Chapter 5
Archiving of Experimental Data for LEAP-UCD-2017

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Abstract This paper describes how the LEAP-UCD-2017 data is organized in DesignSafe; it is intended to help users, archivers, and curators find or organize data of interest. Several key files, folders, and documents included in the archive are discussed: (1) an Excel format data template used to document much of the data and metadata for each model (sensor data, cone penetrometer data, and surface marker data as reported by the experimenters), (2) processed sensor data files with time offsets and zero and calibration corrections that facilitate comparison of consistently formatted data from various model tests, (3) plots of processed data for quick overview and comparison of results among experiments, and (4) photographs taken during construction and testing.

5.1 Introduction

Twenty-four separate model tests were conducted at nine different centrifuge facilities for this LEAP exercise. The first goal of this paper is to describe how the data is archived and organized to help future users of the data. The data are archived in a Project: PRJ-1843: LEAP-UCD-2017 Experiments (Liquefaction Experiments and Analysis Projects) in the NSF-funded DesignSafe (https://www.designsafe-ci.org/) developed by the NHERI cyberinfrastructure center.

The original basis of the archived data was an Excel workbook data template distributed to each of the experiment sites; each site reported their data from each model test using this data template. Different worksheets in the workbooks contain the following data: a summary of the key initial conditions required for blind prediction, the testing sequence, sensor data for each event, long-term sensor data, results of cone penetration tests, results of surface marker surveys, and other data. The completed worksheet templates were submitted to LEAP-UCD-2017 organizers in a Box.com folder. These completed worksheets are included in archives for every experiment. The data in these templates were then processed and plotted in a

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consistent format, mostly by researchers at UC Davis, to facilitate consistent cross comparisons between data collected at different facilities.

The authors of the data and experiment were asked to review the data uploaded to the Project in DesignSafe; many of them corrected some errors and added some key information such as photos taken during the sample preparation and testing processes. Each set of experiments from each experimental facility is to be published with a separate publication and different DOI (digital object identifier). So, the LEAP-UCD-2017 project is to include nine different Published Datasets describing two or three model tests in each dataset.

The projects in the DesignSafe Data Depot are presently organized such that experimenters may upload all of the data relevant to conducting the experiment into a "Working Directory". Then a subset of the data in the Working Directory (the portion of the data deemed to be of value to future users of the data) was categorized and published. Thus, there are two hierarchies of interest: (1) Working Directory and (2) Published Datasets. The data in the Working Directory is of interest to researchers conducting and documenting the experiments and data; the Published Datasets contain information deemed useful to numerical modelers and other future users of the data.

5.2   Accessing Published LEAP-UCD-2017 Data in DesignSafe

This section of this paper attempts to walk a future data user along a suggested path to understand and access the nine Published Datasets of LEAP-UCD-2017.

First it is necessary to navigate to the landing page of the published LEAP-UCD-2017 project in DesignSafe. It should look similar to the screenshots shown in Fig. 5.1a, b. Below the title and keywords, a short description of the project is provided and below that is a list of the nine "Experiments"; each experiment contains the two or three model tests performed at a given facility. They are listed in alphabetical order by the name of the test facility. Each experiment has its own author list and digital object identifier (DOI). Below the list of nine experiments, there is a list of Model Config details (one entry per model test) and a list of Sensor Info details (one entry per model test). A general report (describing all 24 experiments) may be also accessed from this page.

From the landing page, it is recommended that the user click on the General Experiment Report to view its contents. The contents of the general report are illustrated in the screenshot at the bottom of Fig. 5.1b. The files and folders have been numbered according to a suggested sequence for navigating through the data for the first time. Each item in the report is briefly described below.
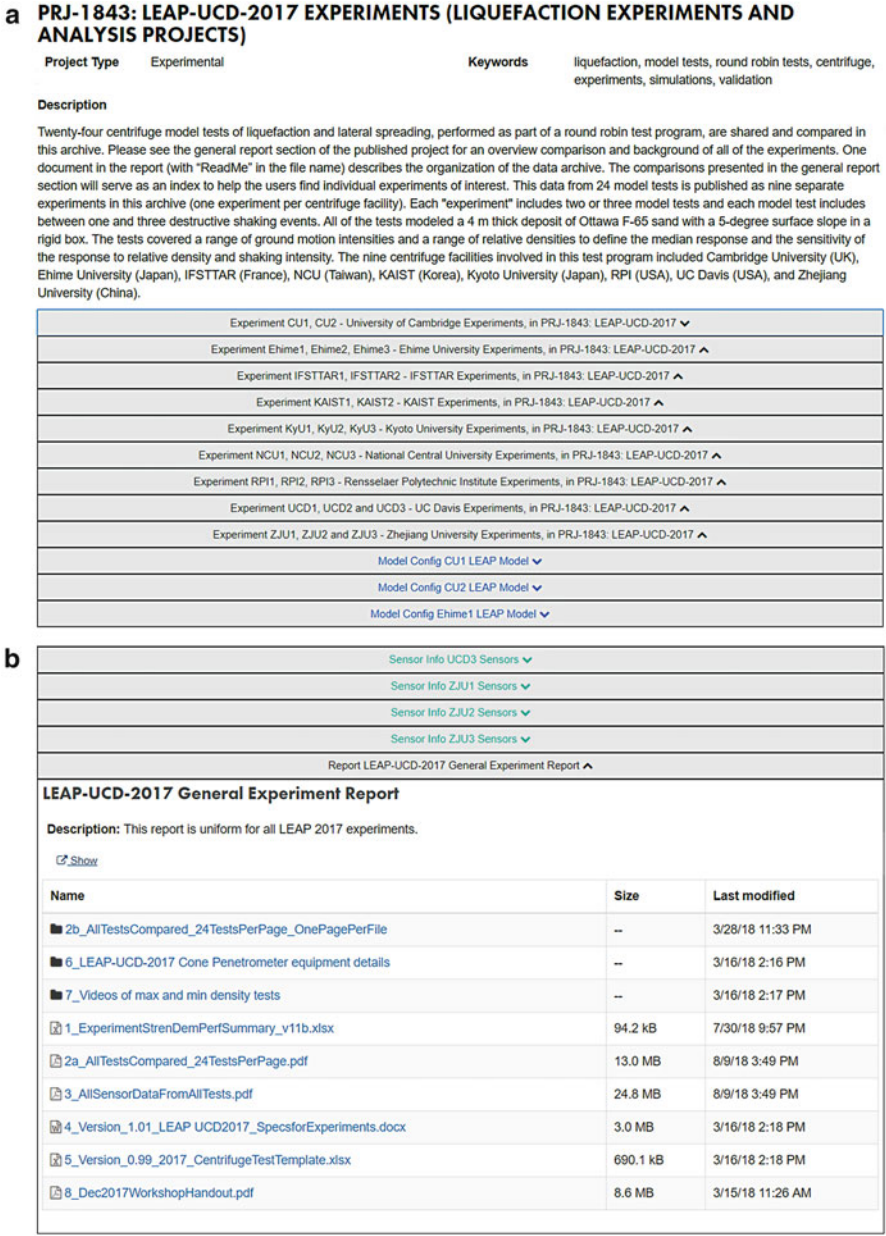
a **PRJ-1843: LEAP-UCD-2017 EXPERIMENTS (LIQUEFACTION EXPERIMENTS AND ANALYSIS PROJECTS)**

Project Type	Experimental	**Keywords**	liquefaction, model tests, round robin tests, centrifuge, experiments, simulations, validation

Description

Twenty-four centrifuge model tests of liquefaction and lateral spreading, performed as part of a round robin test program, are shared and compared in this archive. Please see the general report section of the published project for an overview comparison and background of all of the experiments. One document in the report (with "ReadMe" in the file name) describes the organization of the data archive. The comparisons presented in the general report section will serve as an index to help the users find individual experiments of interest. This data from 24 model tests is published as nine separate experiments in this archive (one experiment per centrifuge facility). Each "experiment" includes two or three model tests and each model test includes between one and three destructive shaking events. All of the tests modeled a 4 m thick deposit of Ottawa F-65 sand with a 5-degree surface slope in a rigid box. The tests covered a range of ground motion intensities and a range of relative densities to define the median response and the sensitivity of the response to relative density and shaking intensity. The nine centrifuge facilities involved in this test program included Cambridge University (UK), Ehime University (Japan), IFSTTAR (France), NCU (Taiwan), KAIST (Korea), Kyoto University (Japan), RPI (USA), UC Davis (USA), and Zhejiang University (China).

Experiment CU1, CU2 - University of Cambridge Experiments, in PRJ-1843: LEAP-UCD-2017 ⌄
Experiment Ehime1, Ehime2, Ehime3 - Ehime University Experiments, in PRJ-1843: LEAP-UCD-2017 ⌃
Experiment IFSTTAR1, IFSTTAR2 - IFSTTAR Experiments, in PRJ-1843: LEAP-UCD-2017 ⌃
Experiment KAIST1, KAIST2 - KAIST Experiments, in PRJ-1843: LEAP-UCD-2017 ⌃
Experiment KyU1, KyU2, KyU3 - Kyoto University Experiments, in PRJ-1843: LEAP-UCD-2017 ⌃
Experiment NCU1, NCU2, NCU3 - National Central University Experiments, in PRJ-1843: LEAP-UCD-2017 ⌃
Experiment RPI1, RPI2, RPI3 - Rensselaer Polytechnic Institute Experiments, in PRJ-1843: LEAP-UCD-2017 ⌃
Experiment UCD1, UCD2 and UCD3 - UC Davis Experiments, in PRJ-1843: LEAP-UCD-2017 ⌃
Experiment ZJU1, ZJU2 and ZJU3 - Zhejiang University Experiments, in PRJ-1843: LEAP-UCD-2017 ⌃
Model Config CU1 LEAP Model ⌄
Model Config CU2 LEAP Model ⌄
Model Config Ehime1 LEAP Model ⌄

b

Sensor Info UCD3 Sensors ⌄
Sensor Info ZJU1 Sensors ⌄
Sensor Info ZJU2 Sensors ⌄
Sensor Info ZJU3 Sensors ⌄
Report LEAP-UCD-2017 General Experiment Report ⌃

LEAP-UCD-2017 General Experiment Report

Description: This report is uniform for all LEAP 2017 experiments.

⌂ Show

Name	Size	Last modified
📁 2b_AllTestsCompared_24TestsPerPage_OnePagePerFile	--	3/28/18 11:33 PM
📁 6_LEAP-UCD-2017 Cone Penetrometer equipment details	--	3/16/18 2:16 PM
📁 7_Videos of max and min density tests	--	3/16/18 2:17 PM
📄 1_ExperimentStrenDemPerfSummary_v11b.xlsx	94.2 kB	7/30/18 9:57 PM
📄 2a_AllTestsCompared_24TestsPerPage.pdf	13.0 MB	8/9/18 3:49 PM
📄 3_AllSensorDataFromAllTests.pdf	24.8 MB	8/9/18 3:49 PM
📄 4_Version_1.01_LEAP UCD2017_SpecsforExperiments.docx	3.0 MB	3/16/18 2:18 PM
📄 5_Version_0.99_2017_CentrifugeTestTemplate.xlsx	690.1 kB	3/16/18 2:18 PM
📄 8_Dec2017WorkshopHandout.pdf	8.6 MB	3/15/18 11:26 AM

Fig. 5.1 (**a**) Screenshot of LEAP-UCD-2017 project in DesignSafe: header, experiment list, and some of the Model Configuration lists. (The appearance of the user interface is subject to change.). (**b**) Screenshot of LEAP-UCD-2017 project in DesignSafe: part of the Sensor Info List and contents of the General Experiment Report. (The appearance of the user interface is subject to change)

5.2.1 General Report File: 1_ExperimentStrenDemPerfSummary_v11b.xlsx

This file is a spreadsheet that tabulates the strength, demand, and performance of the models in the first two destructive motions of each experiment. The strength is characterized by relative density and cone penetration resistance. The demand is characterized by input motion Intensity Measures such as PGA, $PGA_{effective}$, PGV, CAV_5, Arias Intensity, and other quantities. The performance is characterized by performance measures such as the duration of liquefaction, the integrated positive relative velocity, and statistical analysis (mean, median, and standard deviation) of x, y, and z displacements of different subsets of surface markers. Another worksheet in the workbook provides definitions for all of the column headings used in the workbook. The data in this workbook have been presented graphically by Kutter et al. (2018, 2019b).

5.2.2 General Report File: 2a_AllTestsCompared_24TestsPerPage.pdf

This file contains 24 tiny plots per page that allow the reader to quickly and roughly compare results from all of the required sensors obtained from all 24 experiments on a single page; each plot may include time series data or contour plots of surface marker displacements. Figure 5.2 shows an example of the style of plot contained in this file. Similar plots are provided for pore pressures, displacements, CPT profiles, and contours of x, y, and z displacements of surface markers.

5.2.3 General Report Folder: 2b_AllTestsCompared_24TestsPerPage_OnePagePerFile

This folder contains almost the same information as File 2a. However each page of the file is reproduced as a separate file in this folder. This format may be more useful for navigating quickly to the comparisons of interest based on the descriptive file names. In addition to data plotted in File 2a, the folder also contains plotted response spectra of the ground motions.

5.2.4 General Report File: 3_AllSensorDataFromAllTests.pdf

This file contains 151 pages of plots, presenting all of the sensor data from Destructive Motions #1 and #2 for all of the models in one large document. All of the data
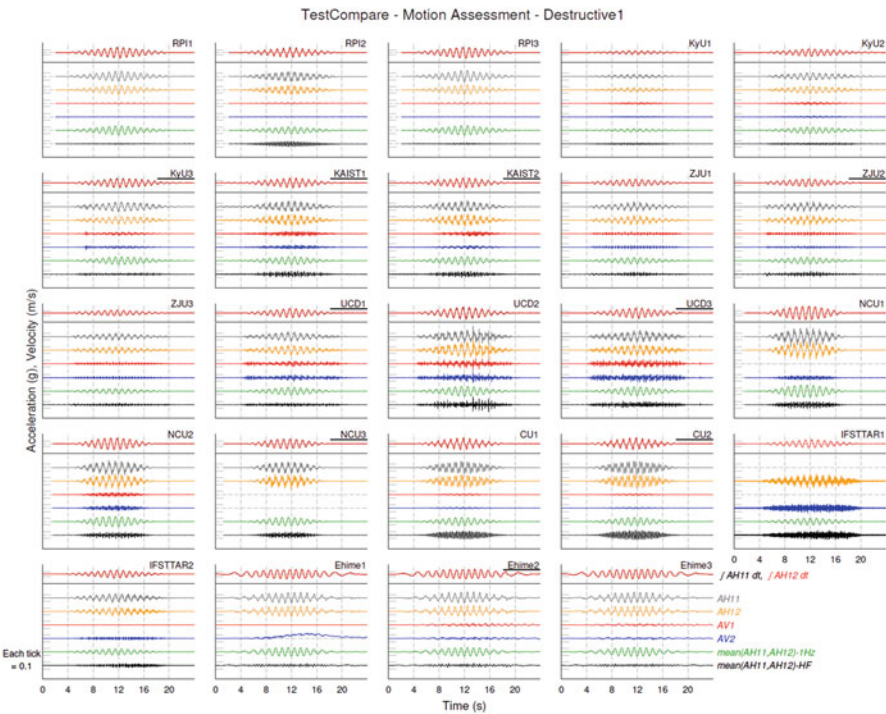
Fig. 5.2 Input motions for Motion #1 for 24 experiments presented as an example of style of plots available in File: 2a_AllTestsCompared_24TestsPerPage.pdf

are processed consistently and plotted at consistent scale. The scale is large enough that the details of the motion can be seen. The experiments are presented in alphabetical order: CU1, CU2,. . ., ZJU3 in this document.

5.2.5 General Report File: 4_Version1.01_LEAP UCD2017_SpecsforExperiments.docx

This file contains all the instructions provided to experimenters in preparation for their centrifuge tests. The previously provided specifications were cleaned up and presented in this proceedings document by Kutter et al. (2019a) because they would be of interest to future users of the data.

5.2.6   General Report File:
5_Version_0.99_2017_CentrifugeTestTemplate.xlsx

Each experimenter was required to submit their data using this blank spreadsheet workbook as a template. The first worksheet in this workbook contains instructions for using the template.

The second worksheet "(o)SummarySheet" summarizes key dimensions and properties essential for the numerical simulation of the experiments (density of soil, radius of the centrifuge, centrifuge acceleration, degree of saturation, viscosity of fluid, and the measurements of the elevation of the ground surface and comparison to the target locations).

The third worksheet "(a)TestLogSequence" is intended to document all of the events and measurements taken during model construction, saturation, and testing. It includes spaces for reporting measurements of grain size distribution, humidity, saturation, and density and asks the researchers to document when they measured surface markers. The time and date of spins, shakes, and CPT data collection are also to be reported in the TestLogSequence.

Other worksheets document:

- A worksheet for recording surface marker location measurements.
- A worksheet with sensor information such as serial number, model number, orientation, and x, y, z coordinates of the sensor during installation and during excavation of the model.
- A worksheet for reporting uncorrected CPT penetration resistance versus depth. Carey et al. (2019a) describes how the CPT data was corrected for more detailed analysis.
- A worksheet for recording residual pore pressure averages (RPPA). This sheet was intended to enable calculation of the settlement of pore pressure sensors by computing how much the water pressure changed during shaking.

Sensor time series data, sampled at high speed, is recorded on a separate sheet for each dynamic event (each ground motion). A separate sheet documents uninterrupted lower-speed sampling of the sensors to document the sequence of each entire spin; this is valuable for checking the response of pore pressure transducers during spin-up and slowdown of the centrifuge. Finally, separate custom sheets were used if researchers collected additional data such as shear wave velocity data or high-speed camera data.

Some of the first completed experiments were submitted using Version_0.96_2017 of this data template; Version 0.96 did not contain the "(o)SummarySheet." For cases where Version 0.96 was completed, a Version 0.99 Template summary sheet was added later to the data set.

5.2.7 General Report Folder: 6_LEAP-UCD-2017 Cone Penetrometer Equipment Details

This folder contains all of the design drawings, design calculations, and instructions for assembly and preloading for the CPT devices constructed at UC Davis and distributed to the LEAP facilities.

5.2.8 General Report Folder: 7_Videos of Max and Min Density Tests

This folder contains video instructions describing the procedure recommended for quality control tests on the sand used at each facility. It was requested that each facility perform maximum and minimum density tests using the same procedure to provide additional assurance that the properties of the Ottawa F-65 sand tested at each facility were the same. The purpose of the video was to improve consistency of test procedure at different sites. Further study of this important topic is described by Carey et al. (2019b).

5.2.9 General Report File: 8_Dec2017WorkshopHandout.pdf

This file, primarily of historical interest, contains the program for the December 2017 Workshop at UC Davis. It also contains some selected experimental results that were printed and distributed to the workshop participants.

5.3 Detailed Data for Each Model Test

5.3.1 Selecting an Experiment Site

After reviewing the information in the General Experiment Report, the interested user may decide to download specific experimental data or to try to figure out some details or metadata for a specific model test. It should be noted that each model test is also explained in some detail in a separate paper in these proceedings. To download or explore the data in DesignSafe, click on the experiment of interest from the menu illustrated in Fig. 5.1a. If you were to click on the Experiment titled "ZJU1, ZJU2 and ZJU3—Zhejiang University Experiments, in PRJ-1843: LEAP-UCD-2017," you would see something like the screenshot shown in Fig. 5.3; this would show the list of authors, the "doi" for the selected experiments, and some basic information about their centrifuge. Below that, the event data for each of their experiments would
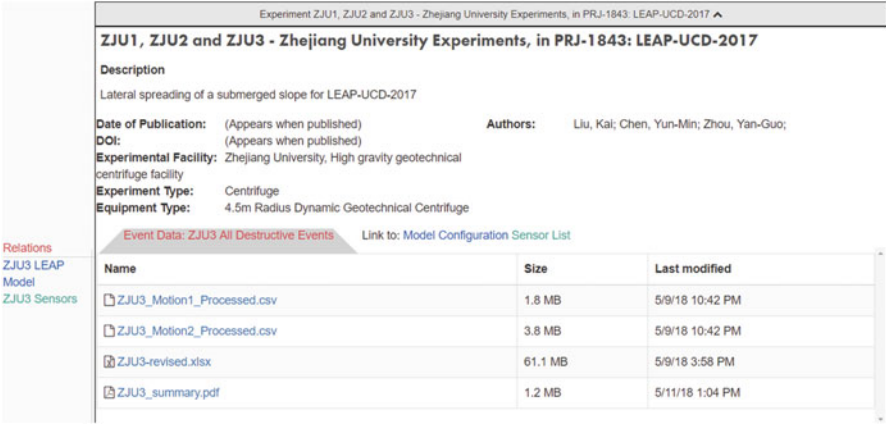
Fig. 5.3 Screenshot that appears after selecting the Zhejiang University Experiments. (The appearance of the user interface is subject to change)

be visible. One of the items in the event data would be the Excel templates (.xlsx files), which could be downloaded to review the summary sheet, surface marker measurements, or other information described in Sect. 2.6. But, for analysis of the dynamic data from the destructive motions, it is recommended to use the processed data in the .csv files, instead of the data in the Excel spreadsheets. The processed data has been processed uniformly from experiment to experiment to offset the zeros, correct the polarity of sensors if necessary, and change the units of the measurement (e.g., g instead of m/s^2). The time range of the processed data has also been truncated consistently to include the most interesting duration of the dynamic sensor data, with $t = 0$ set so that the motions should be in phase if one experiment was plotted with data from another experiment from this LEAP exercise. The summary.pdf file shows all the sensor data for the first two destructive motions; this plotted data, also available in the general report in the large pdf file, is repeated for convenience. The data in the . csv files is the same data that is plotted in the pdf files. All of the above data is intended to be available for every model test of LEAP-UCD-2017 exercise.

In addition, experimenters were encouraged to upload photographs that document their experiments, raw data from other shaking events including non-destructive motions, and other relevant information.

5.3.2 Model Configuration Data

If one selects the link to "Model Configuration" in Fig. 5.3, one would find another link back to the Excel template. The Excel sheet contains the basic model configuration data in various worksheets. In addition, one would find photographs, reports, or powerpoint presentations that describe most of the experiments. It is worth

repeating that the papers published in these proceedings prepared by the experimenters will also be a useful source of information about configuration of every model.
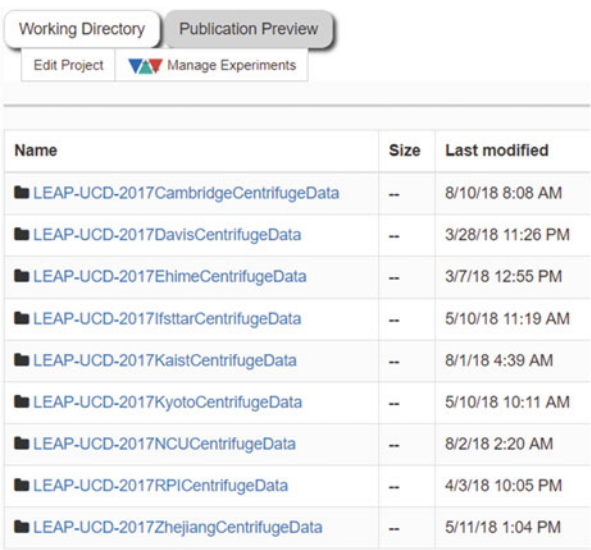
5.3.3 Sensor Information

If one selects the "Sensor List" link in Fig. 5.3, one would be provided again with a link back to the same Excel template. One of the worksheets in this workbook contains all the sensor information including serial number, model number, orientation, and location of the sensor (measured at the time of model construction and at the time of model excavation).

5.4 Working Directory for Data LEAP-UCD-2017

The Working Directory itself is not published, so it is accessible only to the members of the project. The Working Directory for LEAP is the storage location for all of the data to be published. All of the items included in the general report were uploaded to the root folder of the Working Directory. In addition, a folder called "Individual Centrifuge Facility Data" was created in the Working Directory. Inside this folder there are nine subfolders, one for each centrifuge facility as shown by screenshot in Fig. 5.4.

Fig. 5.4 Screenshot of individual centrifuge facility data in the Working Directory. (The appearance of the user interface is subject to change)

Name	Size	Last modified
LEAP-UCD-2017CambridgeCentrifugeData	--	8/10/18 8:08 AM
LEAP-UCD-2017DavisCentrifugeData	--	3/28/18 11:26 PM
LEAP-UCD-2017EhimeCentrifugeData	--	3/7/18 12:55 PM
LEAP-UCD-2017IfsttarCentrifugeData	--	5/10/18 11:19 AM
LEAP-UCD-2017KaistCentrifugeData	--	8/1/18 4:39 AM
LEAP-UCD-2017KyotoCentrifugeData	--	5/10/18 10:11 AM
LEAP-UCD-2017NCUCentrifugeData	--	8/2/18 2:20 AM
LEAP-UCD-2017RPICentrifugeData	--	4/3/18 10:05 PM
LEAP-UCD-2017ZhejiangCentrifugeData	--	5/11/18 1:04 PM

Fig. 5.5 Tagged contents of subfolder LEAP-UCD-2017DavisCentrifugeData/UCD1_TC04. (The appearance of the user interface is subject to change)
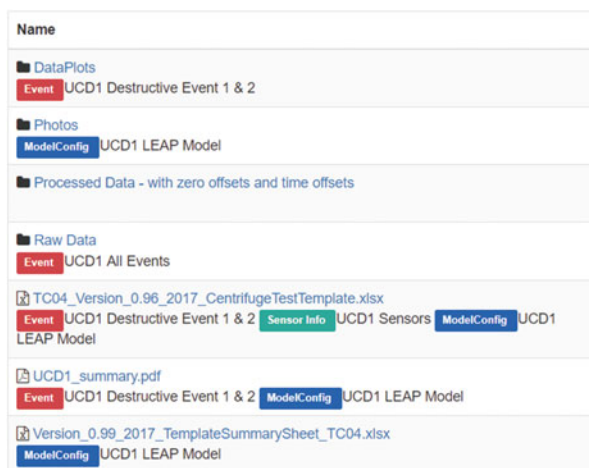
In each of the folders of Fig. 5.4, all of the other important metadata for the experiments may be archived and tagged. An example of a subfolder in the LEAP-UCD-2017DavisCentrifugeData folder is shown by screenshot in Fig. 5.5.

The data is organized in a conventional folder hierarchy that varies to some extent from facility to facility. The example in Fig. 5.5 is a folder of data about experiment UCD1, with a more elaborate structure than those used for most experiments. Subfolders were created for data plots, photos, processed data, and raw data. Files or folders are then tagged as "Event," "ModelConfig," or "SensorInfo" as indicated by the red, blue, and green tags in Fig. 5.5. Some files such as the data in the Excel template have all three tags because some worksheets in the file contain event data, and others contain sensor information for model configuration data. The photos are generally tagged "ModelConfig." The selection of tags in the Working Directory determines where the data would be located in the published data set.

5.5 Summary

This paper is meant to help explain the organization of the data in the LEAP-UCD-2017 project archived in DesignSafe. Most of the paper explains how future users might access the published data. Some of the paper also explains how the producers of the data organized their data in the unpublished Working Directory.

References

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