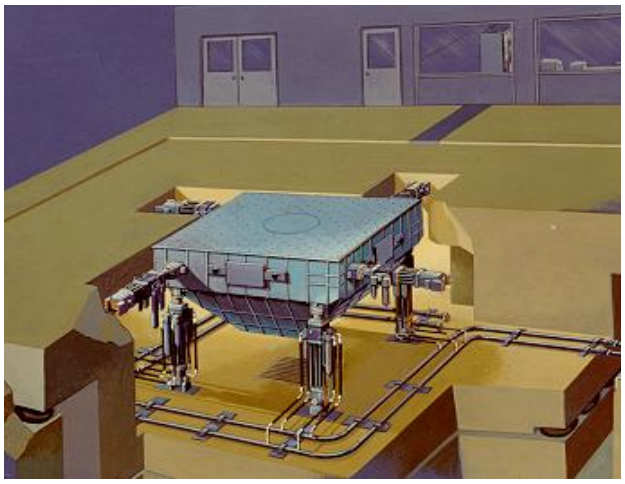


Fig. 1: System 1: 4mx4m a 6GDL Shaking table



Fig.2 test on a roman Arch (scala 1:1) to verify the istability effects on the collapsing mechanisms.

	System 1	**System 2**
Dimensioni della tavola sismica	4m x 4m	2m x 2m
Gradi Di Libertà	6 GDL	6 GDL
Campo di Frequenza	0-50 Hz	0-100 Hz
Acceleratione	3g peak	5g peak
Velocità	0.5 m/s (0-peak)	1 m/s (0-peak)
Spostamento	0.25 m (0-peak)	0.30 m (0- peak
massa ed altezza del baricentro dell'oggetto in prova	10 ton 1m altezza baricentrica	1 ton 1 m altezza baricentrica

The shaking table tests can simulate the real stress fields in the structures due to the dynamic loads induced by mechanical vibrations for systems and components working in extreme environmental conditions like railway and aerospace transportation and for the qualification processes in nuclear applications.
The seismic activities are also devoted to the experimental analysis of innovative systems for the seismic isolation and retrofitting of civil, industrial, and historical buildings, together with the

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seismic tests of sub-structures and scaled mock-ups, in order to evaluate the isolation/dissipation performance of the anti seismic devices, and the failure modes of the building's structural parts.



Fig. 3 View of the laboratory

Shaking Table Performances

Seismic Table N° 1

Frequency range (Hz)	**0-50**
Stroke (mm p-p)	
Horizontal	**250**
Vertical	**250**
Max Velocity (m/s)	
Horizontal	**0.78**
Vertical	**0.78**
Max Acceleration at bare table (m/s^2)	
Horizontal	
harmonic	**49**
impulse	**78**
Vertical	
harmonic	**49**
impulse	**78**
Yaw rotation (+/- degrees)	**4.7**
Yaw velocity (rad/s)	**13.03**
Pitch/Roll rotation (+/- degrees)	**4.7**
Pitch/Roll velocity (rad/s)	**13.03**

Max Overturning Moment (kNxm)	**300**
Max Specimen Dead Weight (kN)	**300**
Dead Weight Compensation	

Seismic Table N° 2

Frequency range (Hz)		**0-100**
Stroke (mm p-p)		
	Horizontal	**300**
	Vertical	**300**
Max Velocity (m/s)		
	Horizontal	**1**
	Vertical	**1**
Max Acceleration at bare table (m/s^2)		
	Horizontal	
	harmonic	**49**
	impulse	**78**
	Vertical	
	harmonic	**49**
	impulse	**78**
Yaw rotation (+/- degrees)		**8.5**
Yaw velocity (rad/s)		**47**
Pitch/Roll rotation (+/- degrees)		**8.5**
Pitch/Roll velocity (rad/s)		**47**
Max Overturning Moment (kNxm)		**50**
Max Specimen Dead Weight (kN)		**50**

OBJECT TRACKING AND 3D-VISION

A new, innovative, high resolution 3-D optical movement detection and analysis tool have been to track the dynamic displacement of the selected points of masonry and concrete buildings mock-up during the dynamic laboratory tests of natural (earthquake) and artificial (mechanical) induced vibrations at the shake table earthquake test facilities of the ENEA Casaccia Research Center, Rome, Italy.

The Object Tracking and 3-D optical movement detection and analysis have been experimented to track the motion during the low frequency (up to 30Hz) vibrations typical of the shake table earthquake tests. Twelve high resolution (up to 4MPixel) Infrared Cameras have been used to measure accurate 3-D positions of hundred of markers placed on the structure during the seismic tests. The innovative monitoring technique allows measuring 3 axial absolute displacements with easy and fast test set-up, high accuracy and the possibility to link the 3D-motion time histories of the tracked markers with CAD drawings of the structure and validate the FE models in real time experimental data assimilation. The new monitoring system have been tested during a shaking table experiment on a masonry building representative of the historical houses still used for civil habitation in Italy. To detect the motion, each marker must be viewed at list by 2 cameras in order to calculate its 3D coordinates with respect the absolute reference. The measure of the displacements is a crucial

task for the numerical and experimental studies in structural dynamics, especially within the displacement based approach in seismic design and calculations.

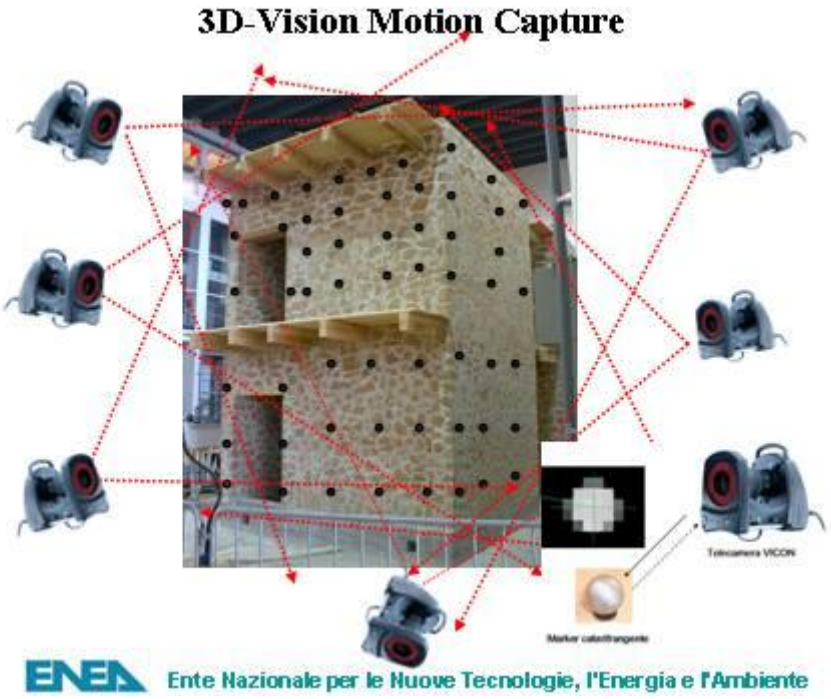


Figure 4a. position of the cameras to detect the motion of the markers for masonry building

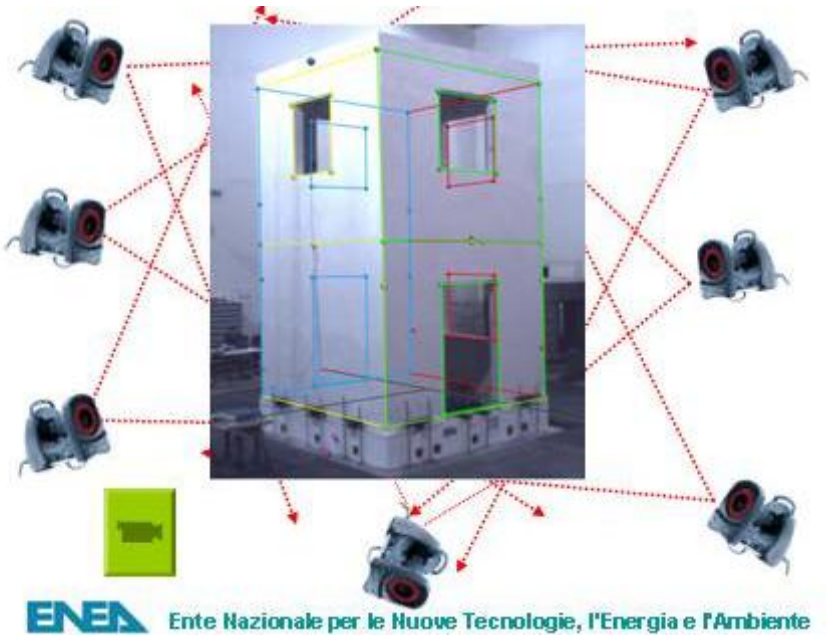


Figure 4b. position of the cameras to detect the motion of the markers for building made by M2 using innovative light concrete material

The first step of the marker displacement data analysis consists in the time histories filtering using a Savitzky-Golay polynomial filter (Sgfilter). Successively, after double derivative to calculate the acceleration, a band Pass filter is applied to the acceleration time history. The choice of the most appropriate filtering parameters has been made comparing the results from different combinations of the parameters. E.G. the figure 5 shows the effect of the SGfilter with different polynomial degree and same windowing width.

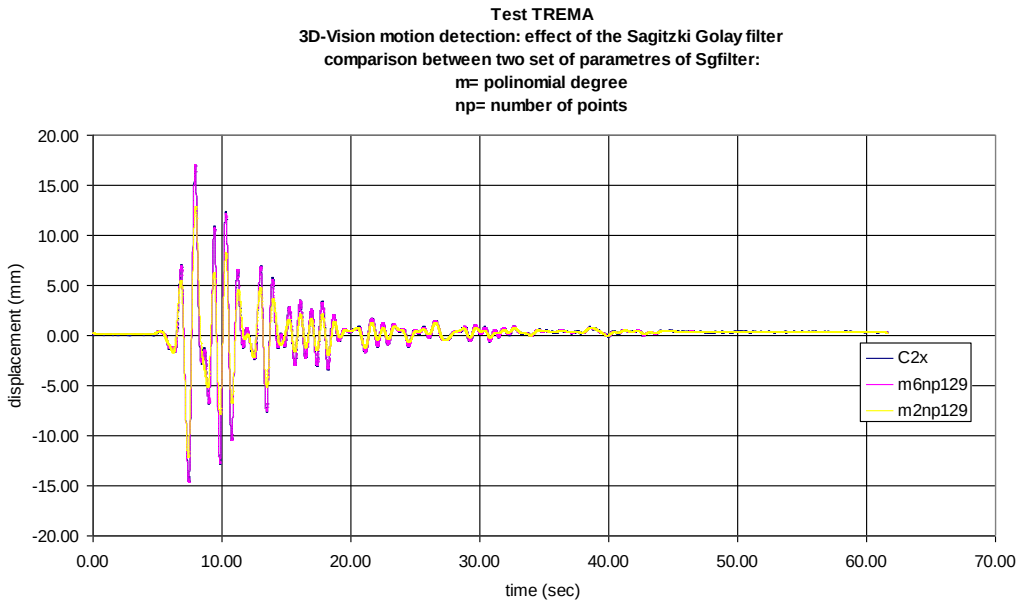


Figure 5a. effect of the polynomial degree values in the Savitzky Golay filter of the Displacement time histories detected by the 3D-Vision motion detection system.

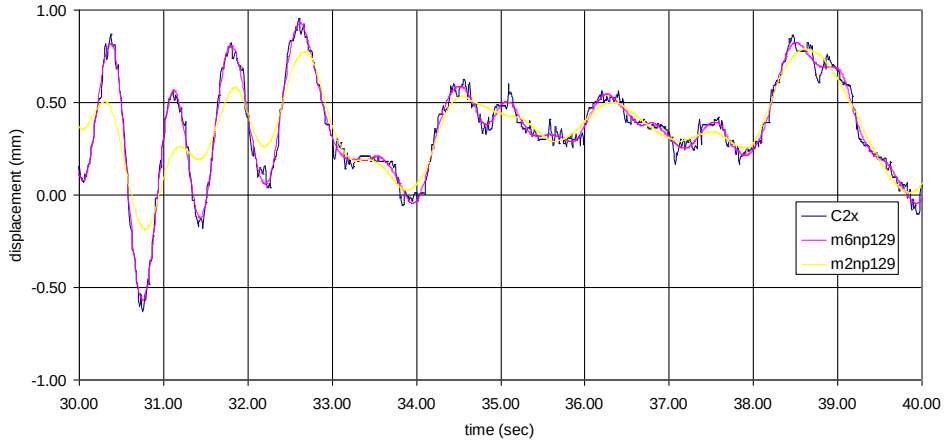


Figure 5b Zoom window of 10 seconds in the interval 30-40 sec

The 3D-Vision system allows to make movies during the tests superposing the numerical model to the imaging detected by two high resolution visible cameras (figure 6)

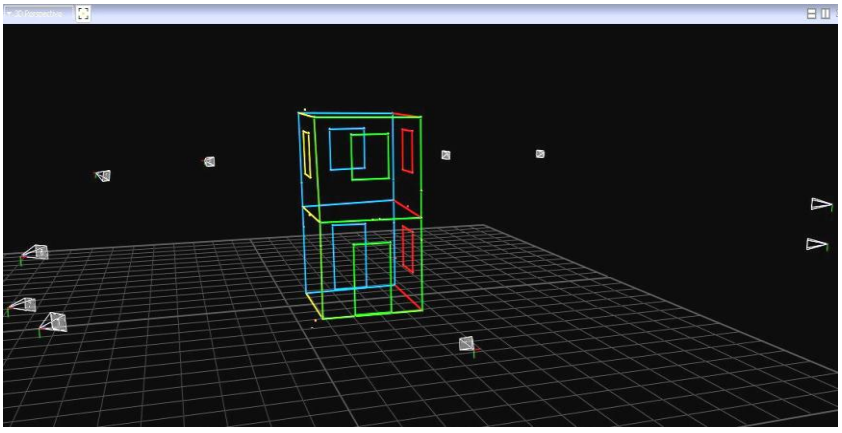


Figura 6. Cluster of infrared cameras and wireframe representation to validate the FEM models using experimental data

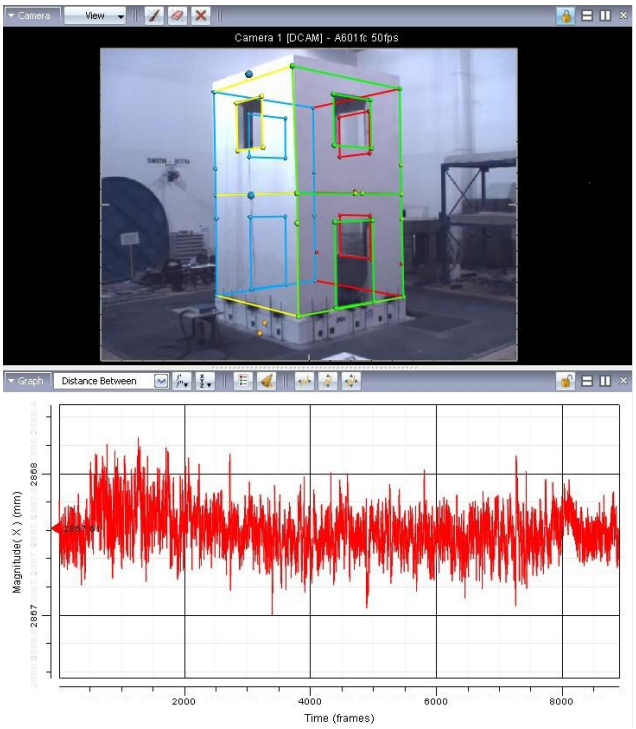


Fig 7. Real time monitorino of the relative displacement (DRIFT) between I and II Floor durino the test il test M2 : sintetico_ec_045g of November 25th 2008..



Fig. 8 : seismic tests on masonry structures

In the following sequence of collapse is evident the capability of the new system to detect the movement of the single points and the collapse mechanisms activated during the seismic experiment.

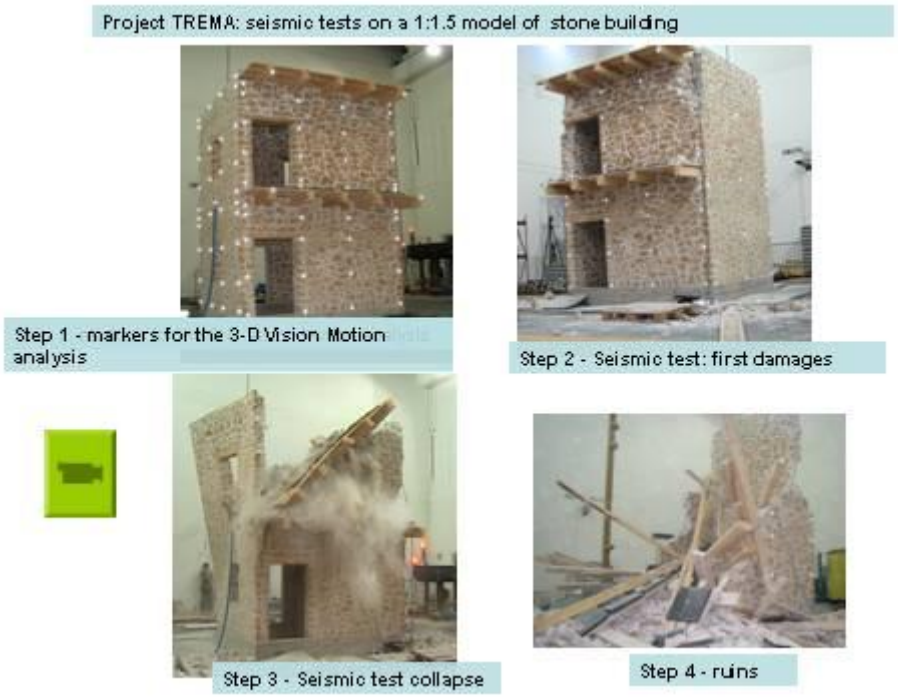


Fig. 9: Sequence of collapse of the building during the seismic test.

The possibility to synchronize visible and infrared cameras allow the remote participation and control of the shaking table tests in a networking configuration of distribuited experiments. In the following figure is showed the conceptual structure of this networking configuration. This test facility is nested within the ENEA Grid of computational and experimental facilities: the Tokomak particle accelerator at the ENEA Frascati Research center, the ABI Prism 3700 DNA sequence system at the ENEA Trisaia Research Center, the 300 KeV Electron microscope at the ENEA Brindisi research center and the (future) CTM test facility for simultaneous mechanical-Climatic experiments at the ENEA Portici Research center.

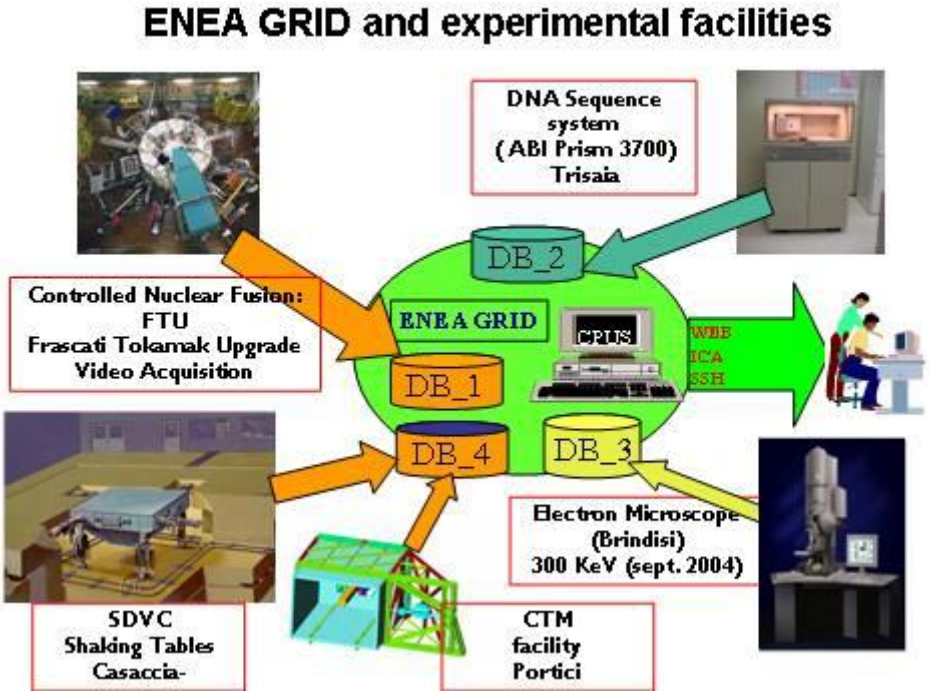


Fig. 10: ENEA Grid of remote controlled test facility

The conceptual structure of the remote shaking table operations is shown in fig. 6. At this stage the remote operator share data and image during the experiments and communicate with the local user, the only operator abilitated to drive the test.

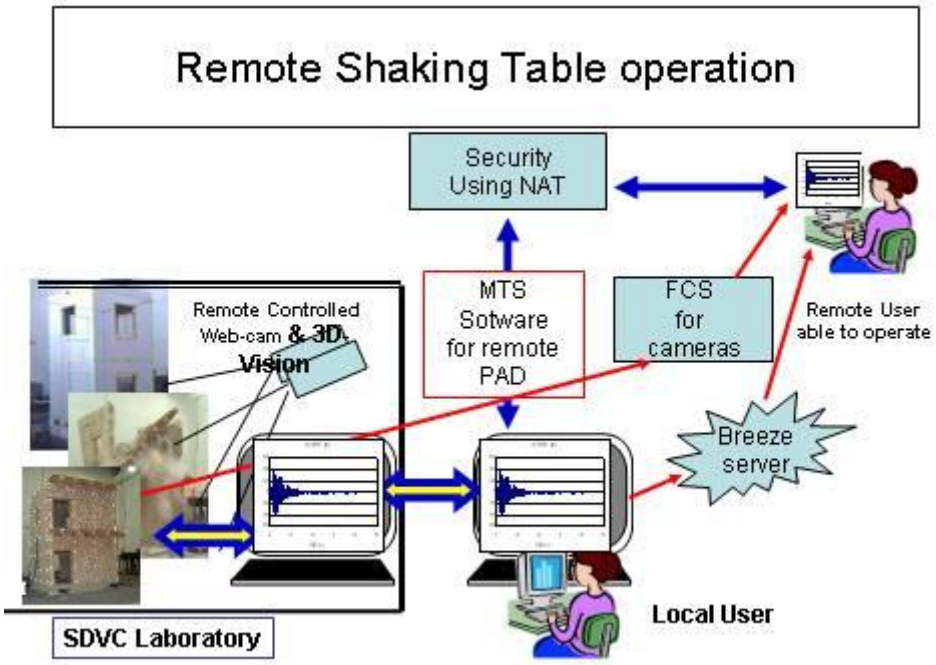


Fig. 11: remote shaking table operations