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# AN INITIATIVE TO PRESERVE INFORMATION ABOUT THE 2010 MAULE, CHILE, EARTHQUAKE: FOLLOWING THE ROADMAP LAID OUT BY SHIGA AND SHIBATA

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**ABSTRACT:** Earthquakes affecting urban areas generate large amounts of invaluable information about the seismic vulnerability of the built environment. It is difficult to conceive scenarios in which the same amount and quality of information can be produced through numerical or experimental work. Yet, of all the information generated by an earthquake, only a fraction is collected, and even less reaches practitioners and researchers. The reasons for this information "loss" vary from legal matters that prevent release of information about private property to matters having to do with how we collect, organize, and publish the information. The steady progress that has been made in computer and information technologies in the past decades has created unprecedented opportunities to improve the ways in which we collect, organize, and publish information collected in the field. This note describes a data repository created using the latest in computer and information technology to catalog and disseminate data about the response of reinforced concrete building structures to the Maule, Chile, Earthquake of 2010.

**Keywords:** Maule Chile Earthquake, Database, Ground Motion Records, Drawings, Crack Maps.

## INTRODUCTION

Hardy Cross said that all designs are based primarily on experience (Cross, 1932). His statement continues to be true generations later as earthquakes continue to challenge our preconceptions. It is therefore crucial to document our experience (i.e. observations made after earthquakes). Today, the types of media available for this purpose go far beyond printed journals and allow us to combine data in a wide range of formats varying from video to drawings.

## PRECEDENTS

Many researchers have documented damage caused by earthquakes and the properties of the affected structures systematically. But two previous works stand out in the first anniversary of the Tohoku Earthquake of 11 March, 2011: one because it was seminal and because it dealt with structures in the

Tohoku region (which are obviously relevant to understand the disaster of 11 March 2011), and the other because it inspired and provided invaluable information for the database described here. The first is the work that was done by Professor's Shiga and Shibata at Tohoku University after the Miyagi Ken Oki earthquake of 1978 (Shibata, 2010) and served to vet an ingenious and pragmatic method for screening reinforced concrete building structures (Shiga, 1976). The second work was conducted by Riddell et al. (Riddell et al., 1987). In both cases the researchers focused on quantitative information with a clear idea in mind: systematic examination of the possible correlation between structural properties or vulnerability indices and observed damage may reveal trends that can be interpreted to improve design and evaluation procedures.

The work by Riddell et al. was done after the 1985 Valparaiso, Chile, Earthquake. They compiled a database describing buildings and damage in Viña del Mar and Valparaiso. The database included layouts of floor plans and structural systems and ratios of total cross-sectional areas of structural elements to floor areas. Information for a total of 178 buildings was documented. The data were published in reports printed by the University of Illinois at Urbana Champaign and helped to identify the benefits of structural stiffness and strength on seismic response (Sozen, 1989).

The works of Shiga, Shibata, and Riddell inspired the creation of the repository described here which was designed to classify and preserve data from the Maule Earthquake of 2010.

## MAULE EARTHQUAKE OF 2010

Similar to the earthquakes that affected the Tohoku region in 1978 and 2011, the earthquakes of 1985 and 2011 in Chile generated large amounts of data and opportunities to compare the responses of structures to two different strong ground motions.

In general, the damage caused by the Maule Earthquake to reinforced concrete building structures was limited, but there were exceptions. In Concepción, for example, a fifteen-story building collapsed and approximately 7% of buildings with ten or more stories were scheduled for demolition after the earthquake. Understanding the causes of these failures is imperative. And that should be done on the basis of tangible evidence (from as large a number of structures as possible). In this paper, the development of a database conceived to classify, store, and disseminate this evidence is described.

## FIELDS AND ORGANIZATION

Motivated by the need to understand the implications of the failures observed in Chile, a number of organizations[1] deployed reconnaissance teams to the Maule region. These teams collected:

i. structural drawings
ii. crack maps
iii. photographs
iv. material properties
v. soil reports

The database described here was designed to allow its users to:

i. explore photographic evidence of damage caused by the Maule Earthquake .
ii. explore geotechnical and ground motion information about the Maule Earthquake
iii. associate photographs and performance data with building information (ranging from location and number of stories to – where available – seismic vulnerability indices such as the ratio of wall area to total floor area)
iv. associate damage information and information on recorded ground motion

[1] See acknowledgments

v. correlate level of damage and structural properties
vi. explore and export data in a variety of formats including text, kmz and kml (for use with the Google Earth software), and shp (for use with ESRI software).
vii. download full-resolution photographs (one at a time or in groups)
viii. search for entries associated with tags from a list of key terms
ix. download drawings (where available), mathematical models, and reports for selected building structures
x. compare damage caused by the 2010 Maule Earthquake and the 1985 Valparaiso Earthquake (where applicable)
xi. sort and select relevant information using multiple filters
xii. if available, associate drawings, crack maps, and photographs

Establishing a group of arguments that is sufficient to describe a building structure and its performance during an earthquake is, to say the least, challenging (EERI, 2003). But much has been done towards the definition of a manageable set of arguments describing a wide range of building structures (GEM 2011). In the case of Chile, the vast majority of engineered buildings have reinforced concrete structures. The developed database concentrates on such structures, which allowed for a dramatic reduction in the number of arguments needed to describe each structure.

A total of 121 "fields" or "terms"[2] were identified to describe the ground motion, the structure, and the response of the structure to the ground motion. They range from peak ground velocity to ratio of total cross-sectional area of walls to typical floor area (see appendix). The arguments selected are unlikely to be a complete list of relevant parameters. Rather, they are a compromise between the need for detailed information and the resources available today for data collection. It is hoped that the publication of this list of parameters will generate the debate that should take place within the profession to arrive at a better solution.

The data are organized in five tables. In each table, information (numerical values or paths to binary files) is stored in text (ASCII) format. This format was chosen to ensure longevity: ASCII format has proven to be one of the most commonly used and lasting formats for character encoding. Entries are separated by commas to allow the use of spaces within each entry. A "parser" extracts data from the tables and stores it in the database (which is managed using an open-source system called MySQL[3]).

Tables:

Buildings Data Table: Contains information on the geometric and structural properties of the buildings.

Earthquake Damage Data Table: Contains information on the damage caused in each building by a particular earthquake. This information includes: photos, crack maps (where available), a damage ranking,[4] and information on the usability of the structure after the earthquake.

Earthquake Information Table: This table describes the location and time of each of the earthquakes considered (Valparaiso, Chile, 1985 and Maule, Chile, 2010 in the case of the described database) and, for larger databases, should be expanded to include detailed information about magnitude and the seismic source.

Station Data Table: This table stores the records obtained at strong-motion stations operating in Chile in 1985 and 2010. Key information is given for each station including type of soil –if known-, peak

[2] A field refers to an entry in the database. Entries store different types of data ranging from numbers to groups of files in binary format.
[3] http://www.mysql.com/
[4] See Fields 75 and 76 in Appendix

ground acceleration (PGA), peak ground velocity (PGV), network, coordinates, location within housing structure –if applicable,- and orientation.

Data Sources Table: This table lists the sources (references and individuals) who provided the information in the database.

The directory structure used to archive the data is shown in Figure 1. The directory structure shown in Figure 1 provides essential information about each file (metadata) and follows the following format:

Numerical-analysis files
<building ID>
<source ID>
Drawings
<building ID>
<source ID>
General files
<building ID>
<source ID>
Ground motion records
Maule.Chile.2010
<station ID>
<source ID>
Valparaiso.Chile.1985
<station ID>
<source ID>
Photos
Maule.Chile.2010
<building ID>
<source ID>
Valparaiso.Chile.1985
<building ID>
<source ID>

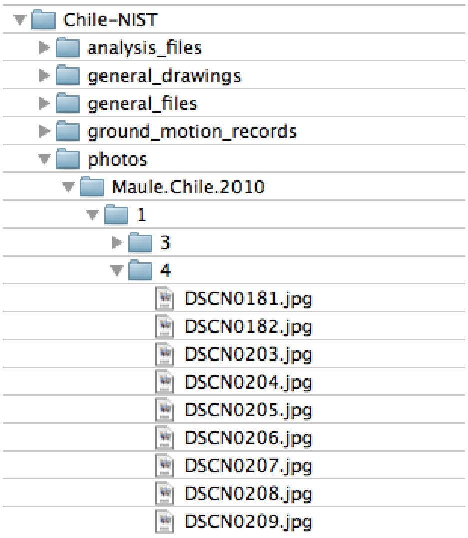


Fig. 1 Directory Structure

## CREDITS

A key to the success of a central data repository is to provide adequate credit to the contributors of information. This is being done by:

-embedding the name of the author in file names and file "headers."
-including a field in the database to specify sources
-providing readily available and complete citation information

## INFORMATION ABOUT THE FILES IN THE DATABASE: "METADATA"

The bulk of the data consists of photographs (more than 20,000). To make this information accessible, each photograph was described with keywords (also called tags). The tags used in this process are listed in Table 1. This list is also a compromise. Tagging of photos, at this point, has not been automated and is, therefore, costly and time consuming.

Tags (or keywords) were inserted into the "headers" of the photographic files. The tags are displayed in the system by a "photo gallery" (Figure 2) that also allows the user to locate the points where photographs were taken using interactive maps (Figure 3).

Table 1 Tags (Keywords)

| Keyword Number | Keyword (or Tag) |
|---|---|
| 1 | Building |
| 2 | Building Elevation |
| 3 | Surroundings |
| 4 | Nonstructural |
| 5 | Reinforced Concrete |
| 6 | Precast Concrete |
| 7 | Steel |
| 8 | Wood |
| 9 | Masonry |
| 10 | Coupling Beam |
| 11 | Truss |
| 12 | Column |
| 13 | Wall |
| 14 | Slab |
| 15 | Beam |
| 16 | Stairs |
| 17 | Boundary Zone |
| 18 | Tie |
| 19 | Bar Splice |
| 20 | Discontinuous Bar |
| 21 | Wall Buckling |
| 22 | Bar Buckling |
| 23 | Bar Fracture |

In addition, and to ensure correct use of the information in the database, the headers of all photographic files were also modified to include name of photographer, building name, building coordinates, address, and earthquake name/date. A customized "processor" was written for this purpose. The processor uses the location of the file in the directory structure described to determine information about the building (name, ID, address, and coordinates) and the photographer. The specifics about the photographer are stored in the sources spreadsheet. Any standard file browser can be used to access photo headers after download.

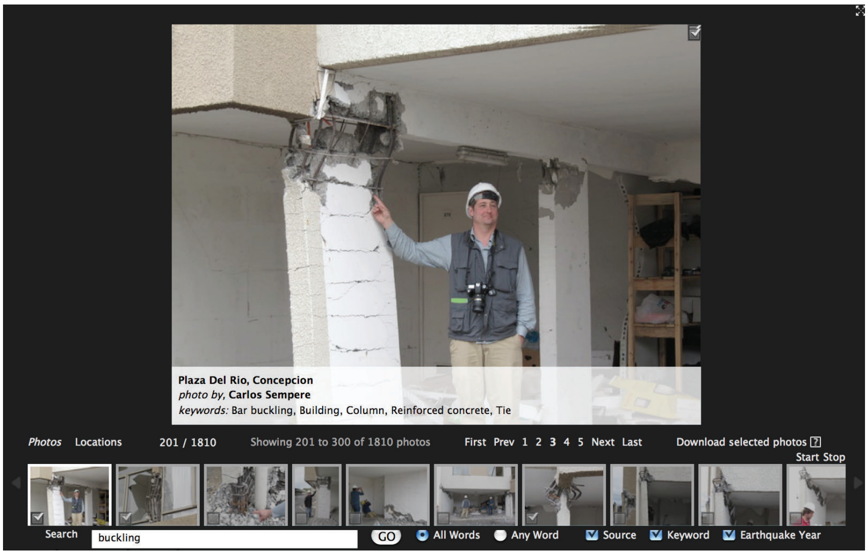


Fig. 2 Photo Gallery

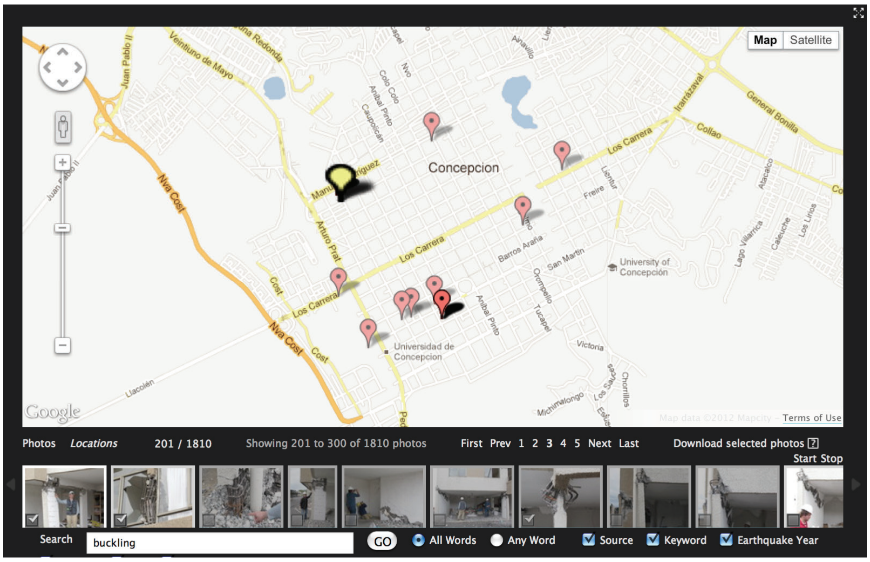


Fig. 3 Interactive Map

Information on files other than photographs is added to the database based on the location of each file in the directory structure (which defines building name, source, and type of file)

## RELEASE AND CONTENTS

It is expected that the database will include more than 20,000 photographs and information for more than 200 buildings. A flexible web-based interface allowing for on-line study of these photographs in addition to maps, photographs, drawings, earthquake records, and other documents was created and will be made public at http://nees.org/resources/databases and a separate website to be maintained by NIST.

Detailed structural drawings were obtained for 13 structures. General drawings showing the layout of structural walls and essential dimensions were obtained for 121 structures. Input files for numerical simulation were obtained for 6 structures. Detailed crack maps were obtained for 7 structures.
At least from Concepción, more information was obtained for damaged structures than for undamaged structures. Understandably, the structures with damage attracted the attention of more researchers than their undamaged counterparts. Nevertheless, it seems information from the latter would have enriched the database as it can be used to test hypotheses about the causes of the failures.

## CONCLUSIONS

The profession needs to coordinate efforts to surpass legal and logistical challenges associated with the collection of information about buildings. This note describes a system that was inspired by the works of Shiga, Shibata, and Riddell. It was used to classify and preserve information collected during and after the Maule, Chile, Earthquake of 2010. The system will be made public at nees.org/resources/databases and will allow its users to explore more than 20,000 photographs and quantitative information for over 200 buildings. It is hoped that the system will spark new research on building performance and initiatives to prepare better repositories for future earthquakes.

## ACKNOWLEDGMENTS

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Penn State University
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Degenkolb Consulting Structural Engineers
Chilean Researcher Patricio Bonelli
BFP Engineers Inc.

The code behind the interface that allows easy exploration of the database and all matters related to the computer- and information-technology aspects of the project were skillfully produced and managed by employees of Purdue's Rosen Center for Advanced Computing under the dedicated guidance of Ann Christine Catlin.

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## APPENDIX

The following is a list of fields (or attributes) that have been identified as relevant parameters to organize and classify field observations on the response of reinforced concrete building structures to strong ground motion.

Field numbers identified with an asterisk are deemed essential.

*Italicized fields are related to a single earthquake.*

| Field Number | Field / Attribute<br><br>Definition of Field/Attribute<br>*Notes about Field/Attribute |
|---|---|
| | **General Building and Site Information** |
| 1* | Structure ID<br><br>Unique identification number assigned to the building |
| 2 | Building Name<br><br>Name displayed on building façade or building drawings |
| 3 | Owner Information<br><br>Information about the owner of the building |
| 4 | Date or Range of Original Construction<br><br>Year or decade (if year unknown) when the construction of the building was completed (e.g. 1985 or 1980s) |
| 5 | Occupancy<br><br>The purpose for which the building was being used at the time of the earthquake(s).<br><br>List of occupancy categories used (adopted from ATC-38). |

1. Apartment
2. Auto Repair
3. Church
4. Dwelling
5. Data Center
6. Garage
7. Gas Station
8. Government
9. Hospital
10. Hotel
11. Manufacturing
12. Office
13. Restaurant
14. Retail

15. School
16. Theater
17. Utility
18. Warehouse
19. Other
20. Unknown
21. Mixed

*Note: Occupancy classification is based on photos, drawings, or reports (when available). Visual evidence is used to classify building occupancy (e.g. buildings with many balconies are classified as apartment or hotel; buildings with kitchens and bedrooms shown in architectural plans are classified as apartments).

6 Development ID

Unique identification number assigned to a group of buildings (i.e. an apartment complex or business park with multiple buildings)

7 Development Name

Name displayed at entrance to complex or on building drawings.

Coordinates*

Approximate GPS (UTM) coordinates and elevation of the centroid of a building roof a plan (as portrayed by areal images).

8* Latitude [decimal degrees]

Geographic coordinate specifying location relative to The Equator.

9* Longitude [decimal degrees]

Geographic coordinate specifying location relative to The Prime (or Greenwich) Meridian.

10 Elevation [m]

Approximate vertical distance to mean sea level.

Address
11* Street Name (required only if no coordinates are available)
12* Street Number (required only if no coordinates are available)
13* City Name
14* Postal Code (required only if no City name is available)
15 Soil Type Class at Building Site

Site classification as described in Chapter 20 of ASCE 7-10 (Type A, B, C, D, or F)

16 Soil Type Class (Chilean Standard) at Building Site

Soil type identified in forensic reports or design documents (if available) and described using the Chilean Standard (NCh433-96).

17 Building Site Description

Geologic description of the site on which the building is located as reported by the source specified in the next field.

18 Source of Site Description

The source of the geologic site description provided in the previous field (e.g. geologic map)

*19 Closest Ground Motion Recording Station ID*

The unique identification number assigned to the strong ground motion recording station that is closest (in terms of straight-line distance) to the building

*20 Distance to Closest Recording Station [km]*

Straight-line distance from the building to the closest strong ground motion recording station

**Building Information on Height and Shape**

21* Total Number of Stories above Ground

*Note: based on drawings, or photos and reports (if drawings are not available). Parking level is counted if it is above ground.

22 Number of Stories below Ground

*Note: based on drawings, or reports (if drawings are not available)

23 Total Floor Area (summation of total horizontal areas of all floors and basements) [m^2]
24 Total Height above Ground [m]
25 First-Story Height [m]
26 Reference Story

The first story with a total height above ground exceeding half the inter-story height or (for buildings with podiums) first story above podium.

*Notes:
“Podium” refers to stories above ground with a larger plan than the stories above them.

For buildings listed in SRS reports No. 532 and 534 (published by The University of Illinois at Urbana Champaign), the reference story coincides with the level reported in those reports as being “the critical story.”

27 Number of Stories above Reference Story + 1
28 Total Floor Area for Reference Story and Stories above [m^2]

Summation of floor area in the reference story and floor areas of all stories above the reference story.

29 Total Height above Reference Story + Height of Reference Story [m]

Total vertical distance from base of reference story to roof.

Directions (Definitions)

*Note: the longitudinal direction of a building is defined here as the direction of the longer side of a rectangle encompassing the entire building plan and the transverse direction is the direction of the shorter side of said rectangle. For buildings listed in SRS reports No. 532 and 534 (published by The University of Illinois at Urbana Champaign), the direction reported here as "the longitudinal direction" coincides with the direction labeled "Y" in the reports. The direction reported here as "the transverse direction" coincides with the direction labeled "X" in the reports.

30 Approximate Azimuth of Longitudinal Building Direction [decimal degrees]

The clockwise angle that the longitudinal direction of the building makes with North direction

31 Approximate Azimuth of Transverse Building Direction [decimal degrees]

The clockwise angle that the transverse direction of the building makes with North direction

32 Typical Plan Shape (R: rectangular, L: L shape, T: T shape, O: Other)

Approximate shape of the building in a plan view

*Note: based on drawings, or aerial images (when drawings not available)

33 Building Aspect Ratio in Longitudinal Direction (above Base of Reference Story)

The ratio of field 29 to field 47

34 Building Aspect Ratio in Transverse Direction (above Base of Reference Story)

The ratio of field 29 to field 48

**<u>Building Structural Properties</u>**

35 Vertical Force-Resisting System

The structural system of the building resisting vertical loads

Vertical Force-Resisting System classification used (adopted from ATC-38):

1. Steel Moment Frame
2. Steel Braced Frame
3. Steel Light Frame
4. Steel Frame w/ Concrete Shear Walls
5. Steel Frame w/ Infill Masonry Shear Walls
6. Concrete Moment Frame
7. *Concrete Shear Walls*
8. *Concrete Moment Frame and Shear Walls*

9. Concrete Frame w/ Infill Masonry Shear Walls
10. Reinforced Masonry Bearing Wall
11. Unreinforced Masonry Bearing Wall
12. Precast/Tiltup Concrete Shear Walls
13. Precast Concrete Frame w/ Concrete Shear Walls
*14. Precast Concrete Frame*
15. Wood Light Frame
16. Commercial or Long-Span Wood Frame
17. Other

*Italicized* building types are additions or changes to the ATC-38 list.

*Note: based on drawings, or photos and reports (when drawings not available). For buildings in SRS Reports No. 532 and 534, the entry reported here coincides with what the reports labeled "framing system."

36 Lateral Force-Resisting System

The structural system of the building expected to resist lateral loads

Lateral Force-Resisting System classification used (adopted from ATC-38):

1. Steel Moment Frame
2. Steel Braced Frame
3. Steel Light Frame
4. Steel Frame w/ Concrete Shear Walls
5. Steel Frame w/ Infill Masonry Shear Walls
6. Concrete Moment Frame
*7. Concrete Shear Walls*
*8. Concrete Moment Frame and Shear Walls*
9. Concrete Frame w/ Infill Masonry Shear Walls
10. Reinforced Masonry Bearing Wall
11. Unreinforced Masonry Bearing Wall
12. Precast/Tiltup Concrete Shear Walls
13. Precast Concrete Frame w/ Concrete Shear Walls
*14. Precast Concrete Frame*
15. Wood Light Frame
16. Commercial or Long-Span Wood Frame
17. Other

*Italicized* building types are additions or changes to the ATC-38 list.

*Note: based on drawings, or photos and reports (when drawings not available). For buildings in SRS Reports No. 532 and 534, the entry reported here coincides with what the reports labeled "framing system."

37 Foundation Type

The structural system that transmits loads from the building to the soil
*Note: based on drawings, or reports (when drawings not available). For buildings in SRS Reports No. 532 and 534 the foundation type was taken directly from the reports.

38 Most Common Type of Partition

Type of non-structural walls separating rooms in a building
List of partitions used (adopted from ATC-38):

1. Gypsum Board
2. Plaster
3. Wood Lath
4. URM
5. Metal
6. Concrete Infill
7. Brick
8. Marble
9. Masonry
10. Other

*Note: For buildings in SRS Reports No. 532 and 534 the partition type was taken directly from the reports.

39 Nominal Concrete Strength [MPa]

The specified compressive strength of concrete cubes or cylinder cast using the same concrete mix that was used to construct the building

40 Nominal Yield Stress of Steel [MPa]

The specified nominal tensile yield stress of samples cut from the same heat(s) of steel that was (were) used to make the reinforcing steel in the building

41 Measured First-Mode Period of Vibration, Longitudinal Direction [s]

The period of vibration of a building primarily in its longitudinal direction as measured using accelerometers

42 Measured First-Mode Period of Vibration, Transverse Direction [s]

The period of vibration of a building primarily in its transverse direction as measured using accelerometers

(for larger database Add comment column to explain type of measurement)

43 Calculated Initial First-Mode Period of Vibration, Longitudinal Direction [s]

The period of vibration primarily in the longitudinal direction computed using a numerical model of the building

44 Calculated Initial First-Mode Period of Vibration, Transverse Direction [s]

The period of vibration primarily in the transverse direction computed using a numerical model of the building

Add comment column to explain assumptions, calculation methodology

45 General Drawings

Structural and/or architectural drawings in digital format

46 Drawing of Typical Floor (above Base of Reference Story)

A structural, or architectural (when structural not available) plan view of the reference story in a building

Typical Floor Dimensions above Reference Story [m]

47 Longitudinal Dimension

Length of longer side of rectangle encompassing the floor plan of the majority of the stories above the reference story

48 Transverse Dimension

Length of shorter side of rectangle encompassing the floor plan of the majority of the stories above the reference story

49 Typical Floor Area above Reference Story [m]

Area of floor plan of the majority of the stories above the reference story

Total Cross-Sectional Wall Area (Ignoring Flanges) for the Reference Story [m^2]

50 Longitudinal Direction

Summation of cross-sectional areas of wall segments oriented in the longitudinal direction of the building (as defined by field 30) in the reference story

51 Transverse Direction

Summation of cross-sectional areas of wall segments oriented in the transverse direction of the building (as defined by field 31) in the reference story

52 Total Cross-Sectional Column Area for the Reference Story [m^2]

Summation of cross-sectional areas of columns in the reference story

Ratio of Total Cross-Sectional Wall Area for Reference Story to Typical Floor Area

53 Longitudinal Direction

Ratio of field 50 to field 49

54 Transverse Direction

Ratio of field 51 to field 49

Ratio of Total Cross-Sectional Wall Area for Reference Story to Total Floor Area of Reference Story and Stories above

55 Longitudinal Direction

Ratio of field 50 to field 28

56 Transverse Direction

Ratio of field 51 to field 28

Aspect Ratio of Dominant Walls

Ratio of Total Wall Height above Base of Reference Story to Wall Length for longest wall in Reference Story

57 Longitudinal Direction
58 Transverse Direction

59 Ratio of Total Cross-Sectional Column Area for Reference Story to Typical Floor Area above Reference Story

Ratio of field 52 to 49

60 Ratio of Total Cross-Sectional Column Area for Reference Story to Total Floor Area of Reference Story and Stories above

Ratio of field 52 to 28

Flags

61 Reinforcement Lap Splices at Base of Structure (0: none, 1: staggered, 2: not staggered)

*Note: based on structural drawings
Base of structure is the base of the first story (e.g. if all the splices in a wall are located in the second story, then “0: none” is reported; if more than 50% the splices are in the first story and the rest are in second story, then “1: staggered” is reported; if all the splices are in the first story but they were not located at the same level in all bars then “1:staggered” is reported; if all the lap splices are in the first story and they are not staggered then “2: not staggered” is reported)

*Note: Lap splices are splices made by overlapping reinforcing bars.

Discontinuities in Elevation

62 Abrupt and significant changes in wall cross section or Discontinuous Flanges in Walls (0: none, 1: present)

The word “reentrant” has been used before to describe discontinuities in slabs and plan views. But the original meaning of the word is not tied to horizontal objects. Here, it is used to refer to a discontinuity in a wall where the length of the wall changes abruptly becoming larger above the corner than below the corner. See Figure A1 for an example of a reentrant corner. In buildings with basements reentrant corners can be located at ground level and are reported in the same way as reentrant corners above ground level are. A discontinuous flange refers to flanges or enlarged boundary elements that are present in one story but not in the story above or the story below.

*Note: based on structural drawings

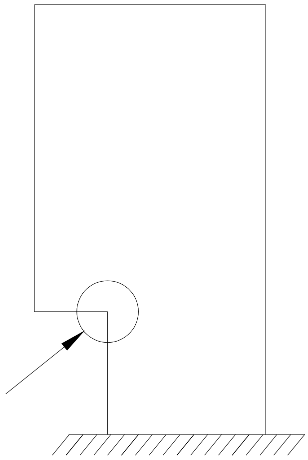

Fig. A1 Example of a reentrant corner

63 Discontinuous Walls (0: none, 1: present)

Walls are reported to be discontinuous if they are present in a story but not in the story below or the story above. Walls present in the basements but not in stories above ground are not reported as discontinuous walls. Walls present in the first story but not in the basements, are reported as discontinuous walls.

*Note: based on structural drawings

64 Walls with T sections (0: none, 1: present)

Structural walls with cross sections resembling the letter T

*Note: based on structural drawings

65 Walls with L sections (0: none, 1: present)

Structural walls with cross sections resembling the letter L

*Note: based on structural drawings

66 Confining Reinforcement in Boundary Elements (0: none, 1: present)

Confining reinforcement is hoop reinforcement placed in boundary elements of structural walls. Buildings having confining reinforcement in the boundary elements of some walls, but not others are classified as having confining reinforcement “1: present.”
*Note: based on structural drawings

**Building Documentation**

67 General Files

Geotechnical Reports, Construction Records, Damage Reports, Videos, or similar files

68* *Photographs (format: JPG)*

69 Main Building Photograph (format: JPG)

Photograph selected to provide as wide a view of the building as possible.

70 Input Files for Structural Analysis Software (each input file is to be associated with a comment containing information on software name and version).

These are files used by structural engineers for numerical analysis of the building response.

**Earthquake Information**

*71** *Earthquake Name (e.g. Maule.Chile.2010 & Valparaiso.Chile.1985)*

Name given by a geological agency to the earthquake

*72** *Earthquake Date (UTC)*

Date and approximate time of occurrence of the earthquake (in Coordinated Universal Time)

**Information about Earthquake Damage****

*73* *Was the building open or closed to public when first inspected? (0: Open, 1: Closed)*

*74* *Tag assigned by local authorities (0: Green, or 1: Yellow –indicating no danger to occupants, 2: Red –indicating danger to occupants)*

*75* *Were clear structural failures or severe damage documented in the available photographs or reports? (0: No, 1: Yes)*

There is no universal definition of structural failure or severe structural damage. The following guidelines were used to label buildings with the flag 1 (yes) in this category:

Reinforcing bars buckled
Cracks in concrete exceeded 0.5 in (approximately 1cm) in width

Because the adopted definition of damage is not universal, a photograph showing what was deemed to be signs of failure or severe damage is provided in the next field.

*76* *Photo showing an example of what was deemed to be severe structural damage (if applicable)*

*77* *Was damage to nonstructural elements documented in the available photographs or reports? (0: No, 1: Yes)*

Nonstructural elements are all the building components not part of the vertical and lateral load resisting systems.

78 *Photo showing an example of what was deemed to be damage to nonstructural elements (if applicable)*

**Ground Motion Recording Station Information**

79* Station ID

Unique identification number assigned to the strong ground motion recording station (accelerometer).

80 Recording Station Name[1]
81 Recording Station Code[1]
82 Recording Station Location[1 2]
83* Latitude of Recording Station[1] [decimal degrees]

Refer to field 8 for a definition of Latitude.

84* Longitude of Recording Station[1] [decimal degrees]

Refer to field 9 for a definition of Latitude.

85 Name of Network Maintaining the Station
*86 Instrument Location (in the structure housing it)*[1]

This entry refers to the story in which the instrument was placed.

*87 Structure Type*

Type of building housing the instrument (accelerometer)

*88 Instrument Type*[1]
*89 Recording Station Site Description*[1]
*90 Azimuth of Instrument, Direction 1*[1]*[decimal degrees]*

Refer to field 30 for a definition of Azimuth.

Note: recording stations usually report accelerations in two perpendicular horizontal directions and the vertical direction. The horizontal directions do not always coincide with the geographic North or East directions.

*91 Azimuth of Instrument, Direction 2*[1] *[decimal degrees]*

Refer to field 30 for a definition of Azimuth.

*92 Maximum Horizontal Peak Ground Acceleration*[1] *[g]*

Absolute maximum of absolute peak recordings in directions 1 and 2 (defined in 90, 91)

*93* *Peak Ground Acceleration in Direction 1[1] [g]*

Absolute maximum recording in direction 1 (defined in 90)

*94* *Peak Ground Acceleration in Direction 2[1] [g]*

Absolute maximum recording in direction 2 (defined in 91)

*95* *Peak Ground Acceleration in Vertical Direction[1] [g]*

Absolute maximum recording in vertical direction

*96* *Maximum Horizontal Peak Ground Velocity[1] [m/s]*

Absolute maximum reported peak ground velocity in directions 1 and 2 (defined in 90, 91)

*97* *Peak Ground Velocity in Direction 1[1] [m/s]*

Absolute maximum of time integrals of recordings in direction 1 (defined in 90)

*98* *Peak Ground Velocity in Direction 2[1] [m/s]*

Absolute maximum of time integral of recordings in direction 2 (defined in 91)

*99* *Ground Acceleration Records from Recording Station[1]*

Text files containing sequence of accelerations measured at a fixed sampling rate

*[1] As reported by entity issuing the record*
*[2] In the case of Chile, this coincides with the name of the city or area where the instrument was located*

**Credits and Comments**

*100** *Full Name(s) of Person(s) Entering Information into Database*
*101** *Full Name(s) of Person(s) contributing Information (Investigators)*
*102* *Investigator Organization (University, Organization, or Company)*
*103* *Reconnaissance Organization (if applicable) (e.g. EERI, ASCE, etc.)*
*104** *Full Citation(s) for any Reports Used*
*105* *Comments (include information on retrofit)*

**Additional Fields for Future, Expanded Database**

106 Roof Type
*107* *Was the structure retrofitted before the earthquake?*
*108* *Earthquake ID*
*109* *Earthquake Time (UTC)*
*110* *Earthquake Time (local)*
*111* *Earthquake Day of Week (Local)*
*112* *Earthquake Magnitude*
*113* *Causative Fault Name*
*114* *Earthquake Fault Rupture Spatial Characteristics*
*Damped Elastic Spectral Acceleration*
*115* *Spectral acceleration at a period of 0.3s.*

| | |
|---|---|
| *116* | *Spectral acceleration at a period of 1s.* |
| *117* | *Spectral acceleration at a period of 3s.* |
| 118 | Reinforcing Steel Production Standard |
| 119 | National Design Standard used for Building |
| 120 | Data about Owner |
| 121 | Presence of Captive Columns |

**<u>Notes</u>**

- * : Required field
- **: at least one field under this category must be provided
- First Story: first story in which more than half the story height is above ground level
- Units: SI
- *Italicized fields are related to a single earthquake.*

## REFERENCES


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