



ELSA - Structure of the experimental datasets

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2025



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JRC141264

EUR 40266

PDF ISBN 978-92-68-25782-1 ISSN 1831-9424 doi:10.2760/6543699 KJ-01-25-190-EN-N

Luxembourg: Publications Office of the European Union, 2025

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How to cite this report: European Commission: Joint Research Centre, Peloso, S., Molina, F.J., Lamperti Tornaghi, M., Peroni, M. and Petit, P., *ELSA - Structure of the experimental datasets*, Publications Office of the European Union, Luxembourg, 2025, <https://data.europa.eu/doi/10.2760/6543699>, JRC141264.

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Abstract

The European Laboratory for Structural Assessment (ELSA) is the research facility of the European Commission DG JRC investigating the behaviour of structures, materials and components. Its research supports disaster risk management and territorial policies, with a focus on seismic risk reduction, structural safety and security.

This document describes the structure and content of ELSA datasets, which are used to store information on projects, specimens, experiments, and data acquisitions, as well as raw and processed data. Besides being a requisite of the high quality standards of ELSA, this document also provides a guide for internal and external users to access, navigate and understand the shared datasets. This enables the efficient reuse and exploitation of the experimental results of past experimental campaigns.

In line with the vision for open science of the European Commission, ELSA shares the datasets created through its work. The standardised structure of the datasets helps to make information findable, accessible, interoperable, and reusable (FAIR), fostering transparency and collaboration among researchers, policymakers, and industry stakeholders.

This work is supporting the European Commission's goals for open science and data-driven decision-making, and contributing to the implementation of the European Union's policies on disaster risk reduction and sustainable development of the built environment.

Acknowledgements

Storing and sharing the data gathered during experimental campaigns is one of the duties of ELSA laboratory, part of Unit E.3 of the Directorate General Joint Research Centre (DG JRC – European Commission).

This document is based on the work of the authors, but contributions by the experience from past projects, such as SERIES (2009) and SERA (2017), and our external ex-colleague Lamata I. as well as by other colleagues were essential for the development of the capabilities of the laboratory and the execution of the tests originating the shared data.

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1 Introduction

The European Laboratory for Structural Assessment (ELSA) is part of JRC Unit E.3 Built Environment. The activities of the Unit and of its laboratories are relevant to the Disaster Risk Management and the Territorial Policies Knowledge Centres and to the Community of Practice on Cities, also fostering normative developments and competitiveness of the European construction sector.

The ELSA Reaction Wall is a research infrastructure (RI), unique in Europe, open to external scientific use. The open access project allows European researchers and industry to perform tests at the ELSA Reaction Wall for research and demonstration projects relevant to the European Green Deal and policies on the built environment. One of the target of the project is to put together top researchers with leading industry, spearheading innovation, including the development of e-infrastructures, resource efficiency issues and resilience of critical infrastructures.

ELSA designs, sets up, and carries out large-scale experimental campaigns on components and structures for scientific and policy support projects ensuring high standards of management, safety and quality. It also implements the experimental work needed in other projects of the current project portfolios. All this requires regular and improved maintenance, strategic planning for new investments, implementation of safety standards, ISO certification, calibration and management of sensors and equipment, maintenance of the ELSA database, implementation of protocols for qualification and procurement.

Recently, ELSA has been supporting research related to the structural and seismic safety of structures, including:

- Reference tests on reinforced concrete buildings with and without infill wall panels;
- Reference and pioneering tests on full-scale bridges, including irregular configurations, isolation and asynchronous input motion using the pseudo-dynamic method with non-linear substructuring;
- Tests on models representing portions of heritage structures for the development of assessment methods and protection techniques;
- Experimental tests on fibre-reinforced and composite structures;
- Reference tests on models representative of existing vulnerable structures for the development of conventional or novel techniques and the calibration of European codes for assessment, strengthening and repair;
- Development of the continuous pseudo-dynamic method, allowing more efficient seismic testing of large-scale specimens.

Furthermore, ELSA also joined a collaboration framework with the Natural Hazards Engineering Research Infrastructure (NHERI) in the USA and with leading RIs in China, Japan and South Korea. This collaboration aims to develop new technologies, techniques and standards that will promote the efficient and joint use of RIs, including web platforms to archive, manage and share research data. Additional activities of ELSA are devoted to evaluate innovative technologies for testing methods and sensors to increase accuracy and efficiency of experimental testing.

As an essential part of the abovementioned activities, and in partial fulfilment of the requirements of quality standards, ELSA adopted an organised structure following a data model (or database design) to store the information about each experimental project and the corresponding data

deriving from the monitoring of the experiments. The same data model, in form of a file system, is used also to share experimental results with authorised external users. Furthermore, using the same format, ELSA shares the results of most of the tests performed in the laboratory (possibly after an embargo period prescribed by the different user agreements) to the public through services such as Zenodo or other similar databases.

This report describes the structure of such structured file system used both to store and to share experiments results and their relative data, as belonging to specimens and projects with their own information. Describing the structure of the datasets, the report also aims at facilitating the access to this information and at helping usability of shared datasets. The structure of the data catalogue was developed in the recent past in collaboration within research networks such as SERIES (2009) and SERA (2017) and external collaborators (Lamata et al., 2017), and it is now applied to all the experimental projects performed at the facility. Although complex, the system adopted to manage the large quantity of information pertaining to each project is characterised by a fixed structure responding to the necessary requisites of i) generality and ii) logical distribution of data. Furthermore, the structure of the adopted file system was lastly improved to increase the FAIRability of data, making information Findable, Accessible, Interoperable, and Reusable (FAIR). This reflects the indication of the Commission Recommendation (EU) 2018/790 on access to and preservation of scientific information.

After a brief description of the general settings of the datasets and the licensing on their use, the report analyses and describes the file system structure used to organise and store the data. As a standard approach, all the information is gathered and structured in nested folders, which are described by the several sections of the report. Starting from the outer layers of the structure containing the most general information, going to the inner layers of the file system, the report describes the content of each folder, also giving a few examples of what can be found in the different folders. Finally, as the most important part of a dataset is the experimental data, a chapter describes the types of acquisition used at ELSA (the outputs of which are available to the users), also distinguishing between the shared unprocessed (raw) and processed data files and graphic output.

2 General setting

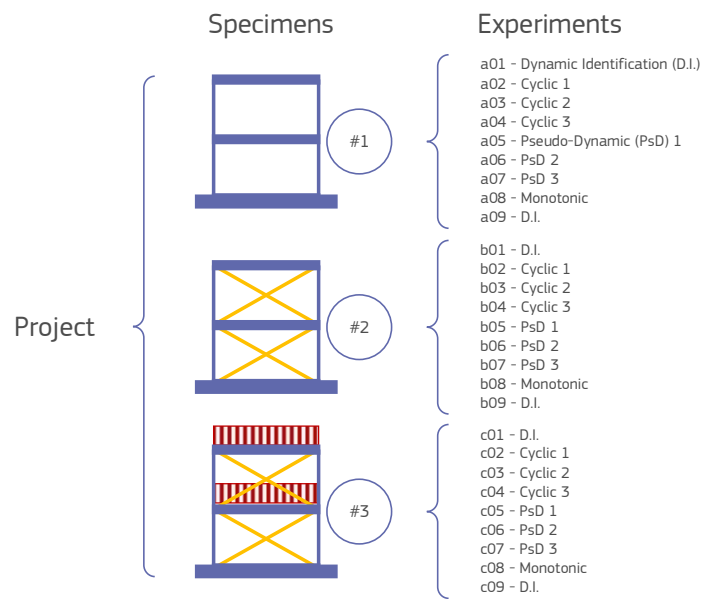
The information, data or “data and metadata”, (terms that will be used as synonyms in this report) relative to the experimental projects performed at the European Laboratory for Structural Assessment (ELSA) are stored in structures having a fixed format. As a standard approach, all the information are shared with authorised users or publicly by means of open-access data-storage services (e.g. Zenodo Open Research Repository, ERIES Data Access Portal, etc.). Despite the location where the data are stored, once a dataset is downloaded (normally a compressed file), all the information are available and organised within a file system structure. Scope of this report is to describe the structure of such file system structure in order to facilitate the users accessing the data. Clearly, the use of the shared materials is free within the limitation of the terms of license, as described in the next chapter 3.

In order to facilitate the understanding of the file system and the access to the information, it is important to note that, as a general rule, the outer layers of this nested structure report the most general data, while moving to the inner layers the level of detail increases. Worth to mention is also that folders with the same name gather the same type of information, but those in inner layers collect information limited to a specific object (specimen, experiment, etc.) of the project (and which may not hold true for the rest of the project).

Furthermore, it is essential to understand that the structure of the file system reflects the structure of the most general experimental projects. A project may involve testing of one or more specimens, and each of these may undergo a testing protocol including one or more experiments. It is also worth mentioning that two different specimens, in fact, may refer to the same physical object but with different details and/or boundary conditions.

As an example, what a project considers three different specimens of an experimental campaign could be in fact the same steel frame structure tested without diagonal bracings (specimen #1), with diagonal bracings (specimen #2), with diagonal bracings and additional dead loads on its storeys (specimen #3). Following this line, each of these three specimens could be the object of a testing protocol including: initial dynamic identification (test #1), preliminary quasi-static cyclic tests (test #2 to #4), pseudo-dynamic tests (test #5 to #7), final quasi-static monotonic test up to incipient collapse (test #8), and final dynamic identification (test #9). **Figure 1** shows a schematic representation of the described structure.

Figure 1. General structure of an experimental project.



Source: Original figure.

3 Licensing

As part of the European Commission DG JRC, ELSA produces and shares data respecting the Commission Decisions on this matter. Consequently, all the datasets shared by ELSA, unless differently specified within the single dataset (see *DataStatementsProps.xlsx* file described in subsection 4.1), are under the reuse policy of the European Commission, implemented by “2011/833/EU: Commission Decision of 12 December 2011 on the reuse of Commission documents”. Reuse is authorised, provided the source is acknowledged as per the Creative Commons standard license CC BY 4.0.

For further and more detailed information, please refer to:

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- European Commission Reuse and Copyright Notice, © European Union, 1995-2024 [https://data.jrc.ec.europa.eu/licence/com_reuse];
- Creative Commons standard license CC BY 4.0 [<https://creativecommons.org/licenses/by/4.0>].

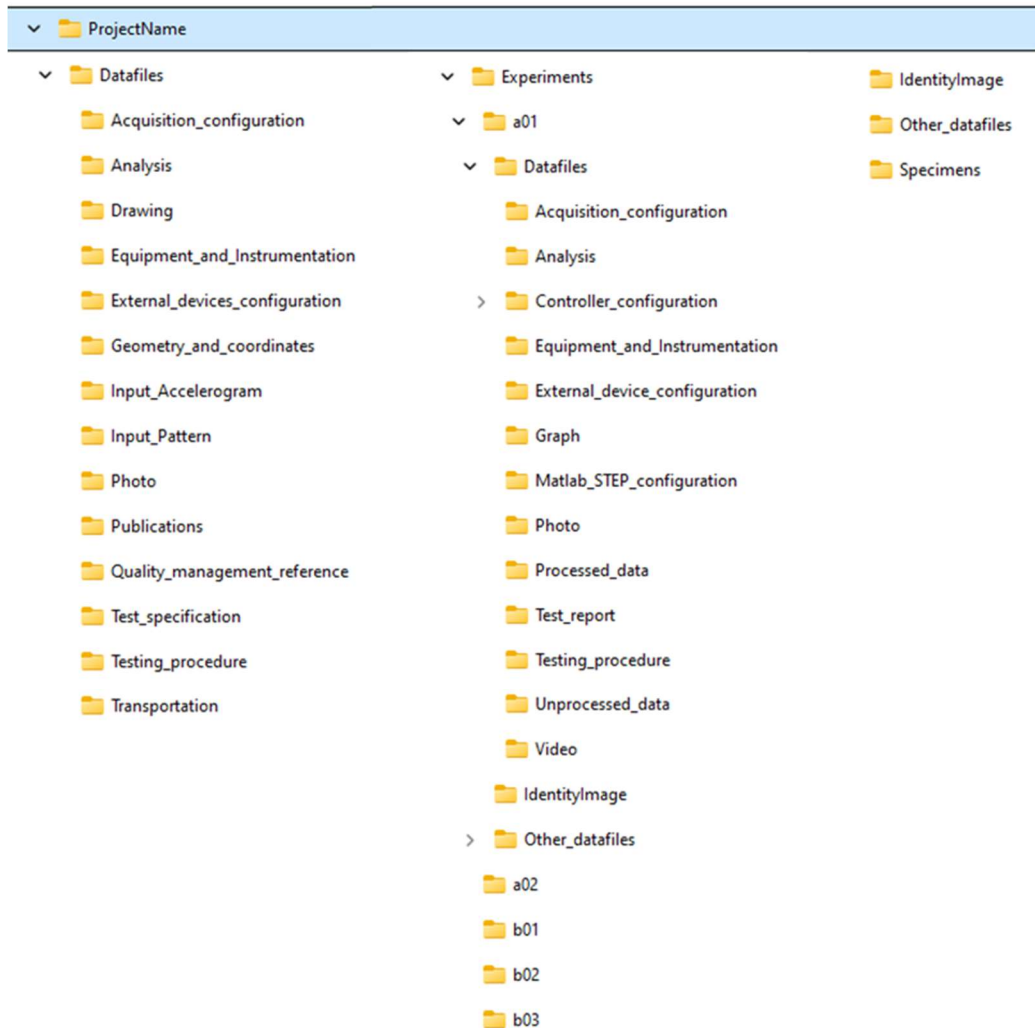
Although already specified in the documents referred above, it is worth recalling that, the following applies to the data/information provided by the JRC (and in this case by the ELSA), unless not permitted or valid under applicable law:

- The JRC data are provided "as is" and "as available" without warranty of any kind, either express or implied, including, but not limited to, any implied warranty against infringement of third parties' property rights, or merchantability, integration, absence of latent or other defects, satisfactory quality and fitness for a particular purpose. The JRC data do not constitute professional or legal advice (if you need specific advice, you should always consult a suitably qualified professional).
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- Any use of the shared data shall reference the relative dataset and acknowledge the project according to what reported in the file *AcknowsProps.xlsx* (see next subsection 4.1).

4 File system structure of experimental results

Figure 2 shows the complete structure, adopted as a standard at ELSA, of the file system gathering all the project information, data and metadata. The following sections briefly describe the content of each folder composing the file system: these descriptions aims at guiding the users in the correct interpretation of shared datasets, as well as in the creation of datasets with similar structure (if of their interest).

Figure 2. File system structure gathering all the project information and data.



Source: Original figure.

4.1 Project root folder

The root folder of a project object (*ProjectName* in **Figure 2**, but normally named after the real name or short acronym of the particular project itself) includes five folders and four Excel files (see **Figure 3**). In more detail, the five folders, whose content is described in the following subsections, are:

- *Datafiles*;
- *Experiments*;

- *IdentityImage*;
- *Other_datafiles*;
- *Specimens*.

The Excel files, summarising certain properties of the project object following a fixed internal format, are:

- *DataStatementsProps.xlsx*, the file presents the conditions for authorised use of the dataset, as also stated at https://data.jrc.ec.europa.eu/licence/com_reuse and envisaged by the standard license CC BY 4.0 (<https://creativecommons.org/licenses/by/4.0>);
- *AcknowsProps.xlsx*, the file shows the mandatory way of referencing the project in the acknowledgement section of future works that will exploit any of the information within the dataset;
- *ProjectProps.xlsx*, the file contains some basic information on the description, purpose, keywords and partners of the project;
- *ExtIdentifiersProps.xlsx*, the file gathers external links to the project (if any).

Figure 3. Content of the root folder of the project.

Name	Type
Datafiles	File folder
Experiments	File folder
IdentityImage	File folder
Other_datafiles	File folder
Specimens	File folder
AcknowsProps.xlsx	Microsoft Excel Worksheet
DataStatementsProps.xlsx	Microsoft Excel Worksheet
ExtIdentifiersProps.xlsx	Microsoft Excel Worksheet
ProjectProps.xlsx	Microsoft Excel Worksheet

Source: Original figure.

4.2 Datafiles folder

Being at the outermost level, the *Datafiles* folder gathers files regarding general data about the project object. As for other objects in the database, inside the *Datafiles* folder, documents, figures, text files, binary files for that object are grouped in subfolders according to their meaning or type (see **Figure 4**).

A precise description of the content of each folder within the *Datafiles* is not possible, because of the flexibility required by different projects, and allowed by the existing structure of the file system. Nevertheless, without trying to be exhaustive about the content of each folder, the following list roughly describes the files that could be stored inside each subfolder:

- *Analysis*: the folder may include information about analyses of general use for the project. Examples could be: i) data derived by preliminary analyses used to define global response quantities useful for the design of the set-up and/or the specimen(s), ii) general data derived by the post-processing of the data acquired during the experimental activity, useful for comparison between experiments or between specimens, iii) functions for the treatment of data possibly generating general response quantities giving a global view on the project;

Figure 4. Content of the *Datafiles* folder.

Name	Type
Analysis	File folder
Drawing	File folder
Equipment_and_Instrumentation	File folder
External_devices_configuration	File folder
Geometry_and_coordinates	File folder
Input_Accelerogram	File folder
Input_Pattern	File folder
Photo	File folder
Publications	File folder
Quality_management_reference	File folder
Test_specification	File folder
Testing_procedure	File folder
Transportation	File folder

Source: Original figure.

- *Drawing*: one of the result of the design of the testing set-up and the specimen(s) are the executive/fabrication drawings of such components. Such drawings, as well as the initial sketch basis of the final implementation, or drawing for the position of actuators and instruments can be included in this folder;
- *Equipment_and_Instrumentation*: most experiments at ELSA involves a specimen loaded by actuators (or other devices) while sensors (e.g. transducers, encoders, strain gauges, etc.) are capturing the response of the specimen itself. This folder gather information about the installed instrumentation and loading devices, example of the content of the folder could be technical sheets or calibration reports for any of the component of both the loading and the acquisition system;
- *External_devices_configuration*: beside the equipment of the laboratory, external devices can be used to complement what available at ELSA. This folder may include all the information considered to be useful for a correct interpretation of the data possibly generated by any external devices, or the calibration certificate of such devices. As an example, configuration files of third party acquisition system used (in parallel to that of ELSA) for the monitoring of an experiment can be stored in this folder;

- *Geometry_and_coordinates*: to complement the information included in the *Drawing* folder, the files in this folder may summarise key dimensions of the specimen(s) or set-up. This may include schematic representation of the specimen(s) as mounted in the set-up and the distances characterising the geometry of the loading scheme. As an example, this information can be important when trying to derive internal actions in a specimen just knowing the external loads applied by the actuators;
- *Input_Accelerogram*: in pseudo-dynamic (PsD) testing, the external actions are evaluated by the control system integrating the equation(s) of motion and using acceleration time-histories as input. This folder gathers the input accelerogram used for PsD tests, together with the information used to select or modify such signals (e.g. for spectrum compatibility);
- *Input_Pattern*: when performing a cyclic test, the loading time-histories are defined through patterns that the controller transforms in the controlled variable(s) (e.g. displacement or force) sequences. This folder gathers such patterns used for cyclic tests, together with the information used to derive or scale such loading time-histories (e.g. scale factors corresponding to the achievement of pre-set target limit states);
- *Photo*: this folder may collect photos about the project from a general point of view. It must be understood that the file system includes several folders to gather photos, beside this one, others are present to store photos with higher level of detail, for instance about a specific experiment;
- *Publications*: after the completion of a project, the ELSA staff and/or the users of the project normally prepare publications. Such publications may include technical reports (published by JRC or other public bodies), journal papers, and book chapters. All the open access publications (or most often their DOI) may be stored in this folder, while other publications are here referenced (e.g. listing complete citations and DOI) for an easy access;
- *Quality_management_reference*: quality control is essential for a successful experimental campaign. This includes all the steps of the process from the construction of the specimen(s) to the calibration of the acquisition system. This folder may be used to store all the information about the management of quality from the different points of view of the general implementation of the project;
- *Test_specification*: in the planning phase of an experimental campaign, the test specification sets the targets of the experiment(s), e.g. giving indication about the quantities of interest to be monitored, or the minimum load levels and sequences to be applied to the specimen(s). This information is gathered in this folder for general reference. This folder stores all the documents listing the complete sequence of tests to be performed on each specimen, also collecting information about specific patterns or acceleration time-histories to be applied and the corresponding scaling factor of each experiments;
- *Test_procedure*: an essential part of the correct implementation of a successful testing campaign is the definition of the test procedure, meaning the correct sequence of actions to be performed for the execution of tests. Note that each experiment folder include a *Testing_procedure* folder gathering information on the procedure of the single test (see subsection 4.3.1.1);

- *Transportation*: the specimens tested at ELSA are often large- to real-scale structures. To limit the occupation of the laboratory and the disruptive impact that a construction site could have on the laboratory environment, such specimens may be built outside the laboratory and then moved to the correct location inside ELSA. Transportation of bulky, heavy and sometimes fragile structures is clearly not an easy task to achieve and it is the object of an accurate design. All the information about the transportation phases, the required equipment and its connection to the specimen are stored in the *Transportation* folder for future reference.

4.3 Experiments folder

As shown in **Figure 5**, the *Experiments* folder includes several subfolders (one for each performed experiment object within the current project) which include information about the specific experiment, as it will be discussed in the following subsection 4.3.1. Furthermore, the *Experiments* folder stores an Excel file (*ExperimentProps.xlsx*) that gathers some metadata about each experiment. The information listed in the file using a fixed format (see **Figure 6**) may include:

- the name of the experiment;
- a short description of the experiment;
- the reference to the tested specimen;
- a short description of tested specimen;
- keyword(s) (if any);
- the purpose of the specimen;
- the experiment starting and end dates;
- additional notes (if any).

Figure 5. Contents of the *Experiments* folder.

Name	Type
a01	File folder
a02	File folder
b01	File folder
b02	File folder
b03	File folder
ExperimentsProps.xlsx	Microsoft Excel Worksheet

Source: Original figure.

Figure 6. Partial view of the *ExperimentsProps.xlsx* file contained in the *Experiments* folder.

	A	B	C	D	E	F	G	H	I
	name	description	specimens	specimen description	keywords	purpose	startDate	endDate	notes
1									
26	a25	Loading of upper floor with nine 5.5-ton blocks	OrigBuildNoWe	Original 2-storey flat slab system without additional weight			03/10/2019	03/10/2019	
27	a26	Loading of first floor by filling in 48 water tanks	OrigBuildNoWe	Original 2-storey flat slab system without additional weight			04/10/2019	04/10/2019	
28	e01	5% 007142ya Y Acc. 4s only	OrigBuildA	Original 2-storey flat slab system with additional weight A			09/10/2019	09/10/2019	3 Column Load Cell channels of shear do not measure properly
29	e02	5% 007142ya Y Acc.	OrigBuildA	Original 2-storey flat slab system with additional weight A			11/10/2019	11/10/2019	2 Column Load Cell channels of shear have been repaired. New signs are introduced for Column Load Cells
30	e03	30.827% 007142ya Y Acc. (TEST A1)	OrigBuildA	Original 2-storey flat slab system with additional weight A			16/10/2019	16/10/2019	
31	e04	1mm cyclic	OrigBuildA	Original 2-storey flat slab system with additional weight A			17/10/2019	17/10/2019	Controller tuning
32	e05	2mm cyclic	OrigBuildA	Original 2-storey flat slab system with additional weight A			18/10/2019	18/10/2019	Controller tuning. New NK
33	e06	87.082% 007142ya Y Acc. (TEST A2)	OrigBuildA	Original 2-storey flat slab system with additional weight A			21/10/2019	21/10/2019	
34	f01	8mm cyclic	OrigBuildB1	Original 2-storey flat slab system with additional weight B1			22/10/2019	22/10/2019	

Source: Original figure.

4.3.1 Single experiment folders (within the *Experiments* folders)

As briefly mentioned in subsection 4.3, the *Experiments* folder include a number of subfolders gathering the information about the single experiments. Next **Figure 7** shows the content of one of these subfolders named after the single experiment object.

Figure 7. Content of a single experiment folder.

Name	Type
Datafiles	File folder
IdentityImage	File folder
Other_datafiles	File folder

Source: Original figure.

Next subsections will describe the content of the few folders present at this inner level, and of the subfolders nested inside these ones; note that some of them have the same names of folders at the outer level of the file system structure, and their full description will not be repeated here. As pointed out in section 2, outer and inner folder sharing the same name are used to gather the same type of information and data. The only difference is that, while outer layers have more general information common to the whole project, inner layers collect information that is more specific (the validity of which may be limited to a specific object/event of the project: for example a specimen or an experiment in this case).

4.3.1.1 Datafiles folder nested in each single experiment folder

As it was for the general *Datafiles* folder under the project object (see subsection 4.2), all the files referring to a single experiment object collected by this inner folder are gathered in subfolders. The

same structure of *Datafiles* can also be found under a single specimen folder in the case it exists. In fact, most of these subfolder names are the equivalent at local level of the folders including the general information about the project. **Figure 8** shows the content of this folder.

What follows briefly describes the content of each subfolder:

- *Acquisition_configuration*: if the experiment is performed using the ELSA REal-time Controller (ELSAREC) in “acquisition node” mode (i.e. just as acquisition software), this folder gathers the configuration files of the acquisition system. Although most of these files are of no use for third-party users, they are often shared for the sake of completeness.
It is worth mentioning that having an “acquisition node” (managing the acquisition) and a separate “controller node” (managing the actuation) was the standard approach until 2022, but this is now obsolete as the last version of ELSAREC allows joining both functions in a single node (i.e. on a single PC). Nowadays, the “acquisition node” mode is used only for the experiments related to the internal calibration of instruments;
- *Analysis*: same kind of information as for the outer layer (see subsection 4.2), but referred to the local level;
- *Controller_configuration*: this folder gathers the configuration files of the ELSA REal-time Controller (ELSAREC) used to manage both the actuation control and the acquisition system of the laboratory for this single experiment. Although most of these files are of no use for third-party users, they are often shared for the sake of completeness;

Figure 8. Content of the *Datafiles* folder nested in each single experiment folder.

Name	Type
Acquisition_configuration	File folder
Analysis	File folder
Controller_configuration	File folder
Equipment_and_Instrumentation	File folder
External_devices_configuration	File folder
Graph	File folder
Matlab_STEP_configuration	File folder
Photo	File folder
Processed_data	File folder
Test_report	File folder
Testing_procedure	File folder
Unprocessed_data	File folder
Video	File folder
AcknowsProps.xlsx	Microsoft Excel Worksheet
DatafilesProps.xlsx	Microsoft Excel Worksheet
ExtIdentifiersProps.xlsx	Microsoft Excel Worksheet

Source: Original figure.

- *Equipment_and_Instrumentation*: same kind of information as for the outer layer (see subsection 4.2), but referred to the local level;

- *External_device_configuration*: same kind of information as for the outer layer (see subsection 4.2), but referred to the local level;
- *Graph*: as part of the data processing, output quantities of interest are often plotted on graphics stored in this folder;
- *Matlab_STEP_configuration*: as an exception to the standard format of the data file system structure, this folder pertains only to those experiments performing substructured PsD tests using an external FEM (Finite Element Method) calculus engine for the integration of the equations of motions. The name reflects the fact that the first version of the external solver was coded in Matlab, but other software is planned to be added in the near future as an alternative to the self-implemented Matlab code. This folder includes the files required to run the numerical simulation of the hybrid specimen;
- *Photo*: typically photographs taken during this experiment or just before or after;
- *Processed data*: this folder collects the outcome of data processing (e.g. data ready for use by partners and third-part users). For further details on the processed data, the reader should refer to subsection 5.3;
- *Test_report*: depending on the type of project and experiment, the data processing could automatically produce a test report summarising the main outcomes of the test and/or compliance with acceptability criteria (for example for a calibration test). If produced, test report are eventually stored in this folder;
- *Test_procedure*: being located at local level, this folder collects the files reporting the instruction for the correct execution of the test. Examples of its contents may be i) the complete sequence of operation required to perform the test, or ii) documents reporting a brief description of the test, or iii) a list of the parameters (e.g. forces or displacements) characterising the amplitude, the speed of the test or the controller PID parameters and with some other notes, or iv) a file collecting the screenshots taken at the end of the test to trace the output of the on-line monitoring used during the test;
- *Unprocessed_data*: this folder collects the original output of ELSAREC (the control and acquisition system of the laboratory), without any treatment. The original data are stored in case a new data processing would be required. For further details on the unprocessed data, the reader should refer to subsection 5.2;
- *Video*: this folder may collect some videos recorded during the corresponding experiment. Note that as ELSA often performs quasi-static and pseudo-dynamic tests, the videos could in fact be time-lapses, created exploiting the pictures grabbed during the test execution.

Besides the abovementioned folder, three Excel files are normally present:

- *AcknowsProps.xls*: same kind of information as for the equivalent file stored in the root folder of the project (see subsection 4.1), but referred to the local level;
- *DatafilesProps.xls*: this file lists all the files automatically created by the preliminary data treatment, as briefly mentioned in 5.3;
- *ExtIdentifiersProps.xlsx*: same kind of information as for the equivalent file stored in the root folder of the project (see subsection 4.1), but referred to the local level.

4.3.1.2 *IdentityImage* folder nested in each single experiment folders

This folder stores the same kind of information of the general *IdentityImage* folder (see subsection 4.4). The information here collected is relative to a specific experiment and is not the general one that characterises the whole project.

4.3.1.3 *Other_datafiles* folder nested in each single experiment folders

As it is for the general *Other_datafiles* folder (see subsection 4.5), most of the information stored in this folder is mainly of use for the ELSA staff and partners of the project. Being at an inner layer of the file system structure, the data are relative just to the specific experiment. Note that, as for the general *Other_datafiles* folder, also this one is generally not included in the shared dataset.

4.4 *IdentityImage* folder

This folder may gather information about the visual identity of the project and, possibly, of its partners. The visual identity is recognised to have much importance in order to make a “product” recognisable by its users, stakeholders and the public. The content of the *IdentityImage* folder aims at giving a uniform aspect to the products of the project in order to bind them together and avoid dispersing possible contributions to its impact. Such information may include (but not be limited to):

- the logo of the project;
- a few significant images or pictures;
- a textual description about the visual identity of the project;
- templates for reports and/or presentation.

4.5 *Other_datafiles* folder

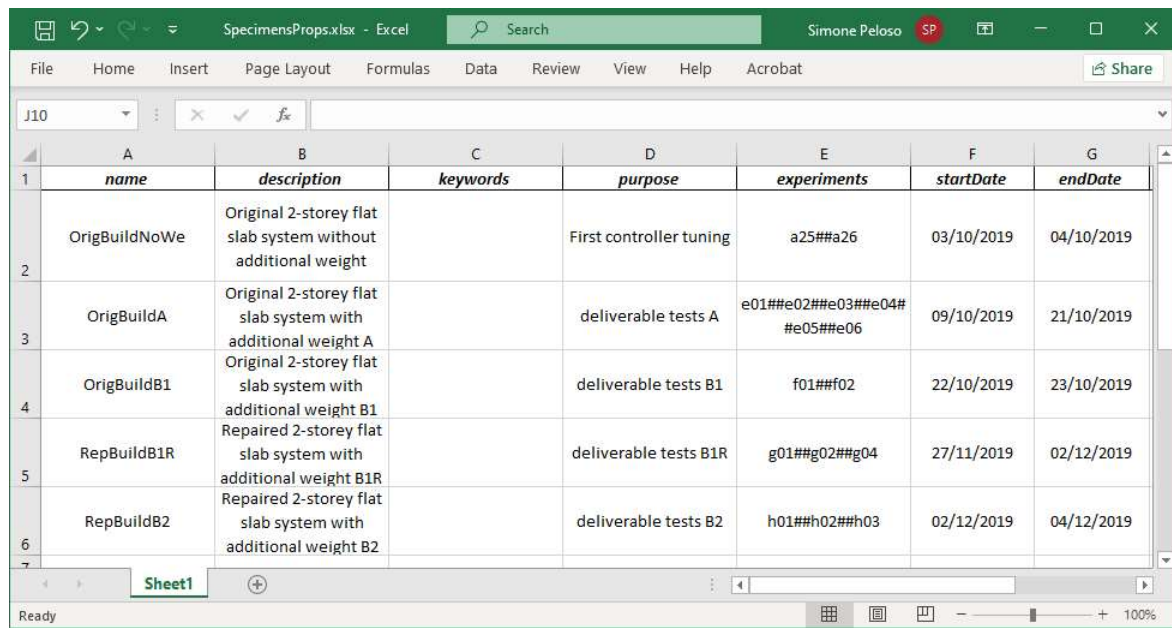
This folder stores the information useful to the partners to track the development of the several phases of the project itself. This information may be of use during the implementation of the project itself but are not to be critical for the future use of the dataset. For this reason, typically the content of this folder is not included in the shared dataset.

4.6 *Specimens* folder

The *Specimens* folder stores an excel file named *SpecimensProps.xlsx* that tables metadata regarding the specimen(s) tested performing the experiments of the project. This file includes the specimen name, a short description of it, keyword(s) (if any), the purpose of the specimen, the list of experiments performed on each specimen, as well as the starting date of the first experiment and end date of the last experiment. **Figure 9** shows an example of such file belonging to a past project performed at ELSA.

Besides, the *Specimens* folder may contain subfolders named after each specimen and used to gather information regarding any particular aspects of the corresponding specimen, in a similar way to the single experiment folders within the *Experiments* folders (see subsection 4.3.1).

Figure 9. View of the *SpecimensProps.xlsx* file contained in the *Specimens* folder.



	A	B	C	D	E	F	G
	<i>name</i>	<i>description</i>	<i>keywords</i>	<i>purpose</i>	<i>experiments</i>	<i>startDate</i>	<i>endDate</i>
1	OrigBuildNoWe	Original 2-storey flat slab system without additional weight		First controller tuning	a25##a26	03/10/2019	04/10/2019
2	OrigBuildA	Original 2-storey flat slab system with additional weight A		deliverable tests A	e01##e02##e03##e04##e05##e06	09/10/2019	21/10/2019
3	OrigBuildB1	Original 2-storey flat slab system with additional weight B1		deliverable tests B1	f01##f02	22/10/2019	23/10/2019
4	RepBuildB1R	Repaired 2-storey flat slab system with additional weight B1R		deliverable tests B1R	g01##g02##g04	27/11/2019	02/12/2019
5	RepBuildB2	Repaired 2-storey flat slab system with additional weight B2		deliverable tests B2	h01##h02##h03	02/12/2019	04/12/2019
6							

Source: Original figure.

5 Data acquisition and processing

The chapter is reporting a basic description of the data acquisition at ELSA, allowing the reader to get an insight at the content and the characteristic of the files collected by project datasets. For a better and deeper understanding of ELSAREC (REal-time Controller developed at ELSA), further information can be found in Peroni et al. [2022].

5.1 Types of acquisition

The configuration of ELSAREC (mentioned in subsection 4.3.1.1) includes files setting the acquisition system. These files are used to select the signals that will be recorded and the adopted sampling rate of each acquisition running during the experiment. At ELSA, it is common practice to have multiple acquisitions running in parallel and recording several sets of variables, possibly at different sampling rates. **Table 1** and **Table 2** list the blocks of variables and the acquisition type commonly adopted for the monitoring of experiments.

Per standard practice, the name given to each acquisition is composed joining:

[Name of the experiment] + [Block of variables to be saved **Table 1**] + [Type of acquisition **Table 2**]

Just to give a few examples of typical names used for the acquisition files:

- “a03avrsIns” identifies the instantaneous (Ins) acquisition of the variables of the control target-generation algorithm (avrs) performed during the experiment named “a03”;
- “b15slvRec” refers to the acquisition of the slave (slv) controller variables for each actuator loading the specimen during the “b15” experiment, the time-step between the values saved is in this case the record duration of the input to the controller target-generation algorithm;
- “e05stdCon” denotes the continuous (Con) acquisition of the output of the standard instrumentation (std) monitoring the specimen while performing the experiment “e05”. These standard instruments are the ones not already existing in the slave controllers set for the actuators;
- “e05slvInsPre” gathers the control variables of the slave (slv) controller variables for each actuator, saving data at the fastest possible rate (Ins) when/if a certain signal triggers the acquisition during the experiment “e05”. Pre-trigger (Pre) is enabled allowing the recording of a certain amount of samples before the triggering of the acquisition.

Table 1. Blocks of variables generally saved by ELSAREC.

Block of variables	Description	Code name
ALGORAV, ALGORRESTART	All the record-averaged (AV) and Record-initial (RESTART) variables of the controller target-generation algorithm (ALGOR)	avrs
C1, C2, C3, ...	Selected control variables of the actuators (slaves of the master control system) loading the specimen during the execution of the tests.	slv
STANDARD	Output of the standard instruments installed and monitoring the response of the specimen	std

Source: Original table.

Table 2. Types of acquisition performed by ELSAREC.

Type	Usual adopted time-step (acquisition rate)	Output and use	Code name
At Record time-step	Fixed by the input, e.g. 1 s (1 Hz)	Acquisition at the same time-step (Record) of the input to the controller target-generation algorithm, generally used to get information about the overall response	Rec
Continuous	0.1 s (10 Hz)	Acquisition performed typically uninterruptedly at faster rate, used to get better/deeper insight into the structural and control behaviour or for backup/diagnosis purposes	Con
Instantaneous	0.001 s (1000 Hz)	Acquisition at each interrupt of the real-time control system, used to investigate the dynamics of the specimen (dynamic identification), or for diagnostic on control issues	Ins
Pre-triggered	-	Pre-trigger is an activation mode that can be used within the other acquisition types to: i) automatically start the acquisition based on a selected signal, and ii) save a certain number of samples preceding the triggering of the acquisition (e.g. InsPre - instantaneous acquisition with pre-trigger). Apart from the case of some dynamic experiments, the InsPre acquisition typically used at every experiment is activated when the oil pumps are shut down, either at the end of the test or by an alarm and should be ignored by the external users	-Pre
Offset	0.1 s (10 Hz)	Continuous acquisition running for a limited time, normally used to evaluate the initial offset of instruments during dedicated pre-test activities on specimen(s). Note that this is normally of scarce or no interest for users	Offset

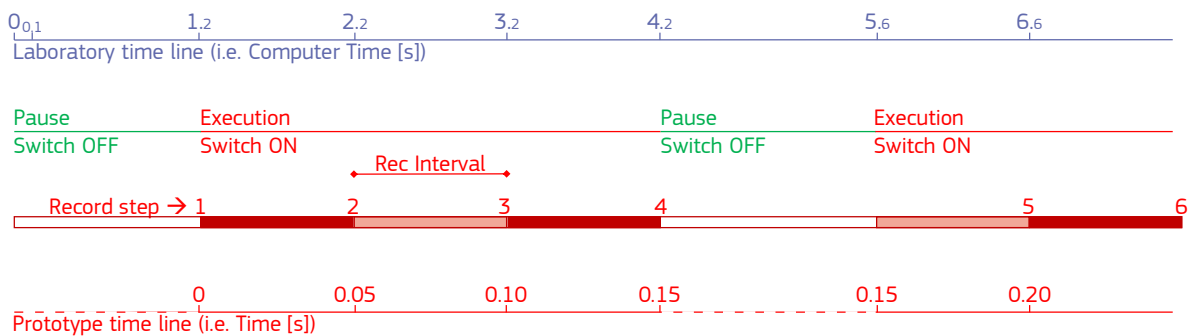
Source: Original table.

It is also worth to mention that some of the acquisition output files may include more than one time vector, namely *Time* and *Computer Time* (both measured in seconds). In general, the two time vectors are different as the *Time* vector is a measure of time in the prototype time line, while the *Computer Time* vector is a measure of time in the laboratory time line. The difference between the two is characteristic of the Pseudo-Dynamic algorithm that is not executing the experiment in the original prototype time (i.e. real-time), but on a dilated time scale. **Figure 10** represents the two time vectors for an experiment running on a time scale equal to 200, and having an input accelerogram the accelerations of which are specified at a time step equal to 0.05 s. To fully understand the concept depicted in **Figure 10** is also important to consider that the execution of a PsD test can be started and paused (as many time as desired or requested) acting on a trigger switch. With reference to **Figure 10**:

- The first line represents the laboratory time line, corresponding to the variable *Computer Time* in the acquisition files. This variable clearly keeps increasing at a constant rate (this is the physical real time measured by the watch of the experimenter in the lab);
- The second line represents the position of the trigger switch managing the execution of the PsD experiment. Initially the position of the switch is OFF and the execution of the experiment is not started yet. When the switch is moved to ON, the PsD algorithm starts the test on the first value of the accelerogram record (*Record* step equals 1). While in the execution mode, the algorithm integrates the equation of motion moving from one *Record* step to the next. Switching OFF the execution, the PsD experiment is paused, to then be restarted moving the switch back to the ON position;
- The third line shows the increase of the number of the step of the input record also showing the *Computer Time* duration of one record of the input accelerogram. According to what discussed above, each accelerogram time step (0.05 s) is executed by the PsD algorithm in 1.0 s, i.e. expanding the time by a scale factor of 200. It should also be noted that the record step only increases during the execution of the algorithm (i.e. switch ON), while is at rest when the execution is paused (i.e. switch OFF);
- The fourth line shows the prototype time vector, corresponding to the variable *Time* in the acquisition files. Comparing this line against the first one in **Figure 10**, it is possible to note that *Time* values increase at a slower rate, and actually they are not always growing since the prototype time can be paused by the execution of the PsD test. Also, the zero instants are not aligned since the 0 of the *Computer Time* is at the start of the acquisition, while the 0 of the *Time* vector identifies the starting of the PsD algorithm.

The following example can further clarify the difference between the two time vectors. Consider the execution of a PsD test on a two-storey building, and imagine to have one actuator attached at each floor. The ratio between the top actuator displacement and the *Computer Time* (i.e. laboratory time) equals the velocity at which the actuator is moving during the test. On the other hand, the ratio of the top actuator displacement to the *Time* (i.e. prototype time) equals the velocity of the top storey of the building during the seismic event.

Figure 10. Definition of *Computer Time* and (Prototype) *Time*.



Source: Original figure.

For the sake of completeness, it may be worth mentioning that **Figure 10** shows the switching from ON to OFF position (i.e. the pausing of the execution of the experiment) at the end of a *Rec Interval*, which is at the completion of the execution of one of the time steps of the input

accelerogram. This is just a simplification, as in fact the switching can be performed whenever required, even during the execution of one of the input record.

Finally, from what discussed above, it should be clear that the values saved as the *Computer Time* variable constitute the only time line of interest for experiments other than PsD ones. In fact, for non PsD tests (e.g. monotonic push-over, quasi-static cyclic experiments), the *Time* variable collects values that have no physical meaning for the specimen, they are just the instant in time corresponding to the achievement of the points forming the input time-history (generally a force or a displacement sequence, depending on the adopted testing protocol).

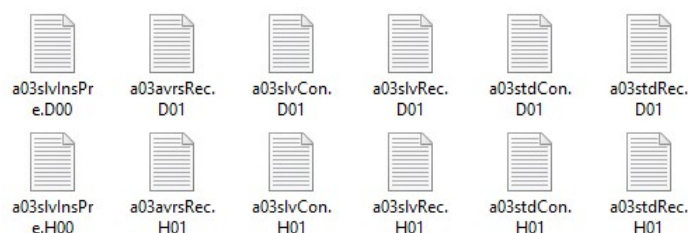
5.2 Unprocessed data

For each of the performed experiments, the *Unprocessed_data* folder collects the output of the acquisition system. **Figure 11** shows an example of the content of the *Unprocessed_data* folder relative to an experiment tagged as “a03”. During the execution of this experiment, six acquisitions were running in parallel, namely: a03svlInsPre, a03avrsRec, a03slvCon, a03slvRec, a03stdCon, and a03stdRec. For each acquisition, the monitoring system creates two files, which can be identified by their file name extension:

- .Hxx: this is the header file that can be opened as a standard ASCII file by any text editor, and gives information about the experiment and the variables saved by the acquisition (e.g. variables name, short description or type of variables, etc.). **Figure 12** shows an example of the content of three header files, from which it is also possible to note that the first signal in every acquisition is the *Computer Time* from which is trivial to determine the adopted recording period (time interval between two consecutive saved samples);
- .Dxx: this is the file containing the data, which are saved as floating-point numbers, in a binary format (called ‘float’ by MATLAB). It is worth to mention that, in general, partners and third-party users are not required to open/use this data as the very same information is available in the *Processed_data* folder, saved using more user-friendly formats.

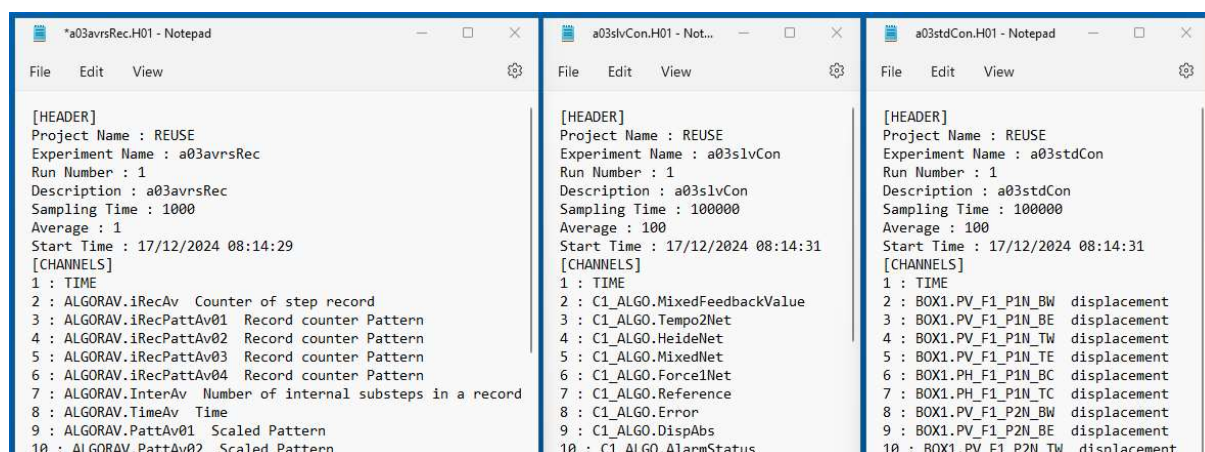
Note that the two characters xx within the file name extension are in fact a two digit progressive number. This xx number increments each time an acquisition is stopped and restarted (generally by the operator of the control system). Additional information on the content of possible subsequent acquisition files (e.g. .D01, .D02, .D03, etc.) may be found in Note column within the *ExperimentsProps.xlsx* file (see subsection 4.3). Also, consider that this split in multiple files may be disregarded by the ELSA data treatment procedure; hence, the shared processed data (see subsection 5.3) may appear as a unique time-series joining the contribution of multiple raw data files.

Figure 11. Example of the content of the *Unprocessed_data* folder.



Source: Original figure.

Figure 12. Examples of the content of the header (.H01) files.



Source: Original figure.

5.3 Processed data and graphics

For each of the performed experiments, right after its conclusion, ELSA staff performs a preliminary data processing useful to perform a first check on the obtained results, and to identify any issue calling for investigation and/or intervention before continuing the experimental campaign. This preliminary data treatment creates several output files that are saved automatically in the *Processed_data* folder, as well as the graphics and figures saved in the *Graph* folder. The complete list of the files generated by this preliminary processing is reported with a short description in the *DatafilesProps.xls* file mentioned in subsection 4.3.1.1 (see **Figure 13**).

Figure 13. Examples of the content of the *DatafileProps.xls* file.

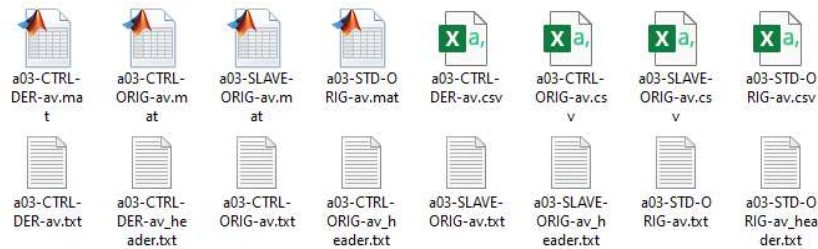
	A	B	C	D	E
	name	roleLabel	description	subfolder	fileName
2	a03---av--001.jpg	Graph	Heidenhain, Temposonics and Load Cell Histories		a03---av--001.jpg
3	a03---av--001.fig	Graph	Heidenhain, Temposonics and Load Cell Histories (MATLAB fig)		a03---av--001.fig
4	a03---av--002.jpg	Graph	Floor Force and Displacement Histories		a03---av--002.jpg
5	a03---av--002.fig	Graph	Floor Force and Displacement Histories (MATLAB fig)		a03---av--002.fig
6	a03---av--003.jpg	Graph	Floor Shear Load / I-S Drift		a03---av--003.jpg
7	a03---av--003.fig	Graph	Floor Shear Load / I-S Drift (MATLAB fig)		a03---av--003.fig
8	a03---av--004.jpg	Graph	Side Shear Load / I-S Drift		a03---av--004.jpg
9	a03---av--004.fig	Graph	Side Shear Load / I-S Drift (MATLAB fig)		a03---av--004.fig
10	a03---av--005.jpg	Graph	Inclinometers		a03---av--005.jpg
11	a03---av--005.fig	Graph	Inclinometers (MATLAB fig)		a03---av--005.fig
12	a03---av--006.jpg	Graph	Inclinometers/Drift		a03---av--006.jpg
13	a03---av--006.fig	Graph	Inclinometers/Drift (MATLAB fig)		a03---av--006.fig
14	a03---av--007.jpg	Graph	Slab S1 X Opening		a03---av--007.jpg
54	a03-CTRL-DER-av.mat	Processed data	Signals in MATLAB format		a03-CTRL-DER-av.mat
55	a03-CTRL-DER-av_header.txt	Processed data	Signals in txt format (header)		a03-CTRL-DER-av_header.txt
56	a03-CTRL-DER-av.txt	Processed data	Signals in txt format (body)		a03-CTRL-DER-av.txt
57	a03-CTRL-DER-av.csv	Processed data	Signals in 2022 csv format		a03-CTRL-DER-av.csv
58	a03-STD-ORIG-av.mat	Processed data	Signals in MATLAB format		a03-STD-ORIG-av.mat
59	a03-STD-ORIG-av_header.txt	Processed data	Signals in txt format (header)		a03-STD-ORIG-av_header.txt
60	a03-STD-ORIG-av.txt	Processed data	Signals in txt format (body)		a03-STD-ORIG-av.txt
61	a03-STD-ORIG-av.csv	Processed data	Signals in 2022 csv format		a03-STD-ORIG-av.csv

Source: Original figure.

One of the operations of the preliminary data treatment is the conversion in user-friendly formats of the output files saved by the acquisition system. These converted files are stored in the

Processed_data folder, which possibly collects also some other file with data derived elaborating the quantities recorded during the test. **Figure 14** shows an example of the content of the *Processed_data* folder relative to an experiment tagged as “a03”. Worth to mention is that the converted files with the original data from the acquisitions include “ORIG” in their name, while the files with the information derived from post-test elaboration include “DER” in their name.

Figure 14. Example of the content of the *Processed_data* folder.



Source: Original figure.

As it was for the configuration files of the acquisition, the name of each output file is composed as in the following:

[Name of the experiment] + [Source of the variable **Table 3**] + [Performed elaboration **Table 4**] + [Type of sampling **Table 5**]

Just to give a few examples of names used for the output files:

- “a03-CTRL-DER-av” is an output file corresponding to experiment “a03” containing variables from the master controller (CTRL), derived (DER) from elaboration of the raw data which has been saved as average (AV) within each step of the input record;
- “a03-STD-ORIG-av” is an output file corresponding to experiment “a03” containing variables from the standard acquisition (STD), the numbers are the original (ORIG) as saved by the monitoring system. This last was saving data as averaging (AV) the reading within each step of the input record.

Table 3. Data sources characterising the output files.

Source type	Description
GEN	General
CTRL	Controller variables
SLAVE	Control and monitoring data relative to the (slave) actuator(s)
STD	Standard acquisition
PHYS	Physical degrees of freedom (for PsD test only)
HYB	Hybrid degrees of freedom (only for PsD substructured tests)

Source: Original table.

Table 4. Types of elaboration characterising the output files.

Elaboration type	Description
ORIG	Original, i.e. measured or controller computed
DER	Derived through data processing
IDEN	Identified through data processing (e.g. identified modal characteristics such as frequencies, damping ratios, and oscillation amplitudes)

Source: Original table.

Table 5. Types of sampling characterising the output files.

Sampling type	Description
Av	Record average
Ins	Instantaneous
Con	Continuous (uninterrupted), with constant average
Re	Resampled

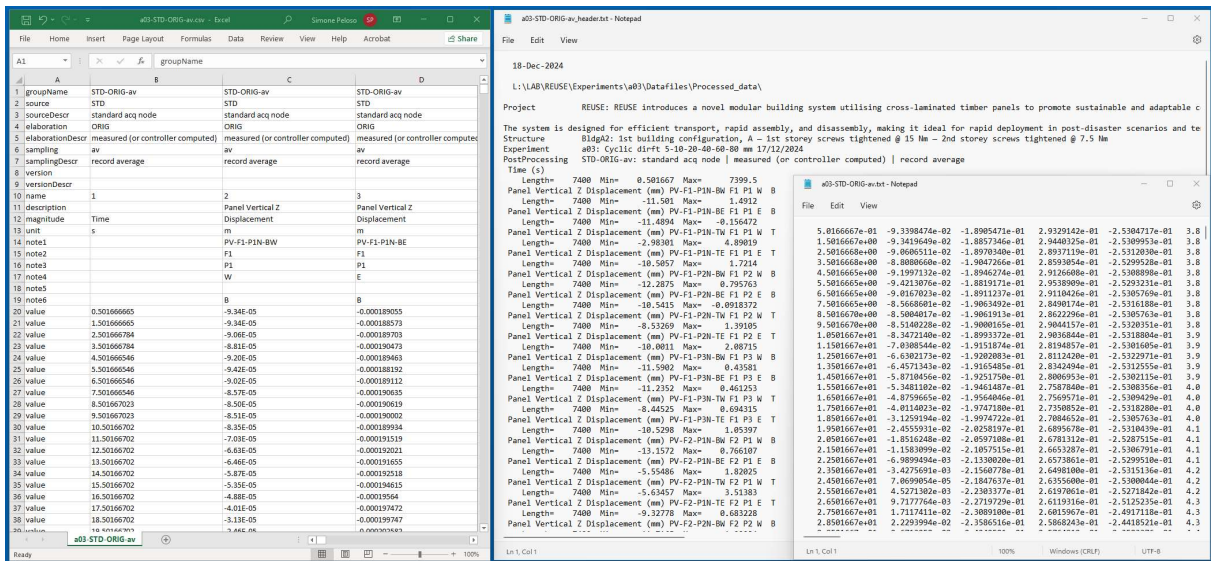
Source: Original table.

The processed data files are ready to use by the users of the dataset, and store the same information saved in several formats:

- .mat files with Matlab variables ready for import;
- .csv files adopt the well-known Coma Separated Values format, and can be accessed using text editors or spreadsheet software (e.g. Excel). The header for the signals is included in the first rows of the file. Also the first column is only used to give the name of every field of metadata of the signals contained in the following columns;
- .txt files are saved using ASCII format, and are probably the ones of easier access by coding software. Note that for each .txt file, which only contains a number-only data-matrix, a companion file _header.txt is present listing the content of the main file.

Figure 15 shows an example of the content of the processed data files comparing csv and text format.

Figure 15. Examples of the content of the processed data files.



Source: Original figure.

6 Conclusions

ELSA (European Laboratory for Structural Assessment) shares the data resulting from the experimental campaigns in line with the address given by the reuse policy of the European Commission. All the information on each project are systematically organised and stored within datasets adopting a standard structure. A file system structure is used to collect preliminary information on the project and its development, details of specimen(s) and testing set-up(s), testing procedures and protocols, raw and processed data.

Although the structure of the dataset was developed and optimised exploiting years of experience of ELSA and other RIs, owing to the complexity of the vast majority of the projects, users may find difficult navigating the dataset while looking for the information of their interest. In an attempt of easing the access, the report thoroughly describes the dataset structures and the content of its folders.

The file system is described from the outer (more general) to the inner (more specific) layers. Furthermore, the types of acquisition adopted during the experiments are described, complementing the discussion on the raw and the processed data included in each dataset.

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SERA, Seismology and Earthquake Engineering Research Infrastructure Alliance for Europe, 2017-2020, Horizon 2020 Framework of the European Commission, Grant agreement ID: 730900,
<https://doi.org/10.3030/730900>

SERIES, Seismic Engineering Research Infrastructures for European Synergies, 2009-2013, 7th Framework Program of the European Commission, Grant agreement ID: 227887,
<https://cordis.europa.eu/project/id/227887/reporting>

List of abbreviations and definitions

Abbreviations	Definitions
CSV	Coma Separated Values
ELSA	European Laboratory for Structural Assessment
ELSAREC	ELSA REal-time Controller
ERIES	Engineering Research Infrastructures for European Synergies
FAIR	Findable, Accessible, Interoperable, and Reusable
FEM	Finite Element Method
ISO	International Organization for Standardization
NHERI	Natural Hazards Engineering Research Infrastructure
PsD	Pseudo-Dynamic
RI	Research Infrastructure
SERA	Seismology and Earthquake Engineering Research Infrastructure Alliance for Europe
SERIES	Seismic Engineering Research Infrastructures for European Synergies

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