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European Laboratory for Structural Assessment (ELSA) (Reaction-Wall Facility) of the JRC Ispra

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ABSTRACT: The present paper describes the main characteristics of ELSA and gives general information on the associated projects and research programmes. In addition a short description of ongoing activities and large scale tests is given.

1 GENERALITIES

The Safety Technology Institute (STI) of the Joint Research Centre (JRC) of the Commission of the European Communities has built a structural assessment laboratory based on a 16m. high, 21m. wide reaction-wall (see figure 1). Designed to resist the forces which are necessary to deform and seriously damage full-scale test models of structures the ELSA reaction-wall is one of the largest facilities of its type in the world, only exceeded in Japan.

In addition to static and cyclic tests on large structures and components, the facility is equipped to perform tests utilizing the so-called pseudo-dynamic (PSD) test technique which enables the simulation of earthquake loading of full-scale buildings.

In order to obtain the maximum benefit from the facility it will be used within the framework of Community-wide integrated research programmes, thus making full use of the existing expertise and facilities within the Member States. To this end the European Association of Structural Mechanics Laboratories (EASML) was set up at the instigation of the Applied Mechanics Division. This association, which has more than twenty five members, is helping to define the detailed programmes.

In addition to programmes of scientific research involving both the study of the nonlinear dynamic behaviour of structures and the development of appropriate testing methods, a specific programme is foreseen in support of the EUROCODES - the harmonized European standards for construction.

The facility is also available to external customers for performing demonstration and qualification tests on large-scale prototypes and/or validating innovative constructions. This is intended to offer a major opportunity to the European industry to enhance its competitive position in world-wide markets, especially in countries with high seismic risk.

2 DATA FOR THE REACTION-WALL SYSTEM

The details of the reaction-wall/ strong-floor system are included in figure 1. The dimensions allow the testing of full-scale buildings up to five-storeys high either quasi-statically or pseudo-dynamically. Real-time dynamic tests can also be performed on lighter models such as piping systems. There is a large area of testing floor and an extended specimen preparation area which can also be employed in testing very large components.

The hydraulic pumping station has a maximum capacity of 1500l/min. and is equipped with six constant pressure piston pumps. The oil distribution system is made entirely in type 304 stainless steel, including the reservoir and the total volume is 5 cubic metres.

Currently there are 12 electro-hydraulic actuators which can be used under either load or displacement control. These are all of 500kN capacity, 4 have a stroke of +/- 0.5m, 8 have +/- 0.25m stroke.

Each actuator is driven via a digital controller which is connected in a local area network (LAN) through an optical fibre to the main computers running the PSD test algorithm (capable of using explicit or implicit methods of time integration).

The deformation of the test structure is monitored primarily by displacement transducers (both digital and analogue transducers are available) covering ranges from 1mm. to 1m. The laboratory also has a long experience in strain-gauge systems and related instrumentation. The data acquisition system is able to record up to 200 channels (distributed on 6 PC's) having a 12 bit resolution and a global sampling frequency of 10KHz.

3 PSD TEST METHOD AND ITS POTENTIAL

A pseudo-dynamic test is one which, although carried out quasi-statically, uses on-line computer cal-

LOAD CAPACITY	REACTION WALL	Bending Moment ....200 MNm
		Base Shear ....20 MN
	REACTION FLOOR	Bending Moment..........240 MNm
	ANCHOR LOAD CAPACITY	Axial Force .... 500 kN
HYDRAULIC CHARAC-TERISTICS	FLOW	1500 l/min.
	PRESSURE	210 bar
	ACTUATORS	Load (MN).................(0.5)
		Stroke (m) ....((+/- 0.25) -- (+/- 0.5))

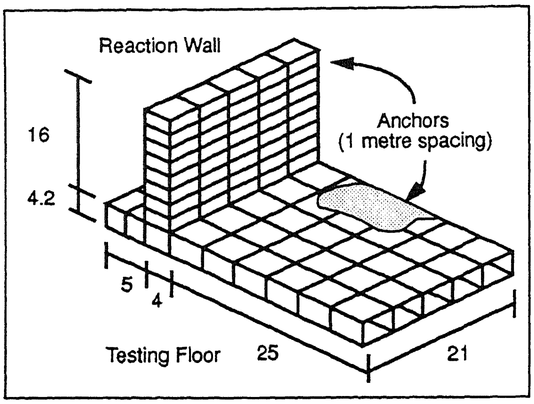

Figure 1: Parameters of the ELSA-Reaction-Wall

culation and control together with experimental measurement of the actual properties of the structure to provide a realistic simulation of the dynamic response.

Because the inertia forces are modelled there is no need to perform the test on the real time-scale. Herein lies one of the major advantages of the method - it is possible to test very large models with only a modest hydraulic power. The second major advantage over a shaking-table is the possibility to monitor very closely the progression of damage in the structure and to stop at any moment for a detailed examination or to prevent complete collapse.

The potential of the PSD test method has not yet been fully exploited and new fields of application can be expected. The JRC installation is the first to use fully digital servo control of the applied displacements (Donea et al, 1992), allowing a highly accurate test procedure and a much more versatile use of the various mathematical algorithms for numerical time integration of the equations of motion.

By using sub-structuring techniques significant further developments are possible namely the testing of models much larger than the laboratory itself, such as a bridge; testing of rate-dependent structural materials in real time (reducing the physical model to just those few components expected to show non-linear behaviour) and soil-structure effects.

4 ACTIVITIES AND LARGE SCALE TESTS

Current activities are concerned with an Integrated European Programme on the Response of Civil Engineering Structures to Severe Earthquake Loading which involves the EASML. The place of ELSA in this programme is to perform the necessary large scale confirmatory tests on various types of structure studied at component level and by analytical methods by the other partners. Additionally, in near future, there is to be a major effort in s- of the Eurocode N.8 (EC8) the design cod engineering structures in seismic zones. Finally negotiations are in progress with several potential customers from industry and with authorities responsible for national research programmes.

Two real scale tests are already planned. One is a PSD test of a 3-storey moment-resisting steel frame with R/C slabs which was specifically designed for commissioning of the testing system. It was designed in accordance with EC8 and was considered as having flexible joints and is expected to help to clarify some open questions regarding the design of those structures. Multi-degree of freedom implementation of the PSD test method has already been applied with success in tests of R/C beams.

The object of the second large test is an R/C 4-storey framed building with in plan dimensions of 10mx10m. Design of this structure was performed in accordance with EC8. The tests are planned for 1993 and the main aims of this study are to verify the EC8 design of a highly ductile structure and to calibrate computer models which will be used in studies of irregular structures.

In parallel with the setting up of the testing facility, analytical work is being performed. This consists of development and calibration of numerical models able to represent the seismic action and the structural response. Different levels of modelling have been considered from the classical FEM to simplified structural models. The new aspects in this regard lie in the object-oriented computer code (CASTEM2000) chosen to host the developments which allows combination of the different types of modelling. In addition constitutive laws based on damage mechanics are being adopted to describe the cyclic behaviour of concrete and masonry.

Finally the role of ELSA in training and education of engineers and scientists is noted. In addition to the hosting of students and visiting scientists it is foreseen to establish networks facilitating human mobility between research laboratories in Europe. The organization of a Eurocourse (Donea and Jones, 1991), was a demonstration of the potential of the laboratory in the field of education and training. Entitled "Experimental and Numerical Methods in Earthquake Engineering" the course was attended by more than 30 engineers and the lectures were given by experts from several Member States and from the USA as well as from the ELSA staff.

REFERENCES

Donea, J., and Jones, P.M. (Eds.) "Experimental and Numerical Methods in Earthquake Engineering", Kluwer Academic Publisher, Ispra, Italy, 1991.

Donea, J., Jones, P.M., Magonette, G. and Verzeletti, G. "The Pseudo-Dynamic Test Method", in "Recent Advances in Earthquake Engineering and Structural Dynamics", AFPS, Paris, 1992.