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Background report accompanying Deliverable D2.7
“Enrichment of the distributed database with existing data”

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ABSTRACT

The present report is a background document accompanying Deliverable D2.7 “Enrichment of the distributed database with existing data” (O). Its aim is to serve as a Manual describing the SERIES RC element structural databases which have been assembled from existing experimental data from literature, to provide researchers with the data needed to evaluate and develop seismic performance models for different RC load bearing elements. Three different databases were established and described in this Manual: RC beam database, RC column database and RC wall database. The present Manual does not deal with the own experimental data of SERIES partners already included in the distributed database during the last phase of the SERIES project via the SERIES Data Access Portal (www.dap.series.upatras.gr).
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1. INTRODUCTION

The present report per se is not a deliverable. It is a background document accompanying Deliverable D2.7 “Enrichment of the distributed database with existing data” which is characterized as “Other” (O) and entails populating the distributed database with data from literature. The enrichment itself is reflected in the SERIES Data Access Portal (www.dap.series.upatras.gr/) and will continue after the formal end of the project. This background document will be updated in future; new versions will be uploaded to the SERIES website (www.series.upatras.gr/public_documents). The present version is the one as of the end of July 2013.

The aim of the work relevant to this SERIES report was to establish an efficient database of experimental data for different types of load bearing reinforced concrete (RC) elements which were available worldwide.

The SERIES RC element structural database has been assembled to provide researchers with the data needed to evaluate and develop seismic performance models for different RC load bearing elements. This database builds on previous work carried out at the Washington University (PEER database), University of Patras (Biskinis et al, 2004, Biskinis & Fardis 2010a, 2010b, Panagiotakos and Fardis, 2001 ), Stanford University (Lignos and Krawinkler, 2009) and University of Ljubljana (Peruš, Poljanšek and Fajfar, 2006; Poljanšek, Peruš and Fajfar, 2008).

In addition to the existing data from literature which are included in the distributed database and are the subject of this report, the SERIES partners have populated the database with own, recent experimental data (some of them produced within SERIES itself). Uploading those latter data via the SERIES Data Access Portal (www.dap.series.upatras.gr/) has taken place during the last phase of the SERIES project and is on-going; it will continue after the formal end of SERIES. As of the end of July, the following SERIES partners have uploaded own experimental
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data: UPAT, EUCENTRE, ITU, IZIIS, LNEC, NTUA, TU IASI, UNAP, UNITN, UCAM and UOXF. Partners which may soon upload theirs include IFSTTAR, METU and UNIVBRIS. As pointed out above, the present report does not deal with that part of the work, but only with existing data from literature which have already been included in the distributed database.
2. STRUCTURE OF THE DATABASE

2.1 BASIC CONCEPTS

In principle, different types of reinforced concrete (RC) load bearing elements require different data, i.e. beams require more data than columns because of a larger variety of possible shapes (rectangular, T- and L-shaped cross sections) and because of asymmetric reinforcement. Different shapes are also characteristic for walls (rectangular, barbell and flanged cross sections). Also in the case of columns, circular or some less common shapes (e.g. octagonal) are used. Therefore, the basic idea is dividing the RC element database into several sub-databases, which correspond to different types (i.e. columns, beams and walls). In such a case the databases are much more transparent and easier to be used for automatic computational procedures. Of course, all databases should be consistent, having as many common parameters as feasible. Moreover, a further division of sub-databases, considering some specific forms of cross-sections (for the same element) is made, e.g. a special database applies for the columns of circular cross-section, a special database for the beams of the I cross-section, etc. In this way, in the main databases (presently: columns and beams) the most common types of these elements are included, whereas less common types (special cross-sections) are in separate databases.

The basic tool for preparing the RC element database is Microsoft Excel®. The main idea in structuring any of sub-databases (RC column and RC beams databases) was dividing the database in two main parts: (1) the basic data, provided by the researchers (papers, reports, etc.) and (2) the derived data, which may assist researchers in their analyses (i.e. developing seismic performance models for different RC load bearing elements).

The first part of any sub-database therefore consists of two sheets: ReportedData and MetaData.
The second part of any sub-database therefore consists of four sheets: MetaData-SI_Units, MetaData-US_Units, CalculatedData-SI_Units, CapacityData-SI_Units.

Note that original data reported in the literature are either in SI or in US units (sheet Metadata). In order to diminish possible errors, the same data are presented in the sheets MetaData-SI_Units and MetaData-US_Units, using SI and US customary units, respectively. In the sheet CalculatedData-SI_Units are collected results of individual experiments in SI units (e.g., hysteretic response, peak points, envelope, energy). In the sheet CapacityData-SI_Units are collected data and results of individual experiments in a form that allows direct development of seismic performance models (derived input parameters that describe the mechanical and geometrical parameters, e.g. shear span index, axial load index, etc., and the parameters of the deformation capacity, e.g. capping drift, ultimate drift etc.).

2.2 RC COLUMN DATABASE

2.2.1 Basic data of the RC column database

The sheet ReportedData consists of:

# is the serial number.

Experiment campaign number is the number of experiment. This is a serial number of the entry in the database.

Test number is the serial number of the RC element in the experiment.

Test ID notation is a unique number notation format, which consists of two parts: the first part is the three-digit number and represents the Experiment number, the second part has two digits and represents the Test number. Any file associated with the data and results for any RC element is identified with this symbol. For example, 00102TH.xls represents the digitized hysteretic response. 001 represents the experiment with serial number 1, 02 represents the test number 2 in this experiment, and TH indicates that this is the hysteretic response.

Reference is the source, for example, article, report or personal communication, where the experiment is described.

Digitized history represents the file names in which the recorded hysteretic response is described. In this particular case, the hysteretic response represents the force-displacement
Comments represent the comments for each test.

X-axis units represents the original unit in which the test results for displacement were provided. Y-axis units represents the original unit in which the test results for forces were provided.

Columns Damage associated with deformation represent the displacements/drifts associated with the defined types of damage.

*Please note that all quantities (e.g. forces, stresses, displacements, ...) are given in the relevant units (SI or US customary units), as defined in the column Units(SI/US).*

Sheet MetaData consists of:

#, Experiment number, Test number, Test ID notation and Reference are the same notations as in the sheet ReportedData.

Units (SI/US) indicates the type of units. As a rule, either SI units or U.S. customary units are used. The given quantities will be converted and presented in both types of units (see sheets MetaData-SI_Units in MetaData-US_Units). This facilitates the review of data to users who are more accustomed with the one or the other unit.

Loading (C/M) indicates the type of load. Two types of loading are possible, namely cyclic (C) or monotonic (M) load.

Cross section indicates the type of the cross-section. Two types of cross-sections are possible, namely square (S) and rectangular (R).

fc indicates the compressive strength of concrete.

fct,fl indicates the modulus of rupture (flexural strength) of concrete.

fct,sp indicates the splitting tensile strength of concrete.

N denotes the axial force.

P-D indicates the P-delta effect. Codes and a more detailed description can be found in the header and Help menu (see Figure 3.2, column L).

b indicates the width of the cross-section.

h indicates the depth of the cross-section.

L denotes the length of equivalent cantilever.

L.splice is the length of longitudinal reinforcement splice.
**Test Configuration** - five different types of test configuration are defined:

- C: Cantilever beam
- DC: Double curvature
- FB: Cantilever beam with flexible base
- DE: Double ended
- HH: Hammerhead

**Area** Cross-sectional area of column.

**Length of equivalent cantilever** is the length from the point of the column base (the maximum bending moment point) to the deflection point (the zero bending moment point).

**Diameter Corner** is the diameter of longitudinal corner reinforcement bars.

**Diameter Interim** is the diameter of longitudinal intermediate reinforcement bars.

**Total # Bars** is the number of longitudinal reinforcing bars.

**Clear Cover (Perpendicular to Load)** represents the distance from the outer surface of column to the outer edge of transverse reinforcement perpendicular to load.

**# Interim Bars (Perpendicular to Load)** is the number of longitudinal intermediate reinforcing bars perpendicular to load.

**Clear Cover (Parallel to Load)** represents the distance from the outer surface of column to the outer edge of transverse reinforcement parallel to load.

**# Interim Bars (Parallel to Load)** is the number of longitudinal intermediate reinforcing bars parallel to load.

**Embedment Type** is the type of longitudinal reinforcement anchorage.

**Straight Embedment length Le.**

**Reinf. Ratio (Calc.)** is the calculated longitudinal reinforcement ratio.

**fyl Corner** is the yield stress of longitudinal corner bars.

**ftl Corner** is the ultimate steel strength of longitudinal corner bars.

**fyl Interim** is the yield stress of longitudinal intermediate bars.

**ftl Interim** is the ultimate steel strength of longitudinal intermediate bars.

**Steel Grade** is steel grade of longitudinal reinforcement.

**Type of Confin.** - nine different types of confinement are defined:

- I Interlocking ties
- R Rectangular ties (around perimeter)
- RI Rectangular and Interlocking ties
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- RU Rectangular ties and U-bars
- RJ Rectangular ties with J-hooks
- RD Rectangular and Diagonal ties
- RO Rectangular and Octagonal ties
- RIJ Rectangular and Interlocking ties, with J-hooks
- UJ U-bars with J-hooks

Nv is the number of transverse shear bars in the cross section parallel to loading direction.

**Ribbed or Smooth bars**

**Bar Dia.** is the diameter of transverse reinforcement.

**Hoop Sets (Region of Close Spacing)** is the number of hoop sets in the region of close spacing.

**Spacing (Region of Close Spacing)** is the spacing of transverse reinforcement in region of close spacing.

**Bar Dia. (Region of Close Spacing)** is the diameter of transverse reinforcement in region of close spacing.

**Hoop Sets (Region of Wide Spacing)** is the number of hoop sets in the region of wide spacing.

**Spacing (Region of Wide Spacing)** is the spacing of transverse reinforcement in region of wide spacing.

**Bar Dia. (Region of Wide Spacing)** is the diameter of transverse reinforcement in region of wide spacing.

**Vol. Trans. Reinf. Ratio** is the reported volumetric transverse reinforcement ratio.

**fyw Trans.** is the yield stress of transverse reinforcement.

**ftw Trans.** is the ultimate steel strength of transverse reinforcement.

**Steel Grade** is the steel grade of transverse reinforcement.

**Failure** provides a code indicating the type of failure, as it occurred during the test. In general, flexural (1), shear (2) or flexural-shear (3) failures are reported.

*Please note that all quantities (e.g. forces, stresses, displacements, ...) are given in the relevant units (SI or US customary units), as defined in the column Units(SI/US).*
2.2.2 Derived data of RC column database

Sheet MetaData-SI_Units

has exactly the same structure as the sheet Metadata, except that all quantities are in SI units!

Sheet MetaData-US_Units

has exactly the same structure as the sheet Metadata, except that all quantities are in US customary units!

Sheet CalculatedData-SI_Units includes data in SI units and consists of:

#, Experiment number, Test number, Test ID notation, Reference are the same notations as in the sheet ReportedData.

Digitized history represents the file names in which the recorded hysteretic response is described. In this particular case, the hysteretic response represents the normalized force-drift relationship.

Peak points gives the names of files containing information on maximum points in the hysteresis (numerical and graphical data). The Test ID notation is followed by a tag PH.

Envelope gives the names of files containing information about the hysteresis envelope (numerical and graphical data). Test ID notation is followed by a tag EV.

Energy gives the names of files containing information about the hysteretic energy (numerical and graphical data). Test ID notation is followed by a tag EN.

Comments represent the comments of each test.

Different input parameters have been used in the literature (i.e. FIB, 2003; Lam et al., 2003; Park et al., 1985; Park et al., 2001; Paulay and Priestley, 1992) for the prediction of deformation capacity of RC elements. For example, the expression for the estimation of ultimate drift (the limit state of near collapse) implemented in Eurocode 8, Part 3 (CEN, 2005), takes into account the axial load index, the shear span index, the concrete compressive strength, the confinement
effectiveness factor multiplied by confinement index and the mechanical reinforcement ratio of the tension and compression longitudinal reinforcement. Therefore, in the sheet **CapacityData-SI_Units** are collected data and results of individual experiments in a form that allows direct development of seismic performance models either by standard parametric statistical approach (e.g. Fardis and Biskins, 2003) or by non-parametric approach (e.g. Peruš, Fajfar and Grabec, 1994; Peruš, Poljanšek and Fajfar, 2006). Presented are different derived input parameters that describe the mechanical and geometrical parameters, e.g. shear span index, axial load index, etc., and the parameters of the deformation capacity, e.g. capping drift, ultimate drift etc.)

**Sheet** **CapacityData-SI_Units** **includes data and results in SI units and consists of:**

- #, **Experiment number**, **Test number**, **Test ID notation** and **Reference** are the same notations as in the sheet **ReportedData**. **Loading (C/M)** is the same notation as in the sheet **MetaData**.

**Report excerpt** allows the view of some details of experiment and/or test samples. The information is scanned from the original sources.

- **fc** indicates the compressive strength of concrete in MPa.
- **N*** indicates the normalized axial force.
- **L*** is the shear span index.
- **L** is the length of equivalent cantilever.
- **Reinf. Ratio* (Longit. Reinf. index)** is the calculated longitudinal reinforcement ratio.
- **Failure** provides a code indicating the type of failure, as it occurred during the test. In general, flexural (1), shear (2) or flexural-shear (3) failures are reported.
- **Capping drift – Positive** is the drift at capping point at positive branch of the envelope.
- **Capping drift – Negative** is the drift at capping point at negative branch of the envelope.
- **Capping drift – Average** is the average drift at capping point of the envelope.
- **Max. drift – Positive** is the maximum drift, which is achieved during the experiment (at positive branch of the envelope).
- **Max. drift – Negative** is the maximum drift, which is achieved during the experiment (at negative branch of the envelope).
- **Max. drift – Average** is the average maximum drift of the envelope.
- **drift at 10% drop – Average** is the average drift at 10% drop of strength.
**drift at 15% drop** — **Average** is the average drift at 15% drop of strength.

**drift at 20% drop** — **Average** is the average drift at 20% drop of strength.

**Ultimate drift** is the drift representing “failure” of the element. Typically, drift at 20% drop is used. However, any other definition of the ultimate state can be used.

**Type of the ultimate drift** gives the codes related to different definitions of the ultimate drift as explained in the comments by the person compiling the database.

**Maximum force - Positive** is the maximum force at positive branch of the envelope in SI units.

**Maximum force - Negative** is the maximum force at negative branch of the envelope in SI units.

Columns **Damage associated with deformation [%]** represent the drifts associated with the defined types of damage:

1) **Cracking** is described as onset of cracking, defined as the first observation of cracking.

2) **Spalling**: Onset of spalling, defined as the first observation of spalling.

3) **Significant spalling**: Onset of significant spalling, defined by the reported observation of “significant spalling” or “considerable spalling.” Alternatively, if spall heights could be determined, significant spalling was defined as a spall height equal to at least 10% of the cross-section depth.

4) **Longitudinal bar buckling**: Onset of bar buckling, defined as the observation of the first sign of longitudinal bar buckling.

5) **Longitudinal bar fracture** is defined as the observation of the first sign of a longitudinal bar fracturing.

6) **Transverse reinforcement fracture** is defined as the observation of the first sign of the transverse reinforcement fracturing, or becoming untied.

7) **Loss of axial-load capacity** is defined as the observation of loss of axial-load carrying capacity of the column.

8) **Failure**: Column failure is defined as the first occurrence of one of the following events: buckling of a longitudinal bar, fracture of transverse reinforcement, fracture of a longitudinal bar, or loss of axial-load capacity.
2.3 RC BEAM DATABASE

The structure of the database for the RC beams is the same as the database structure for the RC columns, the essential difference is only in the sheet Metadata, where some parameters are not necessary, while others are modified or new.

Sheet Metadata consists of:

- **#.** Experiment number, **Test number,** **Test ID notation** and **Reference** are the same notations as in the sheet ReportedData.
- Units (SI/US) indicates the type of units. As a rule, either SI units or U.S. customary units are used. Regarding the unit, the given quantities are converted to both types of units (see sheets Metadata-SI_Units in Metadata-US_Units). This make it possible to facilitate review of data to users who are more accustomed with one or other units.
- **Loading** (C/M) indicates the type of load. Two types of loading are possible, namely cyclic (C) or monotonic (M) load.
- **Cross section** indicates the type of cross-sectional area. Different types of cross-sections are possible, namely square (S), rectangular (R), T-shaped (T) and L-shaped (L).
- **fc** indicates the compressive strength of concrete.
- **fct,fl** indicates the modulus of rupture of concrete.
- **fct,sp** indicates the splitting tensile strength of concrete.
- **bw** indicates the width of the beam web.
- **bf** indicates the width of the beam flange.
- **hb** indicates the total depth of the beam
- **hf** indicates the depth of the beam flange.
- **L** denotes the length of equivalent cantilever.
- **Lsplice** in the length of longitudinal reinforcement splice.

**Test Configuration** - five different types of test configuration are defined:

- C: Cantilever beam
- DC: Double curvature
- FB: Cantilever beam with flexible base
- DE: Double ended
• HH: Hammerhead

Area Cross-sectional area of column.

*It follows the description of longitudinal reinforcement of typical rectangular cross-section:*

**Diameter Corner (Perpendicular to Load)** is diameter of longitudinal reinforcement bars at location A1 layer 1.

# **Bars (Corner, Perpendicular to Load)** is the number of longitudinal reinforcing bars at location A1 layer 1 perpendicular to load.

fyl **(Corner, Perpendicular to Load)** is the yield stress of longitudinal bars at location A1 layer 1.

ftl **(Corner, Perpendicular to Load)** is the ultimate steel strength of longitudinal bars at location A1 layer 1.

**Diameter LocA1L1 (Perpendicular to Load)** is diameter of longitudinal reinforcement bars at location A1 layer 1.

# **Bars (LocA1L1, Perpendicular to Load)** is the number of longitudinal reinforcing bars at location A1 layer 1 perpendicular to load.

fyl **(LocA1L1, Perpendicular to Load)** is the yield stress of longitudinal bars at location A1 layer 1.

ftl **(LocA1L1, Perpendicular to Load)** is the ultimate steel strength of longitudinal bars at location A1 layer 1.

**Diameter LocA1L2 (Perpendicular to Load)** is diameter of longitudinal reinforcement bars at location A1 layer 2.

# **Bars (LocA1L2, Perpendicular to Load)** is the number of longitudinal reinforcing bars at location A1 layer 2 perpendicular to load.

fyl **(LocA1L2, Perpendicular to Load)** is the yield stress of longitudinal bars at location A1 layer 2.

ftl **(LocA1L2, Perpendicular to Load)** is the ultimate steel strength of longitudinal bars at location A1 layer 2.

**Diameter LocBL1 (Perpendicular to Load)** is diameter of longitudinal reinforcement bars at location B layer 1.

# **Bars (LocBL1, Perpendicular to Load)** is the number of longitudinal reinforcing bars at location B layer 1 perpendicular to load.
fyl (LocBL1, Perpendicular to Load) is the yield stress of longitudinal bars at location B layer 1.

ftl (LocBL1, Perpendicular to Load) is the ultimate steel strength of longitudinal bars at location B layer 1.

What follows is the description of the longitudinal reinforcement of the additional parts of the cross-section (this description may be hidden in order to improve the transparency of the database):

Diameter LocBL2 (Perpendicular to Load) is diameter of longitudinal reinforcement bars at location B layer 2.

# Bars (LocBL2, Perpendicular to Load) is the number of longitudinal reinforcing bars at location B layer 2 perpendicular to load.

fyl (LocBL2, Perpendicular to Load) is the yield stress of longitudinal bars at location B layer 2.

ftl (LocBL2, Perpendicular to Load) is the ultimate steel strength of longitudinal bars at location B layer 2.

Diameter LocA2L1 (Perpendicular to Load) is diameter of longitudinal reinforcement bars at location A2 layer 1.

# Bars (LocA2L1, Perpendicular to Load) is the number of longitudinal reinforcing bars at location A2 layer 1 perpendicular to load.

fyl (LocA2L1, Perpendicular to Load) is the yield stress of longitudinal bars at location A2 layer 1.

ftl (LocA2L1, Perpendicular to Load) is the ultimate steel strength of longitudinal bars at location A2 layer 1.

Diameter LocA3L1 (Perpendicular to Load) is diameter of longitudinal reinforcement bars at location A3 layer 1.

# Bars (LocA3L1, Perpendicular to Load) is the number of longitudinal reinforcing bars at location A3 layer 1 perpendicular to load.

fyl (LocA3L1, Perpendicular to Load) is the yield stress of longitudinal bars at location A3 layer 1.

ftl (LocA3L1, Perpendicular to Load) is the ultimate steel strength of longitudinal bars at location A3 layer 1.
\( y_{A1} \text{ (Perpendicular to Load)} \) is the distance from the outer surface of the beam side A to the center of mass of longitudinal reinforcement in layer 1 on side A.

\( y_{A2} \text{ (Perpendicular to Load)} \) is the distance from the outer surface of the beam side A to the center of mass of longitudinal reinforcement in layer 2 on side A.

\( y_{B1} \text{ (Perpendicular to Load)} \) is the distance from the outer surface of the beam side B to the center of mass of longitudinal reinforcement in layer 1 on side B.

\( y_{B2} \text{ (Perpendicular to Load)} \) is the distance from the outer surface of the beam side B to the center of mass of longitudinal reinforcement in layer 2 on side B.

Note that the next 8 data represent summary information about the longitudinal reinforcement. These data are calculated automatically from the more detailed data about the longitudinal reinforcement. Alternatively, if more detailed data are not provided, these data should be provided as input data.

**Total area of top reinf.** is the total reinforcement area of longitudinal bars at the top (side A, perpendicular to load).

**Total area of bottom reinf.** is the total reinforcement area of longitudinal bars at the bottom (perpendicular to load).

\( y^T \) is the distance from the outer surface of the beam at the top (side A) to the center of mass of longitudinal reinforcement on the same side (side A).

\( y^B \) is the distance from the outer surface of the beam at the bottom (side B) to the center of mass of longitudinal reinforcement on the same side (side B).

\( f_{yl}^T \) is the yield stress of longitudinal bars at the top (side A).

\( f_{ul}^T \) is the ultimate steel strength of longitudinal bars at the top (side A).

\( f_{yl}^B \) is the yield stress of longitudinal bars at the bottom (side B).

\( f_{ul}^B \) is the ultimate steel strength of longitudinal bars at the bottom (side B).
Clear Cover (Perpendicular to Load) represents the distance from outer surface of beam to outer edge of transverse reinforcement perpendicular to load.

Clear Cover (Parallel to Load) represents the distance from outer surface of column to outer edge of transverse reinforcement parallel to load.

Embedment Type is the type of longitudinal reinforcement anchorage.

Straight Embedment length Le.

Reinf. Ratio (Calc.) is the calculated longitudinal reinforcement ratio.

Steel Grade is steel grade of longitudinal reinforcement.

Type of Confin. - nine different types of confinement are defined:
- R - Peripheral rectangular tie
- HR - horizontal rectangular tie (greater dimension of tie along smaller dimension of specimen)
- VR - vertical rectangular tie (greater dimension of tie along greater dimension of specimen)
- U - U-loop
- L - link
- H – hair pin tie
- D – diamond shape tie
- VL – vertical link (along greater dimension)
- HL – horizontal link (along smaller dimension)

Nv is the number of transverse shear bars in the cross section.
Deformed bars

**Bar Dia.** is diameter of transverse reinforcement.  
Hoop Sets (Region of Close Spacing) is number of hoop sets in the region of close spacing.  
**Spacing (Region of Close Spacing)** is spacing of transverse reinforcement in region of close spacing.  
**Bar Dia. (Region of Close Spacing)** is diameter of transverse reinforcement in region of close spacing.  
**Hoop Sets (Region of Wide Spacing)** is number of hoop sets in the region of wide spacing.  
**Spacing (Region of Wide Spacing)** is spacing of transverse reinforcement in region of wide spacing.  
**Bar Dia. (Region of Wide Spacing)** is diameter of transverse reinforcement in region of wide spacing.  
**Vol. Trans. Reinf. Ratio** is the reported volumetric transverse reinforcement ratio.  
**fyw Trans.** is yield stress of transverse reinforcement.  
**ftw Trans.** is ultimate steel strength of transverse reinforcement.  
**Steel Grade** is steel grade of transverse reinforcement.  
**Failure** provides a code indicating the type of failure, if it was occurred during the test. In general, flexural (1), shear (2) or flexural-shear (3) failures are reported.

*Please note that all quantities (e.g. forces, stresses, displacements, ...) are given in the relevant units (SI or US customary units), as defined in the column Units(SI/US).*

### 2.4 RC WALL DATABASE

The structure of the database for the RC walls is the same as the database structure for the RC columns, the essential difference is only in the sheet *Metadata*, where some parameters are not necessary, while others are modified or new.

**Sheet Metadata** consists of:

- **#, Experiment campaign number**, **Test number**, **Test ID notation** and **Reference** are the same notations as in the sheet *ReportedData*. 
Units (SI/US) indicates the type of units. As a rule, either SI units or U.S. customary units are used. Regarding the unit, the given quantities are converted to both types of units (see sheets MetaData-SI_Units in MetaData-US_Units). This make it possible to facilitate review of data to users who are more accustomed with one or other units.

Loading (C/M) indicates the type of load. Two types of loading are possible, namely cyclic (C) or monotonic (M) load.

Cross section indicates the type of cross-sectional area. The following types of cross-sections are possible: rectangular (R), barbell (B), flanged (F) and other (O).

fct,fl indicates the modulus of rupture (flexural strength) of concrete.

fct,sp indicates the splitting tensile strength of concrete.

N denotes the axial force.

P-D indicates the P-delta effect. Codes and a more detailed description can be found in the header and Help menu (see Figure 1, column L).

b indicates the width of the boundary element.

hb indicates the depth of the boundary element.

lw indicates the total depth of the wall cross section.

bw indicates the width of web.

H indicates the total height of the wall.

Ls indicates the length of equivalent cantilever.

Test Configuration - six different types of test configuration are defined:

- C: Cantilever beam
- DC: Double curvature
- FB: Cantilever beam with flexible base
- DE: Double ended
- HH: Hammerhead
- N-point loading:N is the number of loading points along the height of the wall (for N>1)

Area Cross-sectional area of wall.

It follows the description of longitudinal reinforcement of the boundary element’s cross-section:

Diameter Corner is the diameter of longitudinal corner reinforcement bars.
Diameter Interim parallel to Load is the diameter of longitudinal intermediate reinforcement bars parallel to load.

Diameter Interim Perpendicular to Load is the diameter of longitudinal intermediate reinforcement bars perpendicular to load.

Total # Bars is the number of longitudinal reinforcing bars.

Clear Cover (Perpendicular to Load) represents the distance from the outer surface of column to the outer edge of transverse reinforcement perpendicular to load.

# Interim Bars (Perpendicular to Load) is the number of longitudinal intermediate reinforcing bars perpendicular to load.

Clear Cover (Parallel to Load) represents the distance from the outer surface of column to the outer edge of transverse reinforcement parallel to load.

# Interim Bars (Parallel to Load) is the number of longitudinal intermediate reinforcing bars parallel to load.

Embedment Type is the type of longitudinal reinforcement anchorage.

Straight Embedment length Le.

Ribbed/Smooth Bars.

Reinf. Ratio (Calc.) is the calculated longitudinal reinforcement ratio of each boundary element (area of steel of the boundary element divided by cross-sectional area of wall).

Lsplice Length of longitudinal reinforcement splice of boundary element.

fyl Corner is the yield stress of longitudinal corner bars.

ftl Corner is the ultimate steel strength of longitudinal corner bars.

fyl Interim parallel to Load is the yield stress of longitudinal intermediate bar parallel to load.

fyl Interim perpendicular to Load is the yield stress of longitudinal intermediate bars perpendicular to load.

ftl Interim parallel to Load is the ultimate steel strength of longitudinal intermediate bars parallel to load.

ftl Interim perpendicular to Load is the ultimate steel strength of longitudinal intermediate bars perpendicular to load.

Steel Grade is steel grade of longitudinal reinforcement.

It follows the description of tranverse reinforcement of the boundary element’s cross-section:
Type of Confin. - nine different types of confinement are defined:
- I Interlocking ties
- R Rectangular ties (around perimeter)
- RI Rectangular and Interlocking ties
- RU Rectangular ties and U-bars
- RJ Rectangular ties with J-hooks
- RD Rectangular and Diagonal ties
- RO Rectangular and Octagonal ties
- RIJ Rectangular and Interlocking ties, with J-hooks
- UJ U-bars with J-hooks

$N_v$ is the number of transverse shear bars in the cross section parallel to loading direction.

**Ribbed or Smooth bars**

**Bar Dia.** is the diameter of transverse reinforcement.

**Hoop Sets (Region of Close Spacing)** is the number of hoop sets in the region of close spacing.

**Spacing (Region of Close Spacing)** is the spacing of transverse reinforcement in region of close spacing.

**Bar Dia. (Region of Close Spacing)** is the diameter of transverse reinforcement in region of close spacing.

**Hoop Sets (Region of Wide Spacing)** is the number of hoop sets in the region of wide spacing.

**Spacing (Region of Wide Spacing)** is the spacing of transverse reinforcement in region of wide spacing.

**Bar Dia. (Region of Wide Spacing)** is the diameter of transverse reinforcement in region of wide spacing.

**Trans. Reinf. Ratio parallel to Load (region of close spacing)** is the reported transverse reinforcement ratio parallel to load in the region of close spacing.

**Trans. Reinf. Ratio parallel to Load (region of wide spacing)** is the reported transverse reinforcement ratio parallel to load in the region of wide spacing.

**fyw Trans.** is the yield stress of transverse reinforcement.

**ftw Trans.** is the ultimate steel strength of transverse reinforcement.

**Steel Grade** is the steel grade of transverse reinforcement.

*It follows the description of longitudinal reinforcement of web’s cross-section:*
Bar Diameter is the diameter of web’s longitudinal reinforcement.
s_v is the spacing of web’s longitudinal reinforcement.
Layers # denotes the number of layers of web’s longitudinal reinforcement.
Reinf. Ratio (Calc.) is the calculated longitudinal reinforcement ratio of web (Bar area multiplied by Layers # and divided by s_v and b_w).
Lsplice Lap-splice length of web’s longitudinal reinforcement.
f_yv longitudinal is the yield stress of longitudinal web’s bars.
f_t e longitudinal is the ultimate steel strength of longitudinal web’s bars.
Steel Grade is steel grade of longitudinal reinforcement of web.

It follows the description of transverse reinforcement of web’s cross-section:

Bar Diameter is the diameter of web’s transverse reinforcement.
S_w is the spacing of web’s transverse reinforcement.
Reinf. Ratio (Calc.) is the calculated transverse reinforcement ratio of web (Bar area multiplied by Layers # and divided by s_w and b_w).
f_yt Trans is the yield stress of transverse web’s bars.
f_t e Trans is the ultimate steel strength of transverse web’s bars.
Steel Grade is steel grade of transverse reinforcement of web.

It follows the description of diagonal reinforcement of wall’s cross-section:

Bar Diameter is the diameter of diagonal reinforcement.
# Diagonal Bars is the number of diagonal bars.
Diagonal Reinf. Ratio (Calc.) is the calculated diagonal reinforcement ratio.
f_y diagonal is the yield stress of diagonal bars.
Steel Grade is steel grade of diagonal reinforcement of web.

Failure provides a code indicating the type of failure, as it occurred during the test. In general, flexural (1), shear (2), shear-tension (3), shear compression (4), flexural-shear (5), lap-splice failure (6), anchorage failure (7), sliding shear (8) or non-failure (9) failures are reported.
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2.5 CAPACITY

The drift of the RC element, sometimes called the drift ratio, which is equal to the chord rotation, is obtained as the displacement at the top of an equivalent cantilever divided by the length of this cantilever (also called »shear span«). In this manual it will be called »drift«.

The ultimate displacement, representing a “near collapse” limit state, is usually defined as the displacement at a predefined drop below maximum strength. A 20% drop in maximum strength (i.e. when the restoring force reaches 80% of its maximum value) is commonly used, although this definition may significantly underestimate the true axial load-carrying capacity of the columns.

Figure 2.2: An example from the database of the processing of the hysteresis data: (a) hysteretic force-displacement relationship from the experiment, (b) the normalized force - drift envelope for both positive and negative loading and the mean envelope, (c) the mean envelope and idealized force – drift relationship. The effective yield, capping and ultimate (at 20% drop) drifts are shown.

The characteristic drifts, which represent specific points on the mean force – drift envelope (also for beams with effective width), are the capping drift \( \delta_c \) and the ultimate drift \( \delta_u \) (Figures 2.2b and 2.2c). The capping drift is the drift at maximum strength. The ultimate drift was conservatively assumed as the drift at the “near collapse” limit state, defined as the drift at a 20%
Background report accompanying D2.7 — Enrichment of the distributed database with existing data drop below maximum strength. In addition, the ultimate drift was determined also at a 15% and 10% drop in mean maximum strength. Other drift-related output parameters, which have been determined, are the effective yield drift $\delta_y$ and the ductility $\mu_y$, defined as the ratio between the ultimate and the effective yield drift. Note that in cases of un-symmetrical hysteresis the mean envelope equals either to the positive either to negative envelope where the other ends (see Figure 2.3).

Ultimate drift according to the above description is uniquely defined in case of failure in flexural mode. In case of other failure modes, i.e. shear failure, axial load failure etc., where there is no degradation part of the envelope, drifts at different strength drops are determined as equal. In most of these cases also the capping point coincides with the ultimate drift point (see Figure 2.4).

Figure 2.3: An example from the database representing the case with un-symmetrical envelopes.
Figure 2.4: An example from the database representing the case where capping point coincides with the ultimate drift points (no degradation part). Note that the positive envelope is larger than negative envelope.
3. USING THE DATABASE

Figure 3.1 shows the main sheet **ReportedData** of the RCColumnDatabase.xls.

![Figure 3.1: RCColumnDatabase.xls – main sheet.](image)

By clicking on the header in any of the sheets (see Figure 3.2), the user can obtain more detailed descriptions of each parameter. For some of the more important (i.e. more complex) parameters, a click on **Help** offers even more detailed description or image that is associated with the description of that parameter. A click on **Manual** leads to a basic guide, which describes...
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the whole database (currently the PEER database in its original form, however, it will be this guide in the final version).

Figure 3.2: Description of parameters.
4. ADDING DATA IN THE DATABASE

(Authorized/registered) User can simply add new samples of RC elements into the database by typing the available data into sheets **ReportedData** and **MetaData**.
5. CONCLUSIONS

This report documents the RC structural element database, developed within the Series project. The Series RC element (columns, beams and walls) structural database has been assembled to provide researchers with the data needed to evaluate and develop seismic performance models for different RC load bearing elements.
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**Sources related to RC beam database**


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