

Organization of the dataset

This report is an auxiliary document to the dataset. If using the data please cite:

Hoult, R. D., Appelle, A., Almeida, J., Beyer, K. Seismic Performance of Slender RC U-shaped Walls with a Single-Layer of Reinforcement.

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This paper presents the organization of the dataset corresponding to the experimental campaign conducted on two large-scale reinforced concrete U-shaped wall specimens. The tests were conducted at the Earthquake Engineering and Structural Dynamics Laboratory (EESD Lab), École Polytechnique Fédérale de Lausanne (EPFL) in Switzerland. Both wall specimens were unconfined and detailed with a single-layer of vertical reinforcement to replicate some of the current construction practices being conducted in Colombia. Both walls reached ultimate drifts larger than 2.5-3.0% and initially failed due to buckling of the longitudinal reinforcement at the flange ends. The buckling length was 700-800 mm, which corresponded to 44-50 bar diameters.

Summary of Experimental Tests

Two full scale RC U-shaped wall specimens were tested as part of an experimental program conducted at the *Earthquake Engineering and Structural Dynamics Laboratory (EESD Lab), École Polytechnique Fédérale de Lausanne (EPFL), Switzerland.*

Both units tested here, denoted TUE (Test Unit E) and TUF (Test Unit F), were full-scale models of the lower three storeys of an idealized core that could enclose a small elevator. A photo of specimen TUE and the test setup is shown in Figure 1a. the walls were loaded horizontally with three actuators: the east-west (EW) actuator loaded the web of the wall at a height (h_{EW}) of 4.65 m, while the north-south (NS) actuators loaded the flanges of the wall at a height (h_{NS}) of 4.25 m.

Throughout testing the wall behavior was monitored with conventional instrumentation (i.e., linear variable differential transducers, or LVDTs, and load cells). Photos, hand notes and some manual measurements of cracks were collected during testing. The layout of the measurement systems is shown in Figure 1b. The LVDTs were used to measure the global horizontal (in-plane) displacements at the collar (top of the wall).

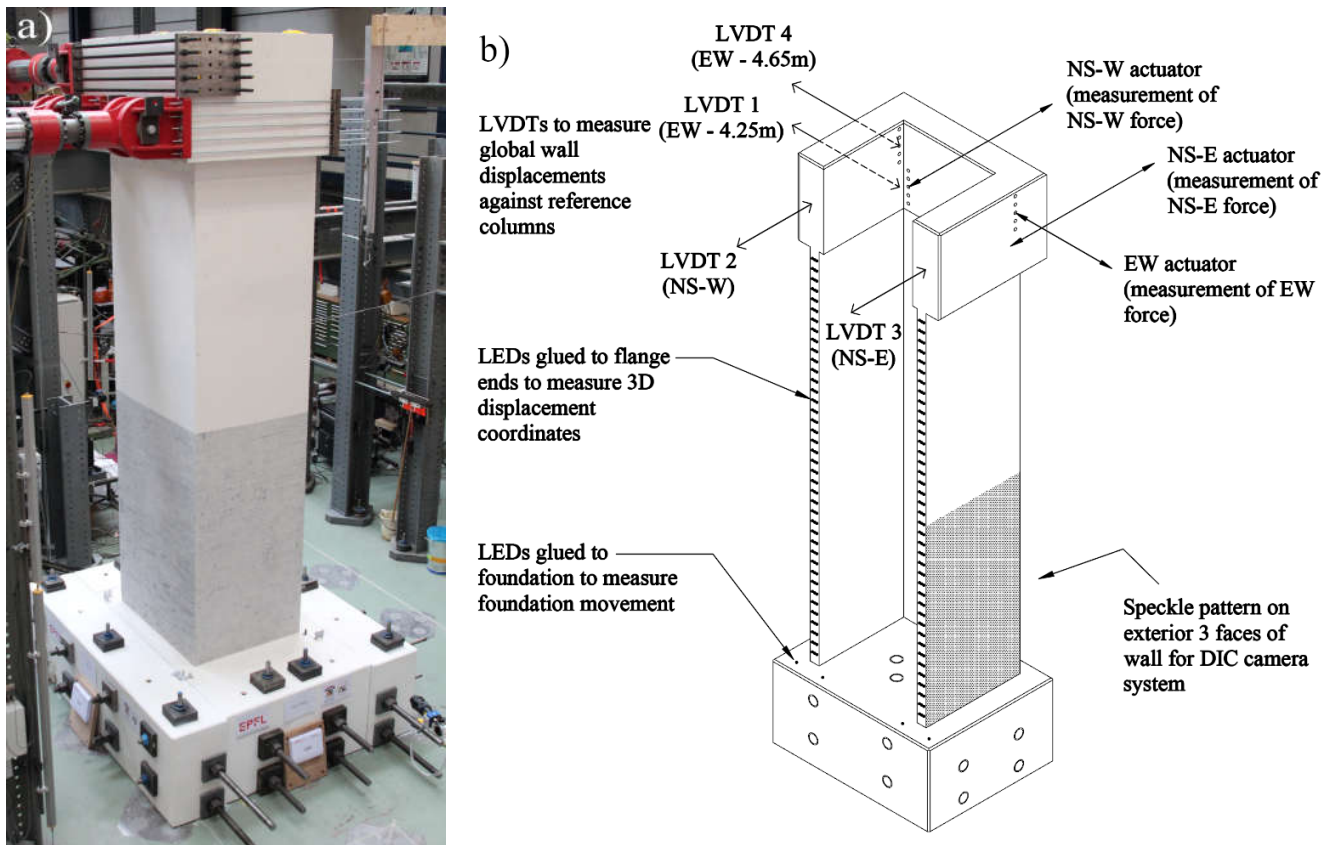


Figure 1 (a) Test setup of TUE and (b) location of conventional and optical measurement devices (dimensions in mm)

TUE and TUF had the same geometry and reinforcement layout but were subjected to different loading protocols. TUE was subjected to loading along the principal axes (NS and EW) while TUF was subjected to loading in the diagonal directions. Rotation of the collar at the top of the wall was restrained by applying equal displacements with the NS-W and NS-E actuators. Note that the loading protocol of TUF also contained small cycles in which a twist was applied at the collar in order to investigate the degradation of the torsional stiffness. One of the

primary objectives of this experimental study is to observe if out-of-plane instability can be an issue for slender RC U-shaped walls that have a single-layer of vertical reinforcement. Hence, the reverse-cyclic loading protocol for TUE and TUF were chosen to promote out-of-plane instability and prevent a premature crushing-type failure due to compression; this type of failure in non-rectangular RC walls is well documented from previous experiments. As such, the loading directions that caused the wall to have a large compression zone were limited for this study. For example, the drift level was limited for the wall bending about its minor axis such that the web is in tension, which can lead to a large compression depth in the flanges. Likewise, for specimen TUF, the diagonal loading causing the flange to lead to a large compression zone was limited. The loading positions for both TUE and TUF are shown in Figure 2b.

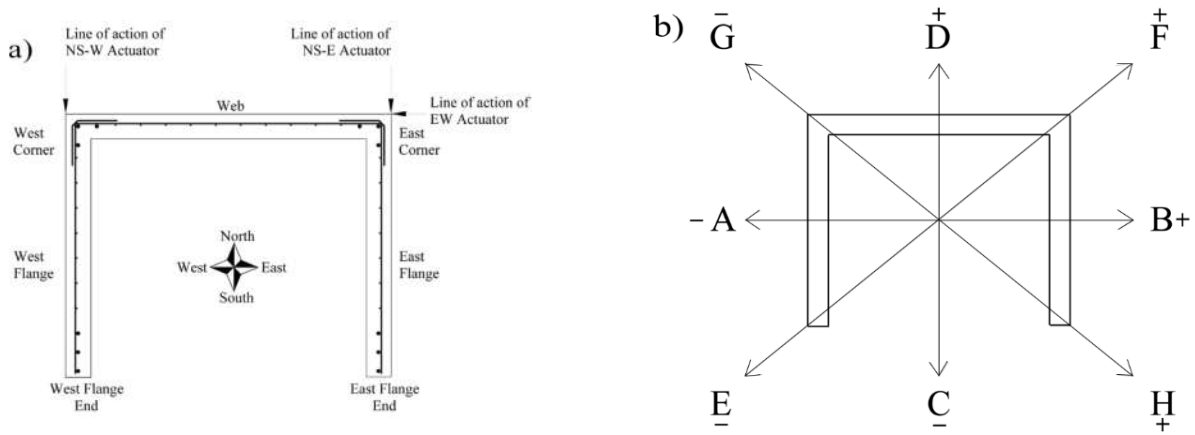


Figure 2 (a) cardinal points, sign convention for forces and displacements, wall parts and (b) loading positions

Organization of the data

All of the experimental data can be downloaded from a publicly accessible platform Zenodo, at DOI 10.5281/zenodo.3614079. The structure of the data folders is summarized in Figure 3.

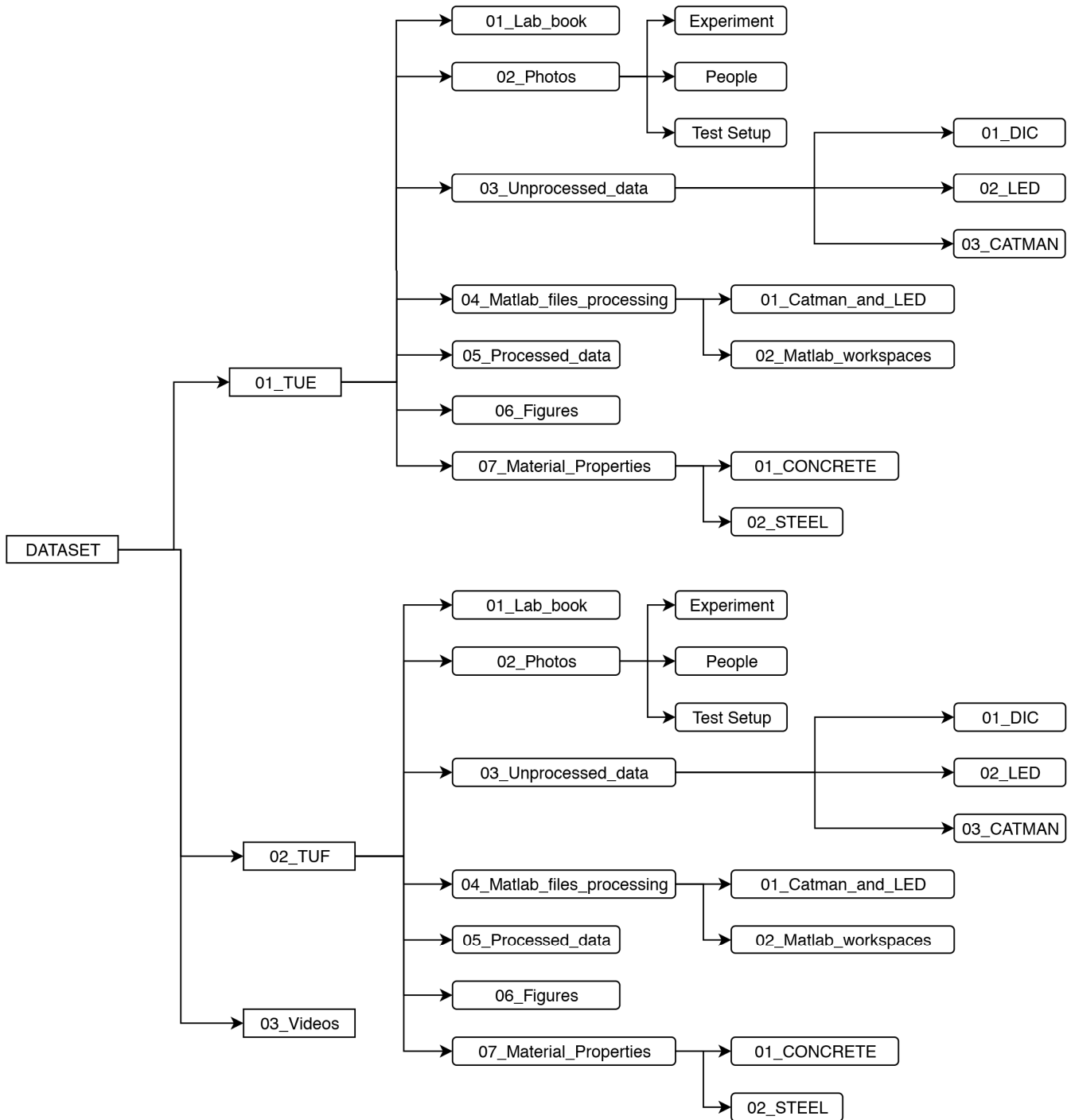


Figure 3 Data organization for the paper

In the main “Dataset” folder, four .csv files contain the post-processed data for specimen TUE and TUF (i.e., “TUE_DATA.csv” and “TUF_DATA.csv”, respectively). The data channels and processed information contained in these files is described in the Appendix.

Each of the main folders here, and the corresponding data, are explained below.

1. Folder “01_TUE” or “02_TUF”

This folder contains the experimental results and other data for wall specimen TUE (or TUF). Seven subfolders are contained in this folder, which contain different data and information. The seven subfolders are discussed below in order.

a. Subfolder “01_Lab_book”

This subfolder contains a Microsoft Excel file (.xlsx), which is a digital copy of the laboratory book written during testing of the specimen. The Excel files contains the following information:

- Load stage numbers and corresponding positions (Figure 2b)
- Time (hour, minute)
- Deformation measurements (in mm) from LVDT1, LVDT2, LVDT3, and LVDT4 (Figure 1b).
- Force measurements (in kN) from EW Actuator, NS-W Actuator, and NS-W Actuator (Figure 1b).
- General comments of observations of the wall during and at the end of the load stage.

It should be noted that the specimen TUE only had three of the four LVDTs active (LVDT4, LVDT2, and LVDT3)

b. Subfolder “02_Photos”

This subfolder contains three subfolders of photos that were taken before and during testing. The first subfolder, “Experiment”, contains photos that were taken during testing of the specimen. The second subfolder, “People”, contains photos that were taking of the researchers observing the wall specimen. The third subfolder, “Test Setup”, contains photos that were taken before testing began on the specimen.

c. Subfolder “03_Unprocessed_data”

This subfolder contains the raw data that was collected during testing. The three subfolders here contain the different raw data that was collect; “01_DIC” contains the DIC data, “02_LED” contains the LED data, and “03_CATMAN” contains the actuator and LVDT data. Each of these subfolders and their corresponding contents is explained below:

i. Subfolder “01_DIC”

A speckle pattern for digital image correlation (DIC) measurements was applied on three outside surfaces of the wall (East flange, web and West flange) covering a height from the base of approximately 2 m. The speckle pattern was applied by a stencil with a computer-generated random pattern to produce black dots with an approximate diameter of 2.5 mm. As each wall was either subjected to bidirectional or diagonal loading, 3-D DIC systems were used. Thus, for each wall, 3 sets of two 3-D Manta camera systems were used, each set capturing a different section of the wall (Figure 4). The Manta cameras recorded black and white photographs to decrease file size and simultaneously have an increased capacity for sensor dimensions, resulting in high resolution images. The DIC systems recorded images of the wall segments at a frequency of 0.05 Hz (i.e., every 20 seconds).

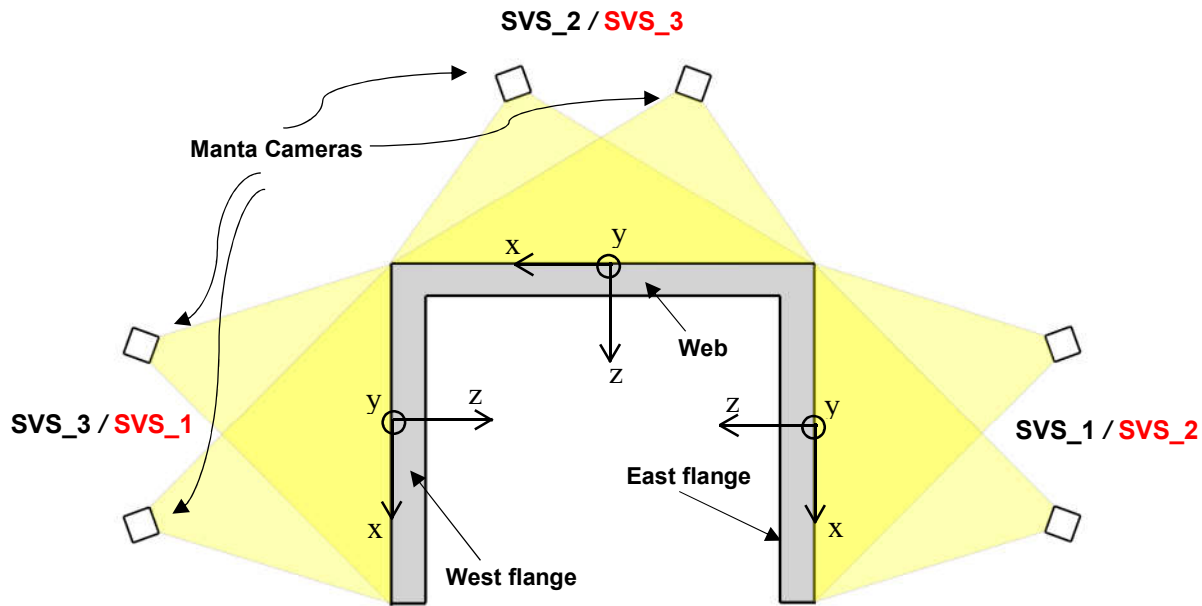


Figure 4 Manta camera locations for DIC with corresponding names (TUE in black, TUF in red)

As the number of images taken by the Manta cameras were excessive, and also large in size, for the sake of brevity this subfolder contains only the converted DIC data; using VIC 3D, the images taken by the Manta cameras were transformed into x-y-z coordinates and output into comma separate variable (csv) files. A 20 mm x 20 mm step size was used for each of the wall parts (i.e., flanges and web), and the corresponding x, y, and z position of part of the wall is given in the first three columns of information within the csv file and in mm.

It is important to note that the directions of x, y and z are different for each camera set, as shown in Figure 4. The x-coordinate is in the direction parallel to the wall (i.e., across the wall length), dependent on the camera location. The y-coordinate is in the direction of the height of the wall, dependent on the camera location. Finally, the z-coordinate is the direction from the camera to the wall. The origin of each respective coordinate system, from each pair of Manta cameras, is placed at the center of the corresponding wall section, as depicted in Figure 4.

The file names are generally given in the following format:

CAMERA_NAME_AND_PAIR_NUMBER / LOAD STAGE / IMAGE NUMBER / _0

The camera name and pair number were different for each wall specimen and corresponded to different parts of the wall; Table 1 provides the camera name and pair number (i.e., SVS_1) for each wall specimen and its corresponding section of the wall.

Table 1 Start of the file name of DIC data for each wall specimen and corresponding geometric part of wall

	TUE	TUF
SVS_1	East flange	West Flange
SVS_2	Web	East Flange
SVS_3	West flange	Web

The Load Stage (LS) corresponds to that given in the Lab Book (see Section 1a). For consistency, the data is provided for all load stages (LS) at a rate of 0.05 Hz (i.e., data for an image taken every 20 s of loading). The

actuators were generally operated at a rate of 0.2 mm/s. It should be noted that some of the DIC data for TUE was taken at a higher frequency; however, for consistency, the data was reduced here to correspond with the same frequency used for TUF of 0.05 Hz. Thus, some of the “Image Numbers” for the TUE data are in multiples of 4.

An example file name is ‘SVS_1_LS1 TO LS2_0004_0’. For TUE, this corresponds to the East flange DIC data for Load Step 1 to 2, and corresponds to the data from the fourth image (but first in the dataset, as the original data was reduced). For TUF, this corresponds to the West flange DIC data for Load Step 1 to 2, and corresponds to the data from the fourth image taken.

ii. Subfolder “02_LED”

The three-dimensional displacement field of the surface ends of the flanges (i.e., boundary ends to the South) of each wall was measured by a grid of infrared light-emitting diodes (LEDs) with a recording frequency of 5 Hz. The position of each LED was tracked by a camera consisting of three digital optical sensors. 120 LEDs were used to track the displacements of the flange ends of both TUE and TUF. The LEDs were glued on the faces of the flange ends in vertical increments of 100 mm to match the horizontal reinforcement spacing. Three LEDs were used across the thickness of the wall, which were spaced 30 mm apart (and 20 mm in from the wall edge). The LEDs are used to track the displacement profile. From these displacements, among others, the out-of-plane displacement profiles of the flanges, the strains at the flange ends as well as the strain variation across the thickness of the wall can be computed throughout testing. Furthermore, to check that foundation displacements remained small during testing, LEDs were attached to small L-shaped steel brackets on the foundation. The LED coordinates were transformed during the data post-processing stage: the origin of the coordinate system is at the center of the web and is illustrated in Figure 5 with corresponding positive coordinate directions; the x-axis refers to the horizontal in-plane direction of the wall parallel to the web (positive direction from center of web to the east flange); the y-axis refers to the vertical in-plane direction (positive direction from foundation to collar, or bottom to top); the z-axis refers to the horizontal in-plane direction of the wall parallel to the flanges (positive direction from the center of web to boundary ends of the flanges).

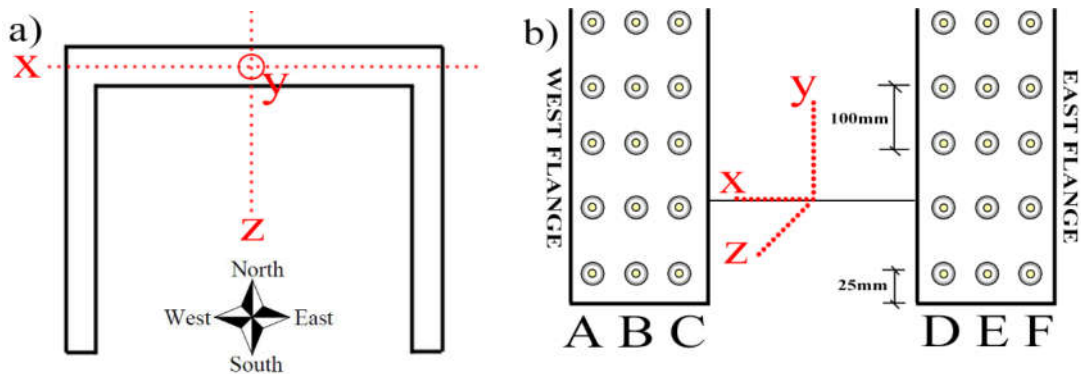


Figure 5 (a) origin and coordinate system of the LEDs (b) LED columns A to E

In the subfolder “02_LED”, Microsoft Excel (.xls) files are provided with the LED data corresponding to each of the different load steps undertaken during testing. Each .xls file contains the x, y and z coordinate (according to the coordinate system in Figure 5) for each of the 240 Markers that were attached to the ends of the flanges of each wall specimen. It should be noted that information for more than 240 Markers are provided for each .xls file, where several LED Markers were also attached to the foundation, as discussed previously.

In the corresponding research paper that is associated with this dataset, the LED data was processed in MATLAB; please see Section 1d and 1e.

iii. Subfolder “03_CATMAN”

CATMAN is the name of the software used for the data acquisition for testing the wall specimens. In subfolder “03_CATMAN”, .asc files are provided for each load step that was conducted during testing for both specimens TUE and TUF. The .asc file contains information of several channels during testing. The channels provided, depending on the wall specimen, are given below with the associated units:

Channel	Specimen	Description
Time (s)	TUE / TUF	Time in seconds during load stage
LED_1 (mm)	TUE / TUF	Signal from LED system to indicate if NDI/LED system "working"
Load 1 (kN)	TUE / TUF	Load from EW Actuator (Figure 1b)
Stroke 1 (mm)	TUE / TUF	Stroke of EW Actuator (Figure 1b)
Load 2 (kN)	TUE / TUF	Load from NS-W Actuator (Figure 1b)
Stroke 2 (mm)	TUE / TUF	Stroke of NS-W Actuator (Figure 1b)
Load 3 (kN)	TUE / TUF	Load from NS-E Actuator (Figure 1b)
Stroke 3 (mm)	TUE / TUF	Stroke of NS-E Actuator (Figure 1b)
LVDT_1 (mm)	TUF	Measurement of movement of top of wall in EW direction at height of 4.65m
LVDT_2 (mm)	TUE / TUF	Measurement of movement of top of wall in NS-W direction at height of 4.25m
LVDT_3 (mm)	TUE / TUF	Measurement of movement of top of wall in NS-E direction at height of 4.25m
LVDT_4* (mm)	TUE / TUF	Measurement of movement of top of wall in EW direction at height of 4.25m
NS_disp (mm)	TUE	Average of LVDT_2 and LVDT_3
EW_disp (mm)	TUE	LVDT_1 or LVDT_4
EG_Disp (mm)	TUF	Square Root of the Sum of the Squares (SRSS) of LVDT_4 and LVDT_2
HF_Disp (mm)	TUF	Square Root of the Sum of the Squares (SRSS) of LVDT_4 and LVDT_3
S2-S1_RATIO	TUF	Ratio of LVDT_2 to LVDT_1; ideally, ratio should be 0.8
S3-S1_RATIO	TUF	Ratio of LVDT_3 to LVDT_1; ideally, ratio should be 0.8

*It should be noted that LVDT_4 (Figure 1b) is not active for specimen TUE

d. Subfolder “04_Matlab_files_processing”

This folder contains two subfolders containing processed MATLAB files. The two subfolders are explained in the following sections. The user is recommended to jump to section 1d(ii), which provides the already-processed files that can be used in MATLAB.

i. Subfolder “01_Catman_and_LED”

This subfolder contains MATLAB files (.m) that process the CATMAN and LED data.

- “read_CATMAN_during_loading.m” reads the raw data from the CATMAN files, ready for processing.
- “data_cleaning_CATMAN_TUE.m” is a file that cleans up the CATMAN measurements.
- “read_NDI_during_loading_TUE.m” reads the NDI-files (i.e., LED data) during loading and synchronises the data to the CATMAN data. Furthermore, it smooths the NDI measurements to reduce the noise and saves the NDI-data as a structured array.
- “compute_rot_matrix_for_TUE.m” computes the rotation matrix needed for the LED data.

For specimen TUF, the same files as those above will be found with the file names ending in “TUF” instead of “TUE”.

ii. Subfolder “02_Matlab_workspaces”

This subfolder contains all of the post-processed MATLAB files as a .mat format from section 1d(i); these files have primarily been saved here to expedite the process for reading the data and, for example, plotting purposes.

e. Subfolder “05_Processed_data”

This subfolder contains all of the MATLAB files for processing the .mat files in Section 1d(ii) to ultimately plot the different figures provided in the corresponding journal paper. The following dot-points provide a quick overview of the different matlab files (.m) and the corresponding figure in the journal paper:

Specimen TUE

- TUE_Force_Displacement_EW: plots the force-displacement response of the wall in the east-west direction (positions A-B); Figure 9a.
- TUE_Force_Displacement_NS: plots the force-displacement response of the wall in the north-south direction (positions C-S); Figure 9b.
- LED_OOPDisplacementProfile_WestFlange_atPositionD_avg: plots the out-of-plane deformation of the West flange when the wall is at position D; Figure 15a.
- LED_OOPDisplacementProfile_EastFlange_atPositionD_avg: plots the out-of-plane deformation of the East flange when the wall is at position D; Figure 15b.
- LED_OOPDisplacementProfile_WestFlange_atPositionO_avg: plots the out-of-plane deformation of the West flange when the wall is at position O; Figure 16a.
- LED_OOPDisplacementProfile_EastFlange_atPositionO_avg: plots the out-of-plane deformation of the East flange when the wall is at position O; Figure 16b.

Specimen TUF

- TUF_Force_Displacement_EW_EF: plots the force-displacement response of the wall from positions E-F from the east-west actuator and east-west displacement; Figure 12f.
- TUF_Force_Displacement_EW_GH: plots the force-displacement response of the wall from positions G-H from the east-west actuator and east-west displacement; Figure 12i.
- TUF_Force_Displacement_NS_EF: plots the force-displacement response of the wall from positions E-F from the north-south actuators and north-south displacements; Figure 12e.
- TUF_Force_Displacement_NS_GH: plots the force-displacement response of the wall from positions G-H from the north-south actuators and north-south displacements; Figure 12h.
- TUF_Force_Displacement_NS2_EF: plots the force-displacement response of the wall from positions E-F from the sum of the north-south actuators and average north-south displacements; Figure 12d.
- TUF_Force_Displacement_NS2_GH: plots the force-displacement response of the wall from positions G-H from the sum of the north-south actuators and average north-south displacements; Figure 12g.
- TUF_Force_Displacement_SRSS_EF: plots the square root of the sum of squares (SRSS) force-displacement response of the wall for positions E-F; Figure 12b.
- TUF_Force_Displacement_SRSS_GH: plots the square root of the sum of squares (SRSS) force-displacement response of the wall for positions G-H; Figure 12c.

- TUF_LED_OOPDisplacementProfile_WestFlange_atPositionF_avg: plots the out-of-plane deformation of the West flange when the wall is at position F; Figure 17a.
- TUF_LED_OOPDisplacementProfile_EastFlange_atPositionG_avg: plots the out-of-plane deformation of the East flange when the wall is at position G; Figure 17b.
- TUF_LED_OOPDisplacementProfile_WestFlange_atO_avg: plots the out-of-plane deformation of the West flange when the wall is at position O; Figure 18a.
- TUF_LED_OOPDisplacementProfile_EastFlange_atO_avg: plots the out-of-plane deformation of the East flange when the wall is at position O; Figure 18b.
- TUF_Twist_PositionO: plots the torque-rotation of the wall at different drift levels at position O; Figure 19b.
- TUF_Twist_PositionG: plots the torque-rotation of the wall at different drift levels at position G; Figure 19c.
- TUF_Twist_PositionH: plots the torque-rotation of the wall at different drift levels at position H; Figure 19d.
- TUF_Twist_StiffnessDuctility_PositionO: plots the normalized rotational stiffness values of the wall at position O as a function of ductility; Figure 20a.
- TUF_Twist_StiffnessDuctility_PositionGandH: plots the normalized rotational stiffness values of the wall at position G&H as a function of ductility; Figure 20b.

f. Subfolder “06_Figures”

This subfolder contains all of the images (.tif) of the plots that were processed in Section 1e and output from MATLAB for publishing purposes.

g. Subfolder “06_Material_Properties”

This subfolder contains two folders for the material properties of steel and concrete; the corresponding files are discussed in the following sections.

i. Subfolder “01_CONCRETE”

This subfolder contains the testing results for the concrete cylinders to determine the tensile and compressive mechanical properties. The first folder, “01_COMPRESSION”, contains .lia files that can be opened by Microsoft Excel (or other); the last two columns of information contain Load (kN) and Stroke (mm) data, both of which can be used to determine the stress-strain behavior of the concrete in compression. It should be noted that the concrete cylinders tested were 16cm in diameter and 32cm in height. The second folder, “02_TENSION”, contains a .pdf document with the results of the tensile strength of the concrete cylinders.

ii. Subfolder “01_STEEL”

This subfolder contains the testing results of the 16 mm reinforcing steel to determine the mechanical properties; primarily, the stress-strain relationship was warranted, which would indicate the yield stress, ultimate stress, yield strain and ultimate strain. The files in this folder are .lia, which can be opened by Microsoft Excel (or other). The last two columns of information in the files are the data for strain (mm/mm) and stress (MPa), respectively.

2. Folder “03_Videos”

This folder contains some relevant videos that were recorded during testing of both specimens TUE and TUF. It also contains some post-processed videos, such as that using RECAP that shows the final condition of specimen TUE.

Appendix

The following information is provided in the processed .csv files for specimen TUE and TUF in Table 1 and Table 2, respectively.

Table 2 Processed channels for specimen TUE

DATA NAME	UNIT	DESCRIPTION
Time 1 CH=1	s	Time during in load step
LED_1 CH=4	-	Indication that LEDs working
Load-1 CH=12	kN	Load from actuator 1
Stroke-1 CH=13	mm	movement of actuator 1
Load-2 CH=14	kN	Load from actuator 2
Stroke-2 CH=15	mm	movement of actuator 2
Load-3 CH=16	kN	Load from actuator 2
Stroke-3 CH=17	mm	movement of actuator 2
LVDT_1 CH=28	mm	Deformation of wall in east-west at height of 4.65m
LVDT_2 CH=29	mm	Deformation of wall in north-south (west) at height of 4.25m
LVDT_3 CH=30	mm	Deformation of wall in north-south (east) at height of 4.25m
Index	-	Index number

Table 3 Processed channels for specimen TUF

DATA NAME	UNIT	DESCRIPTION
Time 1 CH=1	s	Time during in load step
LED_1 CH=4	-	Indication that LEDs working
Load-1 CH=12	kN	Load from actuator 1
Stroke-1 CH=13	mm	movement of actuator 1
Load-2 CH=14	kN	Load from actuator 2
Stroke-2 CH=15	mm	movement of actuator 2
Load-3 CH=16	kN	Load from actuator 2
Stroke-3 CH=17	mm	movement of actuator 2
LVDT_4 CH=28	mm	Deformation of wall in east-west at height of 4.65m
LVDT_2 CH=29	mm	Deformation of wall in north-south (west) at height of 4.25m
LVDT_3 CH=30	mm	Deformation of wall in north-south (east) at height of 4.25m
LVDT_1 CH=31	mm	Deformation of wall in east-west at height of 4.25m
Index	-	Index number