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A European collaboration research programme to study and test large scale base isolated structures

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ABSTRACT: The improvement of the technology of innovative anti-seismic mechanisms, as those for base isolation and energy dissipation, needs of testing capability for large scale models of structures integrated with these mechanisms. These kind experimental tests are of primary importance for the validation of design rules and the setting up of an advanced earthquake engineering for civil constructions of relevant interest.

The Joint Research Centre (JRC) of the European Commission (EC) offers the European Laboratory for Structural Assessment (ELSA) located at Ispra (VA) - Italy, as a focal point for an international european collaboration research programme to test large scale models of structure making use of innovative anti-seismic mechanisms. A collaboration contract, opened to other future contributions, has been signed with the national italian working group on seismic isolation (Gruppo di Lavoro sull' Isolamento Sismico GLIS) which includes the national research centre ENEA, the national electricity board ENEL, the industrial research centre ISMES and the producer of isolators ALGA.

1 INTRODUCTION

The European Commission (EC) is currently engaged in research activities about the seismic behaviour of structures, the technologies to lower the effects of an earthquake and the verification of the rules in the design standards of the field.

The effects of an earthquake on large size structures are investigated in the ELSA Laboratory of the Joint Research Centre (JRC) by means of a Reaction Wall (RW), sited at Ispra (VA), and the Pseudo-Dynamic (PsD) method. Presently the main objectives of the activities of the laboratory are related to the calibration of the rules of the EUROCODE - 8 for the design of steel and reinforced concrete structures.

During the last years the earthquake engineering technology has developed innovative anti seismic techniques, like seismic isolation, to protect the structures of relevant interest. The EC is interested in the follow-up of these techniques, not to develop an independent concept of isolation but to verify the effectiveness of the technology and the reliability of the mechanisms and of the related design standards.

EC/JRC contacted ENEA/ERG/FISS in Italy as chairing organization of the National Working Group on Seismic Isolation (GLIS) with the aim of setting up a collaborative research programme on Seismic Isolation Technology making available the ELSA Lab. for large size base isolated structures assuming that the partners will contribute designing and providing the isolators, performing shaking table tests, analysing the results and verifying/improving Design Standards.

These contacts led to the proposal of collaboration in a Seismic Isolation Programme (SIP). Other members of GLIS (ENEL, ALGA, ISMES) will participate, in the framework of GLIS cooperative activities, to the collaboration research programme through ENEA/ERG/FISS; it also noted that JRC-Ispira and ENEL-CRIS had signed an agreement to exchange experience and knowledge developed by both organizations on structural research, to which the present collaboration on seismic isolation technology is strictly correlated.

The collaboration is open to the contributions of other Organizations from other countries of the Community. The enlargement of the collaboration will be discussed by the partners and the contributions of the Organizations participant to the programme should be, at least partially, balanced.

The experimental results and the acquired engineering conclusions (but not the isolators technology that is property of the manufacturers) will be shared among the actual and future Organizations contributing to the programme.

2 OBJECTIVES OF THE COLLABORATION

The EC/JRC allows the use of the RW and the PsD method to test large size base isolated structures for the effects of a real earthquake. The structures existing in the laboratory (built and tested for other purposes) will be made available for the tests, after repair, to lower the costs of the research. The use of the RW is the only systematic way to test regularly large-size isolated structures.

The main technical objectives expected from the collaborative programme are:

Tests of large-size isolators;

Tests performed with large displacements (of the order of 30 to 40 cm.);

Tests of structures with both small-scale and large-scale isolators for large displacements to verify the validity of the models to account for the scale and experimental technique effects;

Comparison between different systems of isolation (at present the behaviour of some system is not well known);

Experimental verification of Design Standards for the isolators and the structures designed to be isolated.

JRC is particularly interested in this last item in view of a possible support to DG III and CEN. The state of the art in this field is not very advanced and, in particular, there does not exist at present a set of design rules agreed by the Member States of the Community

3 CONTENT OF THE COLLABORATION

3.1 *PsD test method validation and numerical analyses*

In principle there is no doubt about the applicability and the potentiality of the PsD method; the problem is the influence of the velocity of the test on the characteristics of the material of the isolators; some literature exists on the subject and probably the influence of strain rate is not such to invalidate the results of a PsD test; moreover this problem is probably dependent on the isolator materials.

To better clarify this aspect a comparison will be set up of the results obtained at ISMES on a shaking table with those obtained by means of the RW using the PsD method. This can be done only for scaled structures.

Adaptable isolated structures, foreseen for a Brite-Euram II project and another ENEL project, will be designed and constructed by ENEL-CRIS in collaboration with ISMES, ENEA who will cooperate in isolators design, and ALGA who will supply the isolators, to be tested on a shaking table at ISMES in the framework of the aforesaid projects. The same structures under the same condition of isolation will be tested also at the ELSA Laboratory.

In parallel with this experimental validation of the PsD method, a numerical activity will be set up to clarify how the ductility of a structure is related with the effectiveness of the isolation. A certain number of meaningful cases will be selected, numerically analysed, compared and discussed in order to provide data about the level of interest in isolation for structures of various ductility classes.

3.2 *Tests using existing structures not designed to be isolated.*

Some test structures exist at the ELSA_Lab (Figure 1); JRC proposes, for evident economic reasons, to reuse these structures to test different concepts of isolation. This proposal is attractive both for the comparison between the isolators and because the results could be a first step to define how the same structure could have been designed to resist the effects of the earthquake taking into account the isolation.

Because the structures existing at the ELSA_Lab will be tested in the framework of the planned activity of the laboratory, these structures must thus be repaired before being tested in the framework of a Seismic Isolation Programme. Some additional investigations (as the comparison with the original eigen-frequencies, stiffness matrix, structural diagnostic,.) will be performed to verify the integrity of the structure before the reuse to test it with base isolation devices.



Figure 1. Structures existing at ELSA_Lab

3.3 *Tests of structures designed to be isolated.*

When the applicability and the potentiality of the PsD method will be clarified, some tests using structures designed and built to be isolated could be done to contribute to the verification of the Design Standards for the isolators and the isolated structures.

The realization of these tests will be decided taking into account the costs and the eventual interest of DG III for these tests aimed to verify design rules.

4 CONTRIBUTION OF THE PARTICIPANTS

The JRC ELSA Lab. will be a service laboratory in the framework of a common European Seismic Isolation Programme. The following contribution have been agreed:

4.1 *EC/JRC contribution*

The EC/JRC, contributes with large size structures existing in the laboratory (built and tested for other reasons) after repair and verification of their structural integrity, with all the laboratory work (instrumentation, tests, data acquisition...) and with a pre-elaboration of the experimental data to be supplied in the desired format.

4.2 *GLIS contribution*

The GLIS organization, contributes with the design and the supply of the isolators, the follow-up of the tests, the relevant results of dynamic tests with shaking tables, the analysis of the results, the improvement of the technology and the verification and the improvement of Design Standards.

4.3 *Details of the contribution to the planned actions*

In detail, at present the following specific contributions have been agreed:

JRC and ENEA/ERG/FISS, with the cooperation of ENEL/CRIS, will contribute to the preliminary analyses on the effect of isolation on structures; the cases to study will be agreed by the partners and the computational work will be shared between the participating laboratories.

JRC and ENEA/ERG/FISS, with the cooperation of ENEL/CRIS and ISMES, will contribute to tests to verify the applicability and limits of the PsD method by testing at the Reaction Wall a structure provided by ENEL/CRIS, isolated by means of high damping rubber bearings (HDRBs), which will be also tested on a shaking table.

JRC will perform first tests on an existing large scale structure, using HDRBs as isolators, with the cooperation of ENEA, ENEL-CRIS and ISMES as GLIS members.

ENEA/ERG/FISS, through the GLIS member ALGA, will supply all the base isolators of interest for Italy.

The detailed first part of the programme, related to existing structures only, and the planning of the activities is shown as GANTT (Figure 2) and PERT (Figure 3) charts.

It has been agreed also that JRC will be provided with results of previous relevant tests performed by the partners when this is compatible with the protection of the industrial know-how.

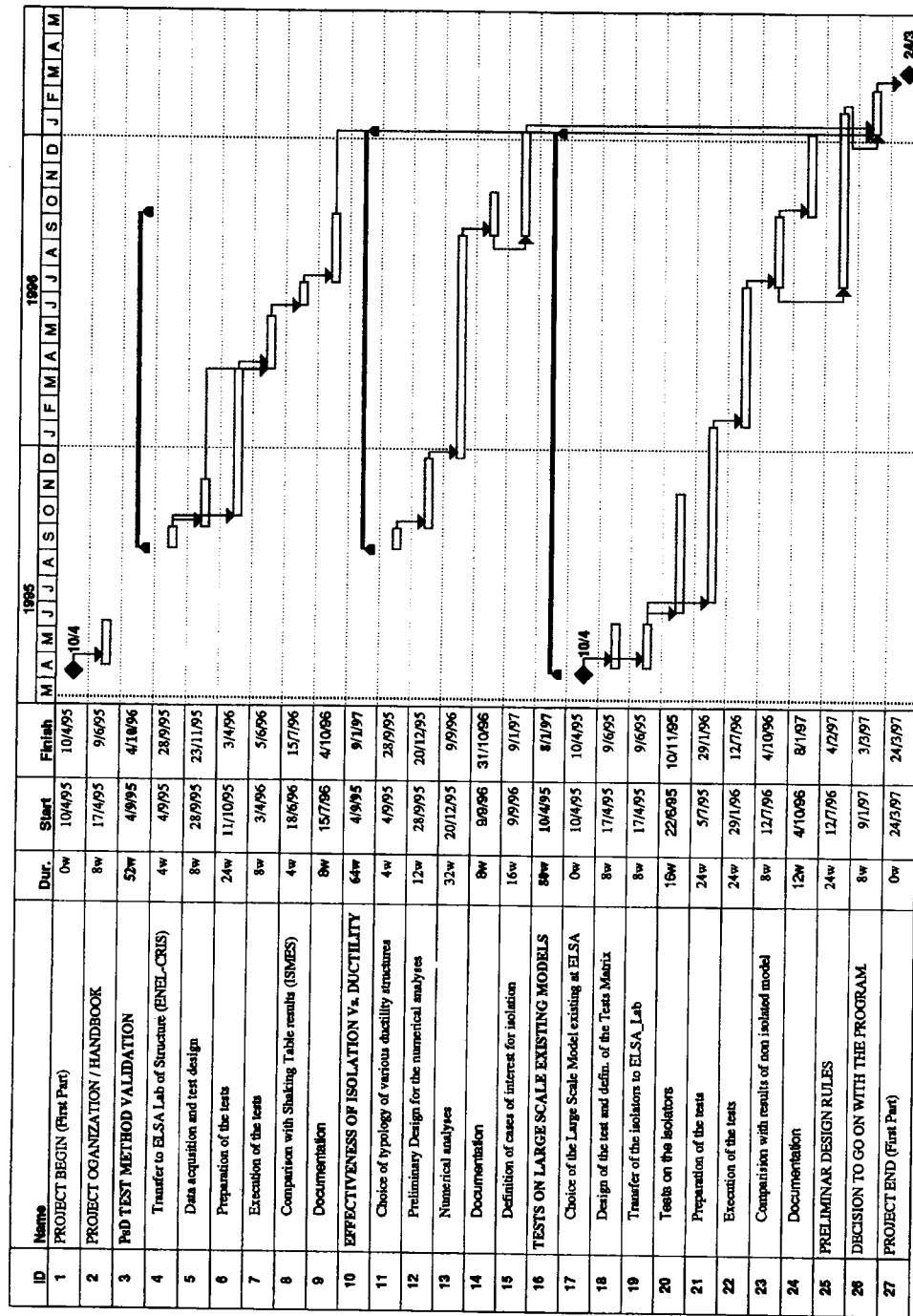


Figure 2. Seismic Isolation Programme - GANTT chart

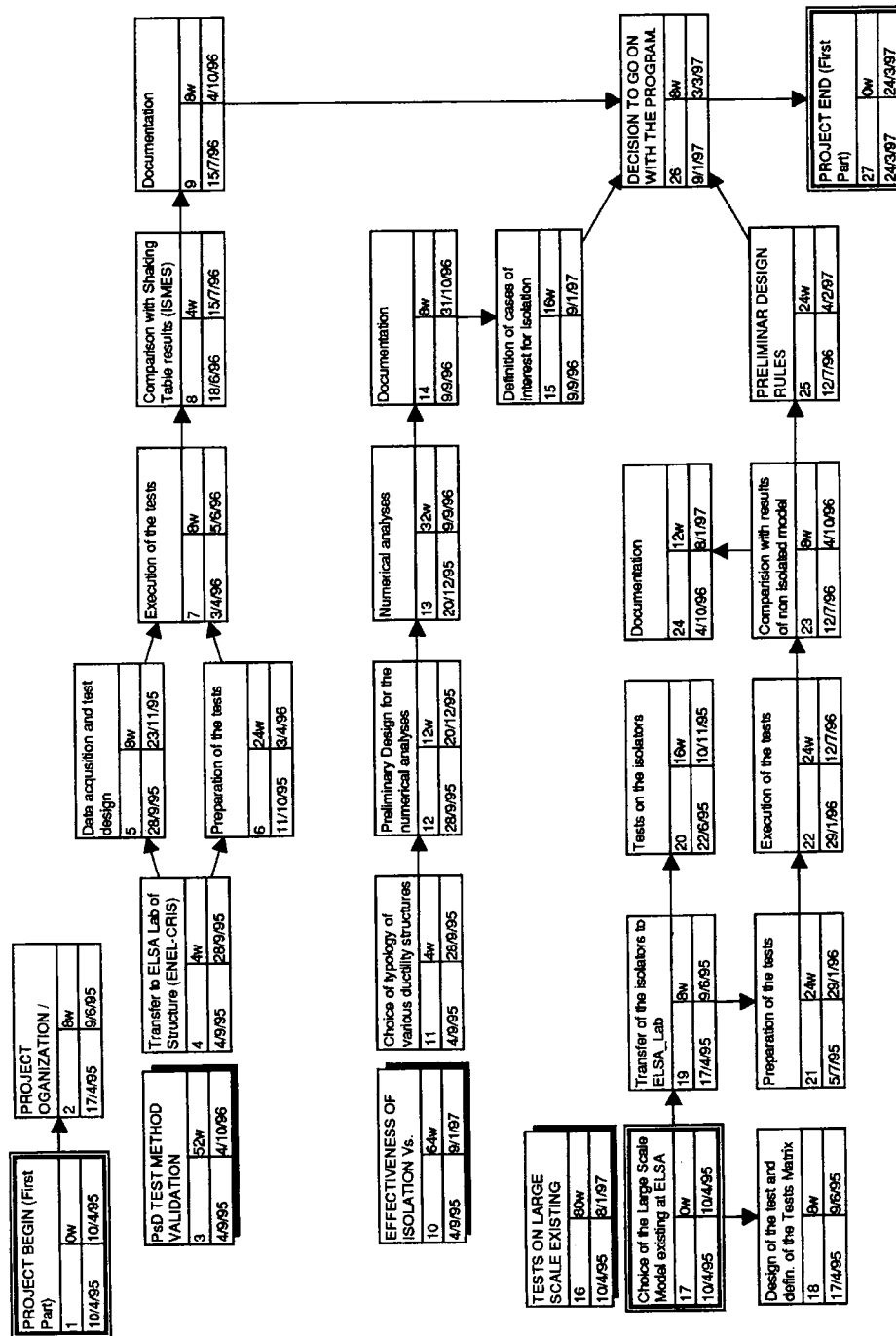


Figure 3. Seismic Isolation Programme - PERT chart