COUPLING POST-EARTHQUAKE BUILDING DAMAGE DATA COLLECTION WITH THE INTERNATIONAL MACROSEISMIC SCALE (IMS)

Al Mouayed Bellah Nafeh, Vitor Silva, Ayse Hortecsu, and David J. Wald

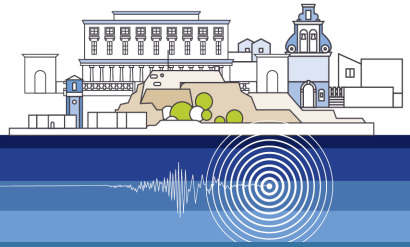
39th GENERAL ASSEMBLY OF THE EUROPEAN SEISMOLOGICAL COMMISSION
ESC2024
22-27 September 2024
CORFU, GREECE



GLOBAL EARTHQUAKE MODEL working together to assess risk

Introduction

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Introduction

Motivation

- Extend the **European Macroseismic Scale** (EMS–98) for global outreach and coverage
- Provide a **standard scale** for international use, reducing the need for inter-scale conversions

Key Principles

- The internal consistency with EMS–98 must be preserved
- The scale must remain robust and simple to use

Introduction



Part One – The International Macroseismic Scale (The "Core Scale"

- *Definition of building and vulnerability classes*
- *Definition of "observations" and quantity*
- *Definition of intensity degrees and scale arrangment*



Part Two – Guidelines

- *Intensity assignments*
- *Usage of intensity*
- *Buildings, damage and vulnerability*
- *Assessing intensity from historical records*

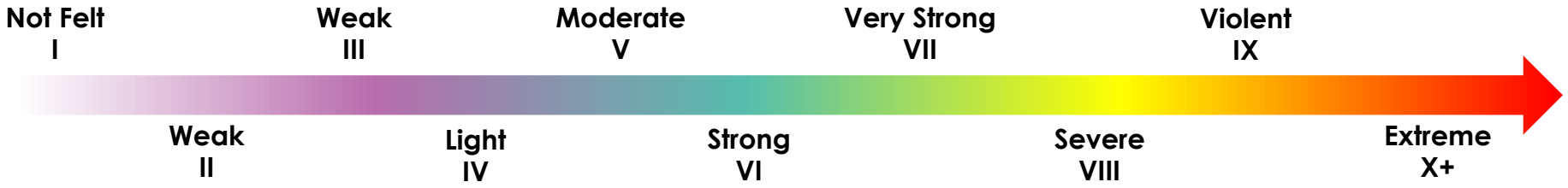


Annexes

- *Annex A: Photograhic illustrations of buildings and damage*
- *Annex B: Earthquake-resistant design*
- *Short-form of IMS-24*

Introduction

- **Intensity** corresponds to the classification of the **severity** of the ground-shaking based on **observed effects** in a limited area
- The primary objective of an intensity scale is to effectively compress a verbose description of earthquake **effects** into a single symbol (usually a number)



Introduction

- Effects (or **diagnostics**) of different degrees of earthquake shaking on a number of elements (or **sensors**) that may be found in an everyday environment
  - **Living things (e.g., people and animals)**



Introduction

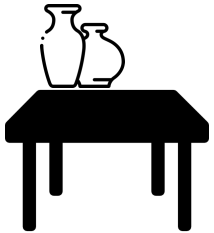
- Effects (or **diagnostics**) of different degrees of earthquake shaking on a number of elements (or **sensors**) that may be found in an everyday environment
  - **Living things (e.g., people and animals):** As intensity increases, a greater proportion of people or animals (a) notice the shaking, and (b) are frightened by it



Introduction

- Effects (or **diagnostics**) of different degrees of earthquake shaking on a number of elements (or **sensors**) that may be found in an everyday environment
  - **Living things (e.g., people and animals)**
  - **Ordinary objects**





Introduction

- Effects (or **diagnostics**) of different degrees of earthquake shaking on a number of elements (or **sensors**) that may be found in an everyday environment
  - **Living things (e.g., people and animals)**
  - **Ordinary objects:** As intensity increases, greater numbers of ordinary domestic items (such as glassware, books, or objects on shelves) begin to shake and are thrown down

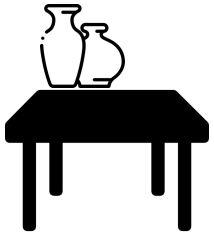




Introduction

- Effects (or **diagnostics**) of different degrees of earthquake shaking on a number of elements (or **sensors**) that may be found in an everyday environment
  - **Living things (e.g., people and animals)**
  - **Ordinary objects**
  - **The natural environment**







Introduction

- Effects (or **diagnostics**) of different degrees of earthquake shaking on a number of elements (or **sensors**) that may be found in an everyday environment
  - **Living things (e.g., people and animals)**
  - **Ordinary objects**
  - **The natural environment:** As intensity increases, there is an increasing likelihood of effects such as liquefaction, cracks in embankments, and landslides and rockfalls

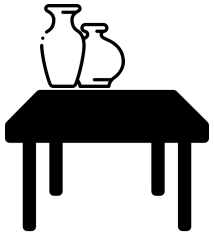






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  - **Living things (e.g., people and animals)**
  - **Ordinary objects**
  - **The natural environment**
  - **Buildings**



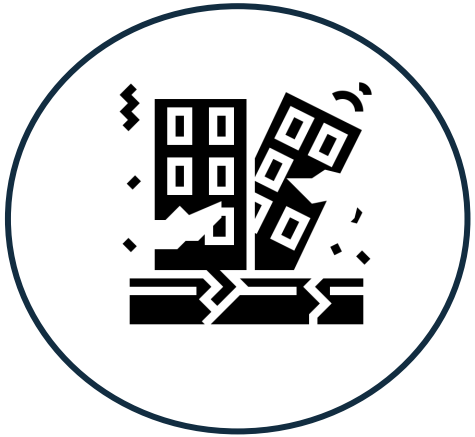
Introduction

- Effects (or **diagnostics**) of different degrees of earthquake shaking on a number of elements (or **sensors**) that may be found in an everyday environment
  - **Living things (e.g., people and animals)**
  - **Ordinary objects**
  - **The natural environment**
  - **Buildings:** As intensity increases, buildings become progressively more severely damaged









International Macroseismic Scale: Extensions to EMS-98

- **Additional building types**
  - Dual systems (e.g., RC wall-frame dual systems, RC concrete-masonry dual systems, RC frames with masonry infills)
  - Precast concrete buildings
  - Adobe building types subdivision
  - Timber building types addition

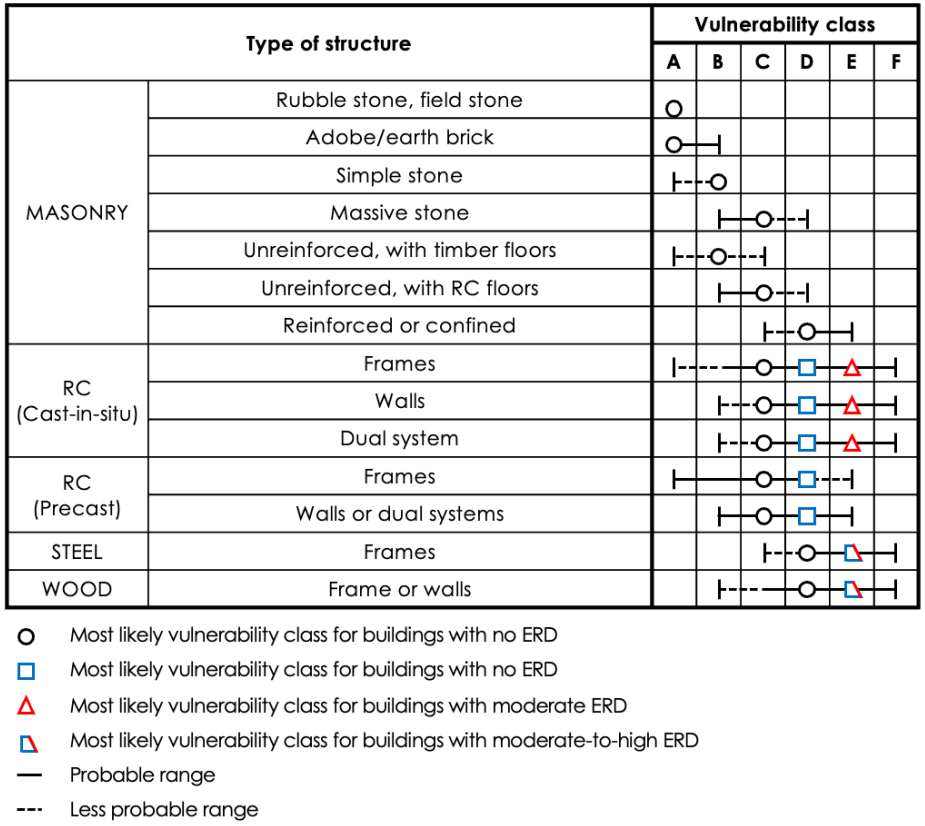






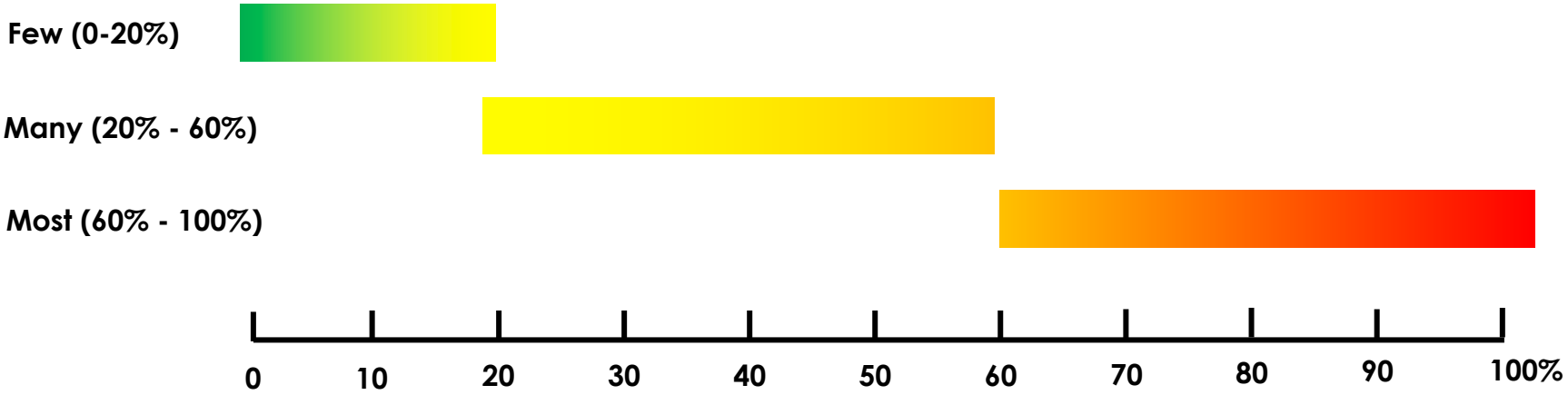
International Macroseismic Scale: Extensions to EMS-98

- **Refinement of the vulnerability table**
  - Refinement of RC frame and wall structures based on number of storeys
  - Refinement of steel structures through earthquake-resistant design level distinction
  - Subdivision of timber structures into distinct categories
  - Vulnerability class (**VC**) refinements based on number of storeys or by building height
  - Improvements of "most likely" values for masonry and RC buildings
  - Regional modifiers



International Macroseismic Scale: Extensions to EMS-98

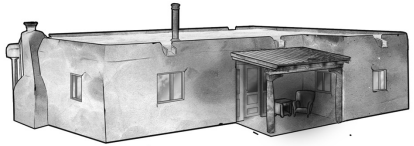
- **Description of damage grades**
  - Improvement of damage grade (**DGs**) descriptions for RC frames with shear failures
  - Introduction of quantitative terms ("few", "many", "most") to provide a statistical element to the scale



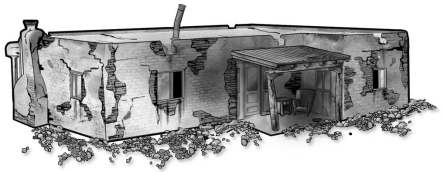
  - Wider damage grade descriptions for building types in terms of structural and non-structural components

International Macroseismic Scale: Extensions to EMS-98

- **Description of damage grades (Adobe)**



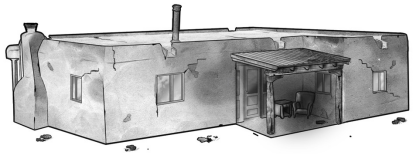
Negligible to slight damage
no structural damage,
slight nonstructural damage



Substantial to heavy damage
moderate structural damage,
heavy nonstructural damage



Destruction
very heavy structural damage,
collapse



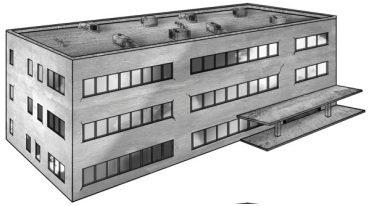
Moderate damage
slight structural damage,
moderate nonstructural
damage



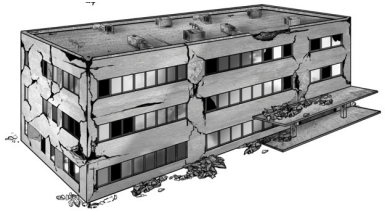
Very Heavy Damage
heavy structural damage,
very heavy nonstructural
damage

International Macroseismic Scale: Extensions to EMS-98

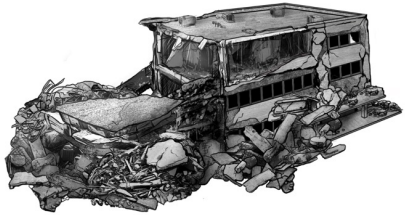
- **Description of damage grades (Reinforced Concrete)**



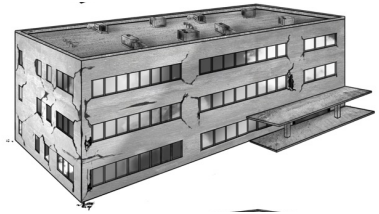
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no structural damage,
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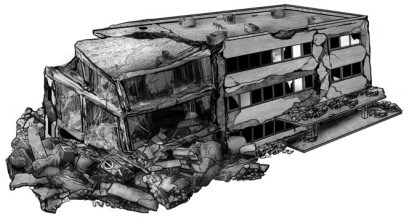
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Moderate damage
slight structural damage,
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Very Heavy Damage
heavy structural damage,
very heavy nonstructural
damage

International Macroseismic Scale: Extensions to EMS-98

- **Description of damage grades (Masonry)**



Negligible to slight damage
no structural damage,
slight nonstructural damage



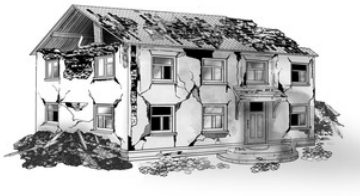
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heavy nonstructural damage



Destruction
very heavy structural damage,
collapse



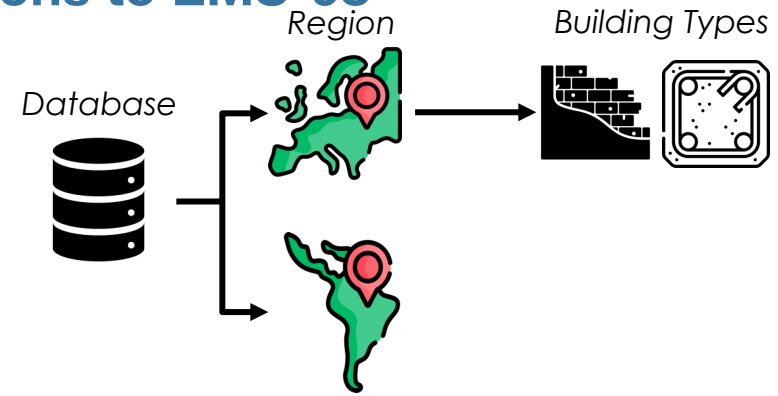
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slight structural damage,
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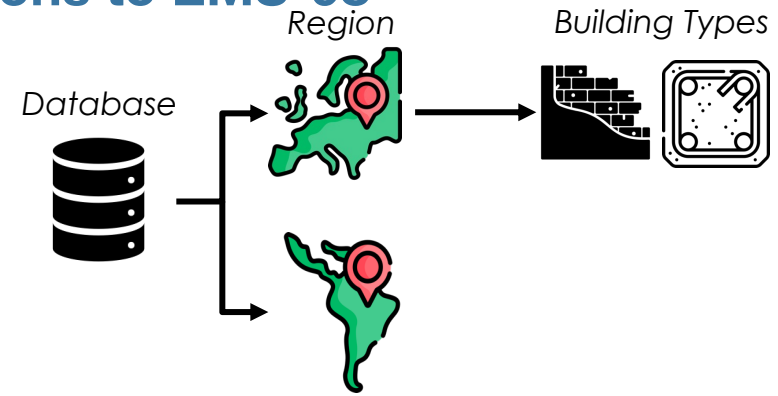
International Macroseismic Scale: Extensions to EMS-98

- **Recommendations for Simplifying Field Work**
  - Compilation of a database with predominant building types for each region

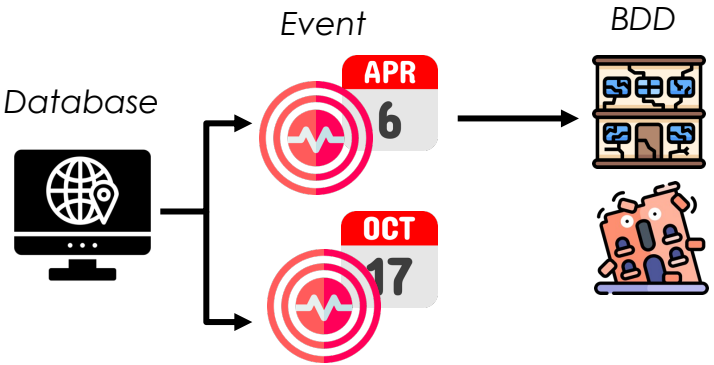


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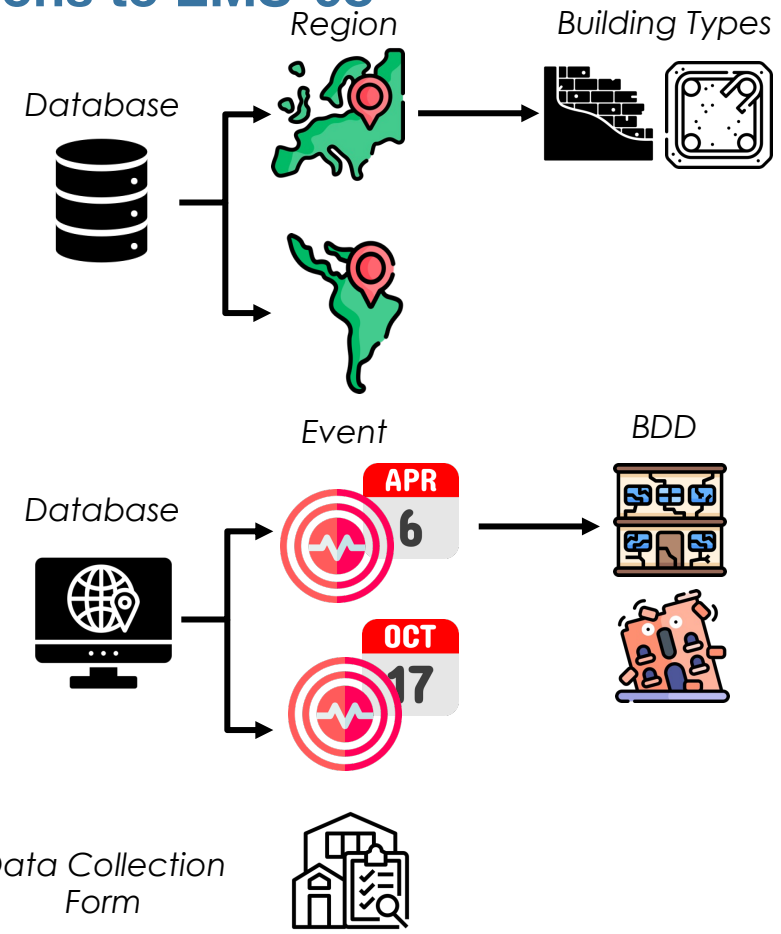


  - Use of geographical information system (GIS) databases of building stock of earthquake-affected or building damage data (**BDD**) areas to simplify the field work



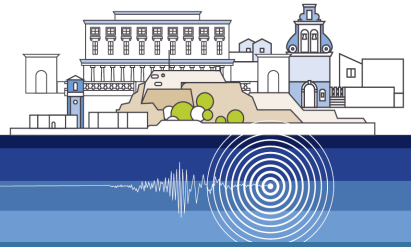
International Macroseismic Scale: Extensions to EMS-98

- **Recommendations for Simplifying Field Work**
  - Compilation of a database with predominant building types for each region
  - Use of geographical information system (GIS) databases of building stock of earthquake-affected or building damage data (**BDD**) areas to simplify the field work
  - Harmonised data collection forms for the calculation of quantities and intensities



Challenges in BDD Collection

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Regional Construction Practices

Reinforced or confined, with RC floors

Perú



Colombia

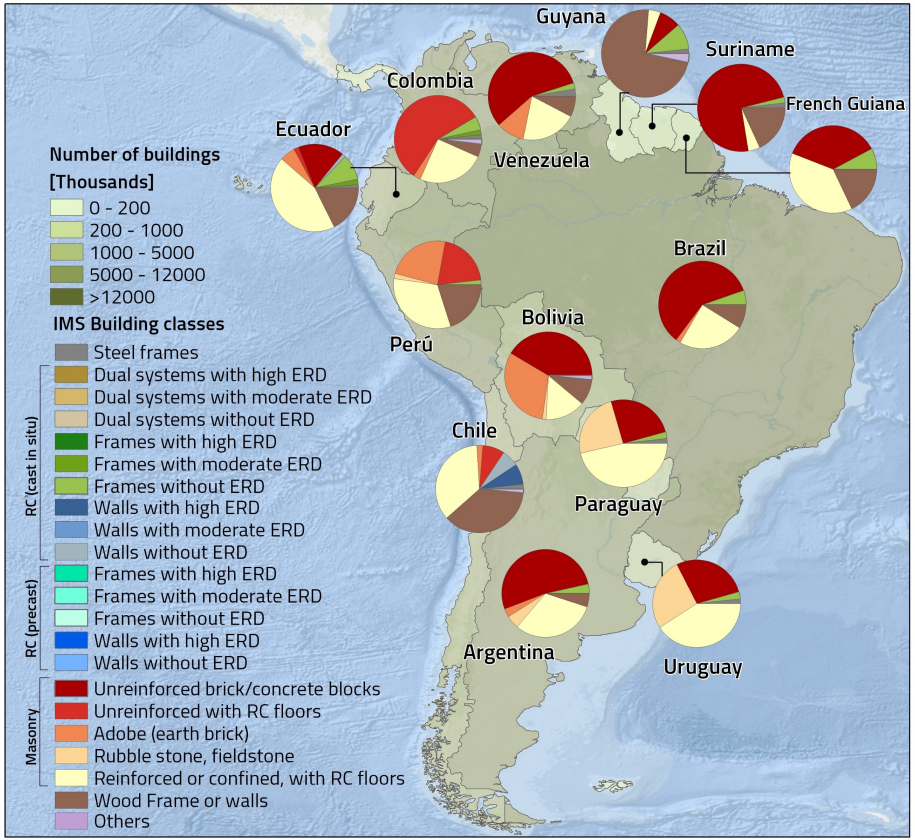


Bolivia



Colombia





Regional Construction Practices

Wood Frame or walls

Brazil



Colombia

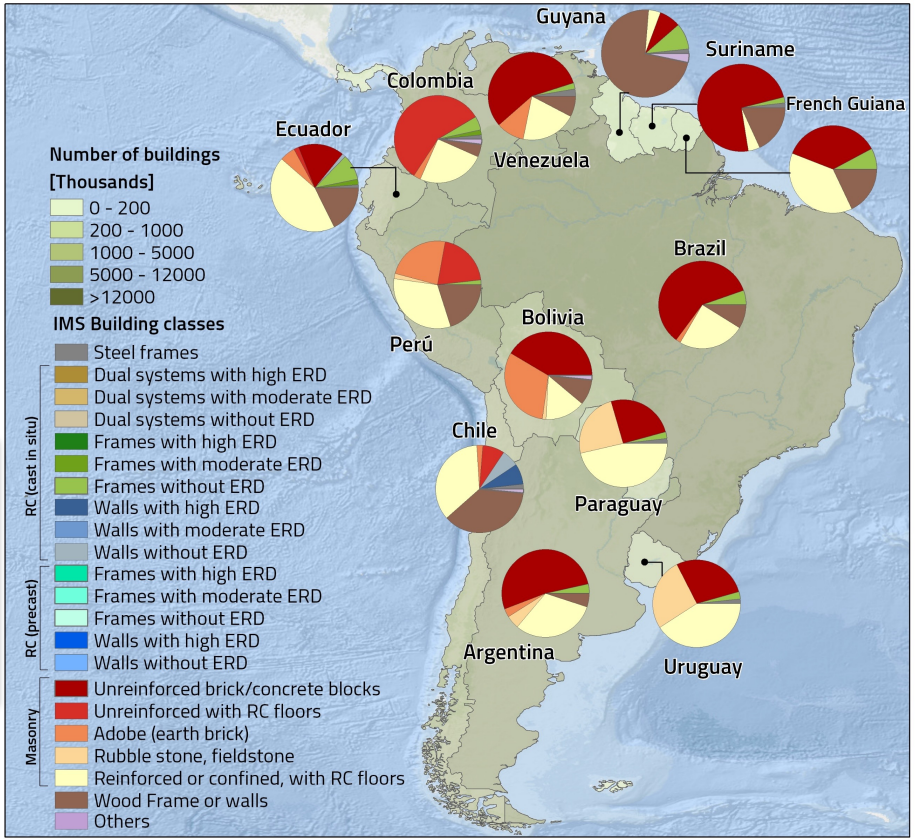


Chile



French Guiana





Regional Construction Practices

Frames without ERD

Colombia



Venezuela



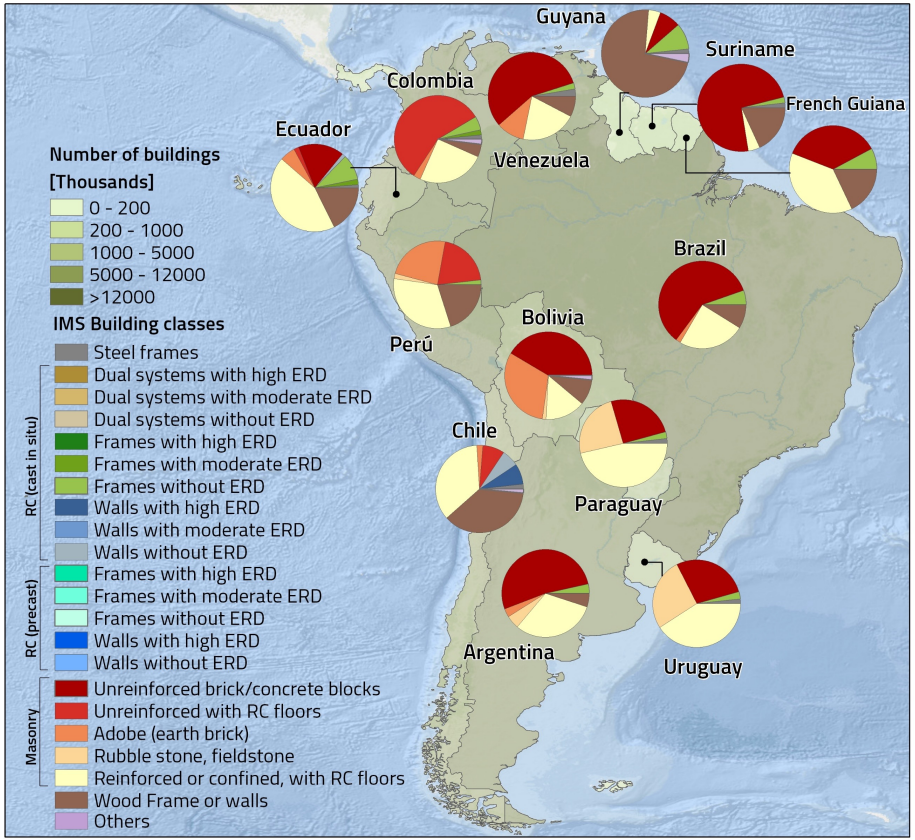
Frames with high ERD
Frames with moderate ERD

Colombia



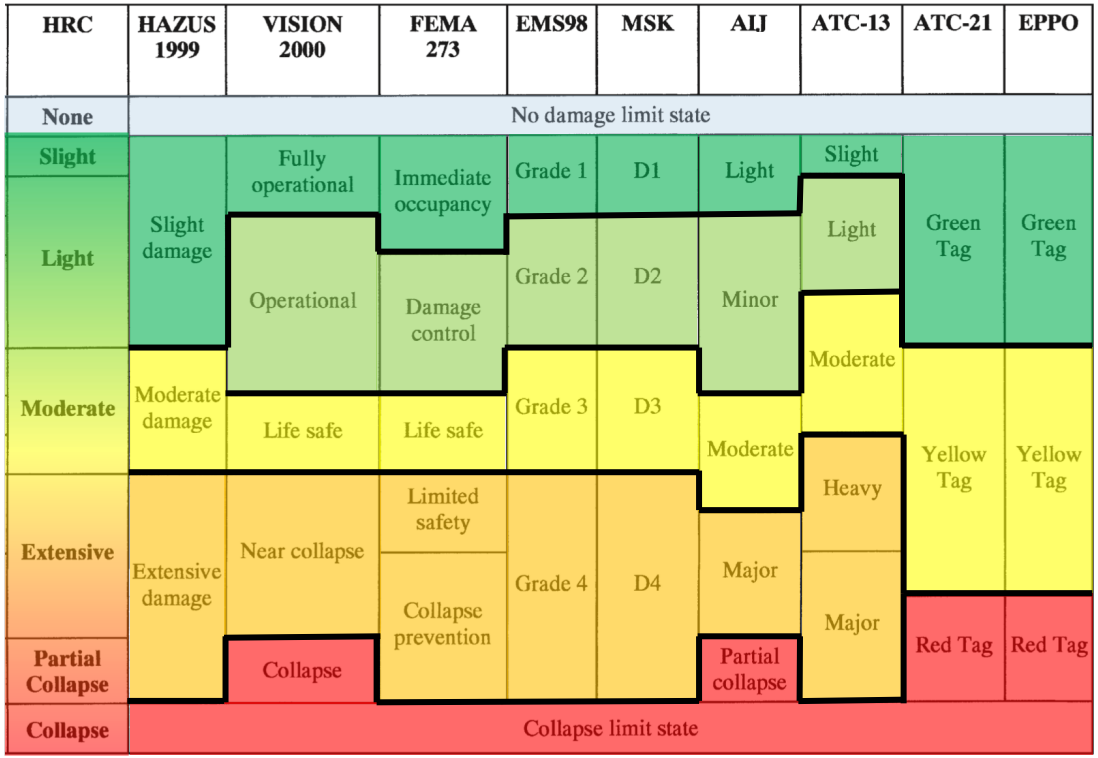
Ecuador





Non-Uniformity of Damage Scales

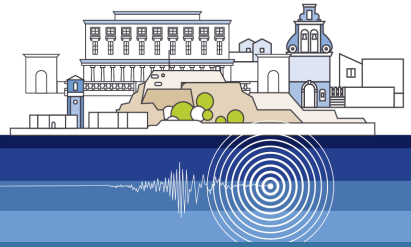
- Post-earthquake building classification into different states allows for a more nuanced understanding of structural performance
- Without a standardized scale, different engineers or observers might classify the same damage differently, leading to inconsistent and unreliable data.
- A common scale allows for comparison between different post-earthquake scenarios and helps in benchmarking damage levels.
- A uniform scale ensures that damage assessments are consistent across different regions, earthquakes, and structures and reduces the implications on empirical fragility



Rosetto & El-Nashai 2003

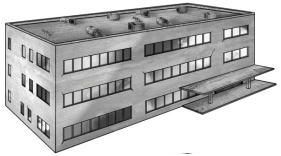
Coupling Visual Inspections with Databases for Enhanced Earthquake Damage Assessment

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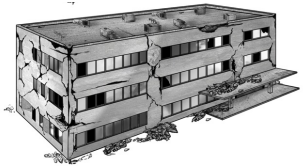


Enhanced Post-Earthquake Building Damage Data Collection

- Following an EQ event, the **DGs** assigned to building types is a combination of:
  - Observed damage sustained by **structural components**
  - Observed damage sustained by **nonstructural components**



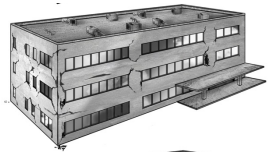
Negligible to slight damage
no **structural** damage,
slight **nonstructural** damage



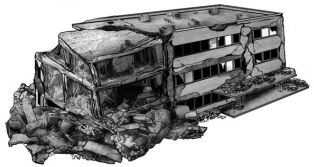
Substantial to heavy damage
moderate **structural** damage,
heavy **nonstructural** damage



Destruction
very heavy **structural damage**,
collapse



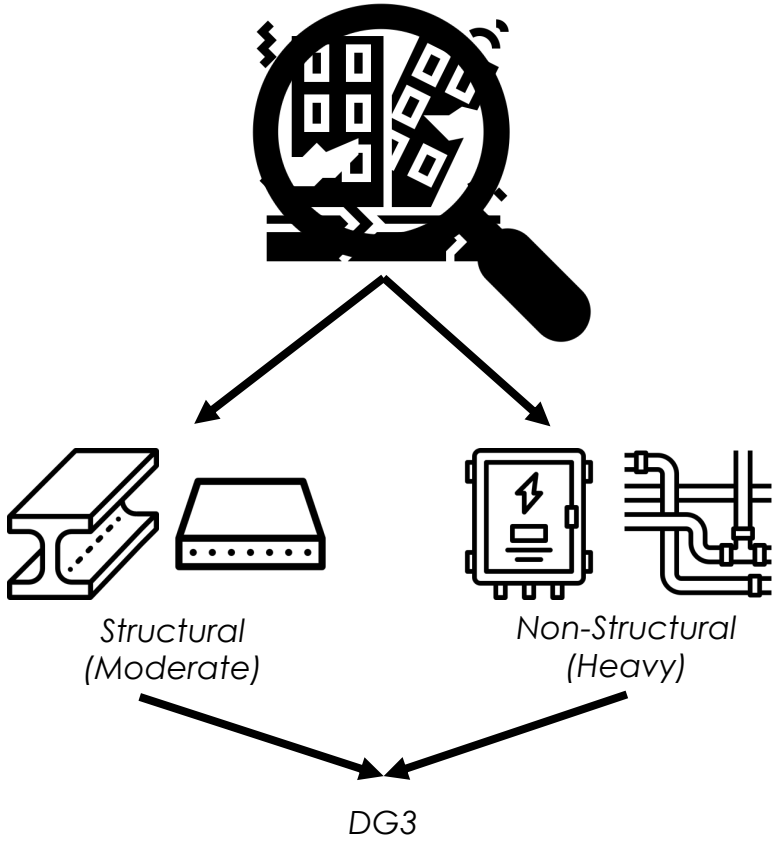
Moderate damage
slight **structural** damage,
moderate **nonstructural** damage



Very Heavy Damage
heavy **structural** damage,
very heavy **nonstructural** damage

Enhanced Post-Earthquake Building Damage Data Collection

- Structural components are elements whose **stability is essential to maintain life-safety**
- Nonstructural components are elements whose integrity **ensures (or not) the functionality of a building class**
- **The variation in the extent of damage** between the two components requires a building class to be thouroughly inspected and thus graded accordingly



Enhanced Post-Earthquake Building Damage Data Collection

- Enhancing the Data Collection Process to ensure consistency and comparability of damage assessments across regions
  - Utilizing Building Class and Damage Databases:

    Databases containing **building class photos** and **pre-categorized damage examples** can significantly improve inspection consistency.

    These databases serve as **reference tools** to facilitate the identification of **building types** (e.g., masonry, steel-frame, wood-frame structures) and specific **damage patterns** associated with different building types
  - Revisiting existing protocols and post-earthquake rapid evaluation forms

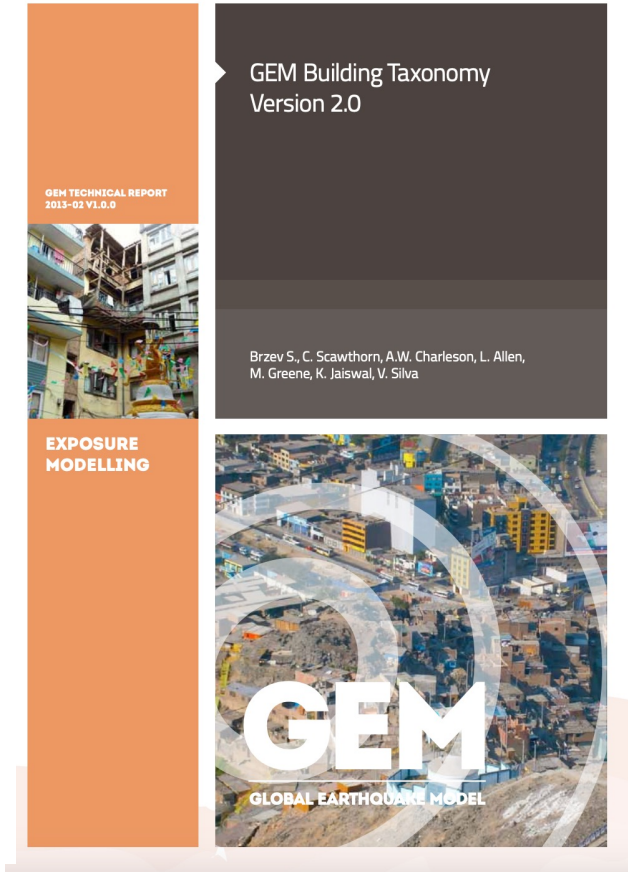
    The ATC-20 Building Safety Tagging Inspection form or AeDES NGDT Building Form is widely used for post-disaster building safety evaluations.

    Minor modifications will enable better mapping of building types to IMS VCs and DGs

GEM Building Taxonomy

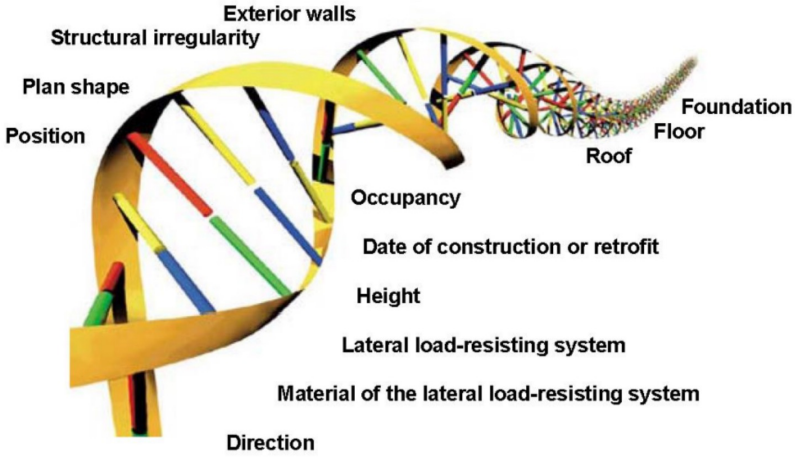
- The GEM Building Taxonomy (currently at v3.2) was developed originally in 2012
- The purpose of the GEM Building Taxonomy is to describe and classify buildings in a uniform manner and relevant to seismic performance of different construction types

Scan me to access database



GEM Building Taxonomy

- The taxonomy is organized as a series of expandable tables, which contain information pertaining to various building attributes and occupancies



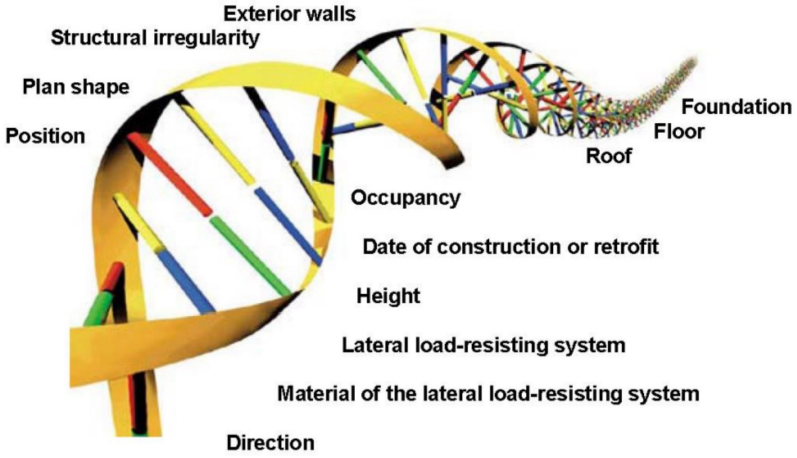


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DXP/

Direction



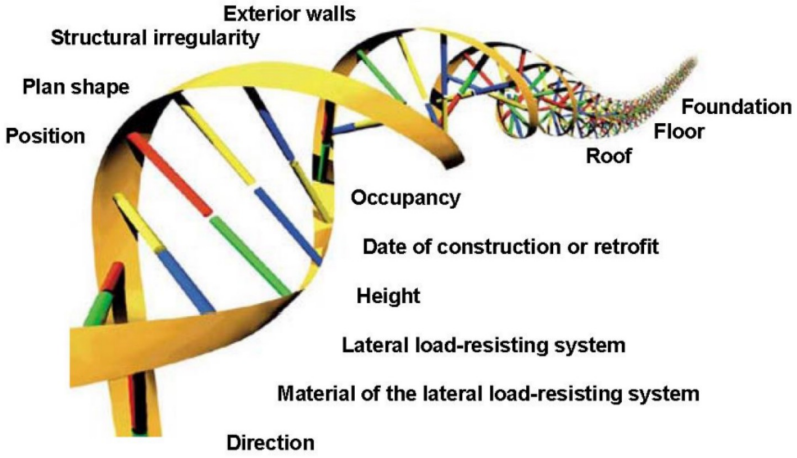


GEM Building Taxonomy

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DXP/MUR/

Material



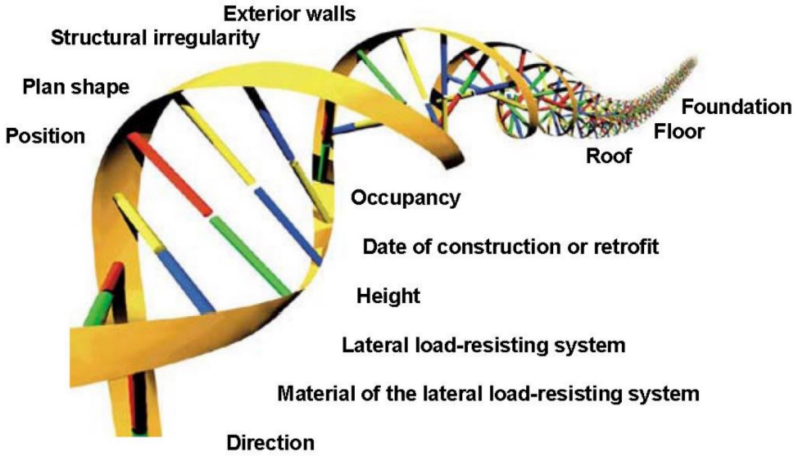


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DXP/MUR/LWAL+CDN+DNO/

Lateral load-resisting system



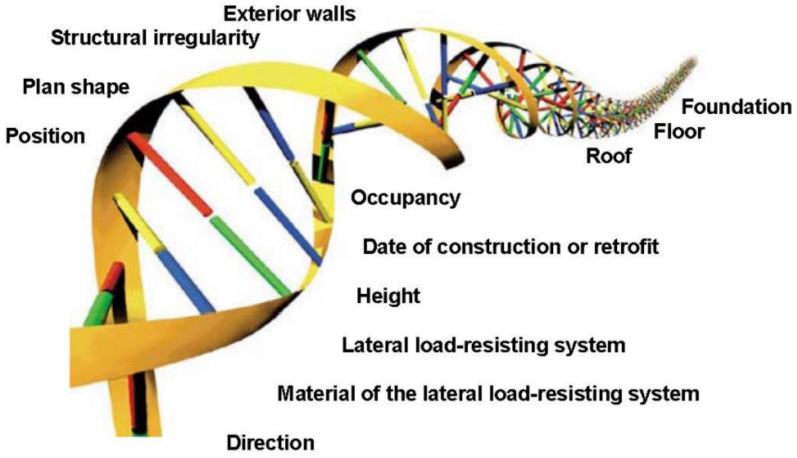


GEM Building Taxonomy

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DXP/MUR/LWAL+CDN+DNO/H1/

Height



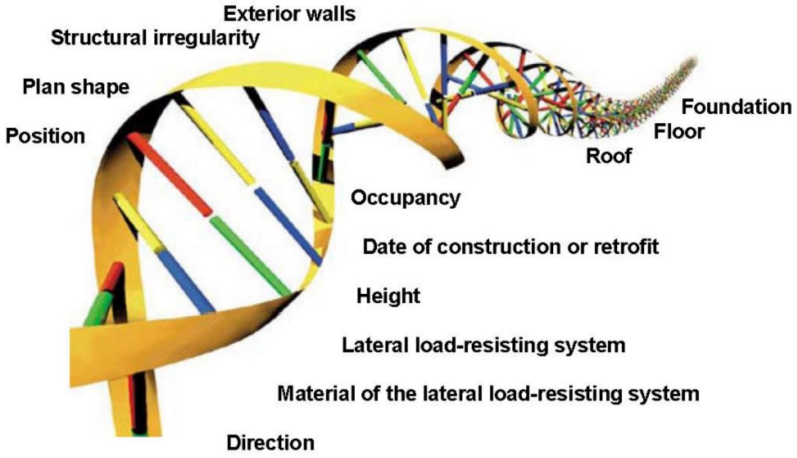


GEM Building Taxonomy

- The taxonomy is organized as a series of expandable tables, which contain information pertaining to various building attributes and occupancies

DXP/MUR/LWAL+CDN+DNO/H1/Y1944/

Year of construction (or retrofit)



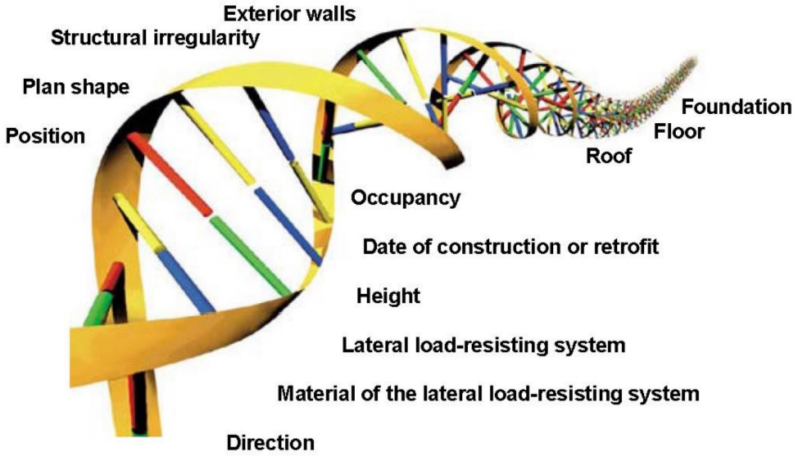


GEM Building Taxonomy

- The taxonomy is organized as a series of expandable tables, which contain information pertaining to various building attributes and occupancies

DXP/MUR/LWAL+CDN+DNO/H1/Y1944/RES/

Occupancy



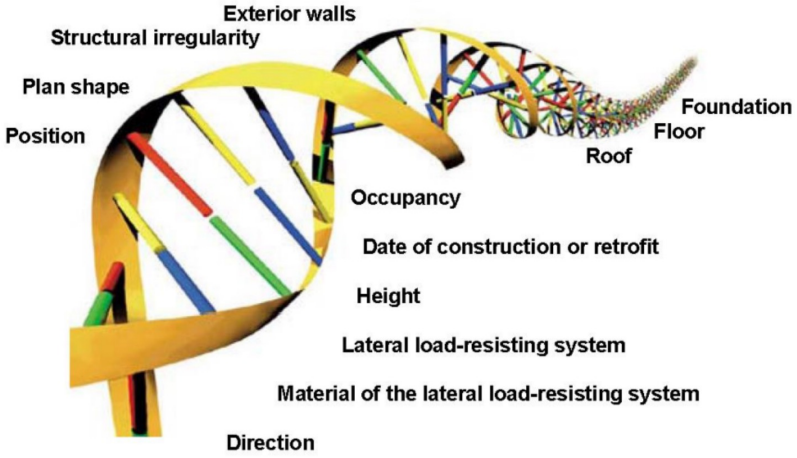


GEM Building Taxonomy

- The taxonomy is organized as a series of expandable tables, which contain information pertaining to various building attributes and occupancies

DXP/MUR/LWAL+CDN+DNO/H1/Y1944/RES/BP1/

Shape of the building plan



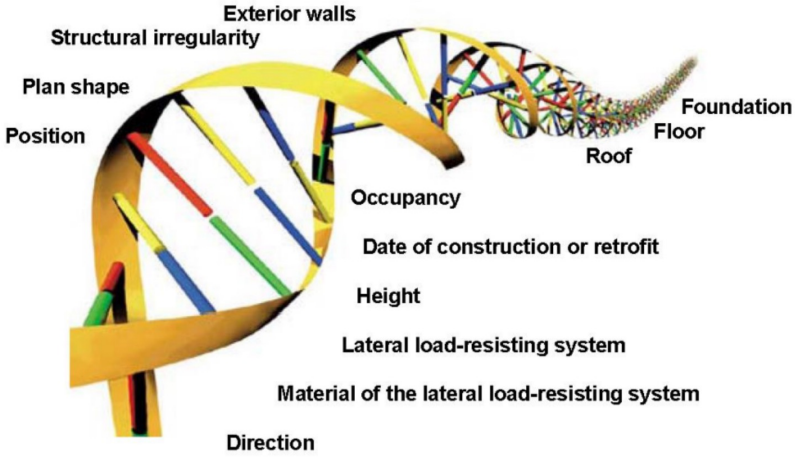


GEM Building Taxonomy

- The taxonomy is organized as a series of expandable tables, which contain information pertaining to various building attributes and occupancies

DXP/MUR/LWAL+CDN+DNO/H1/Y1944/RES/BP1/REC/…

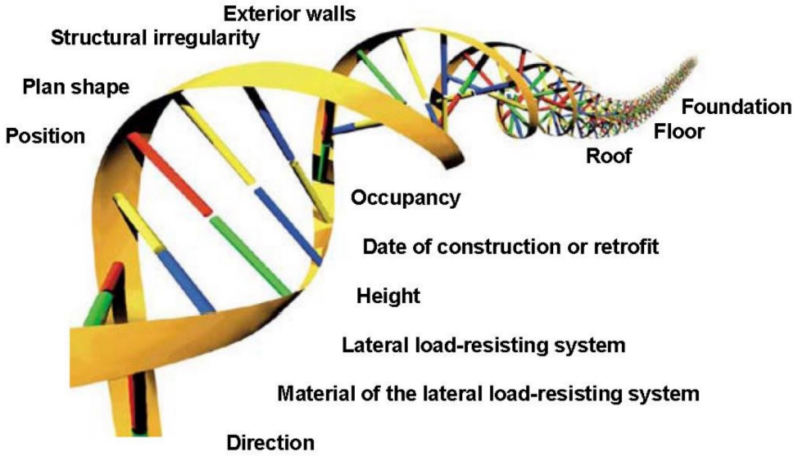
Structural irregularities





GEM Building Taxonomy

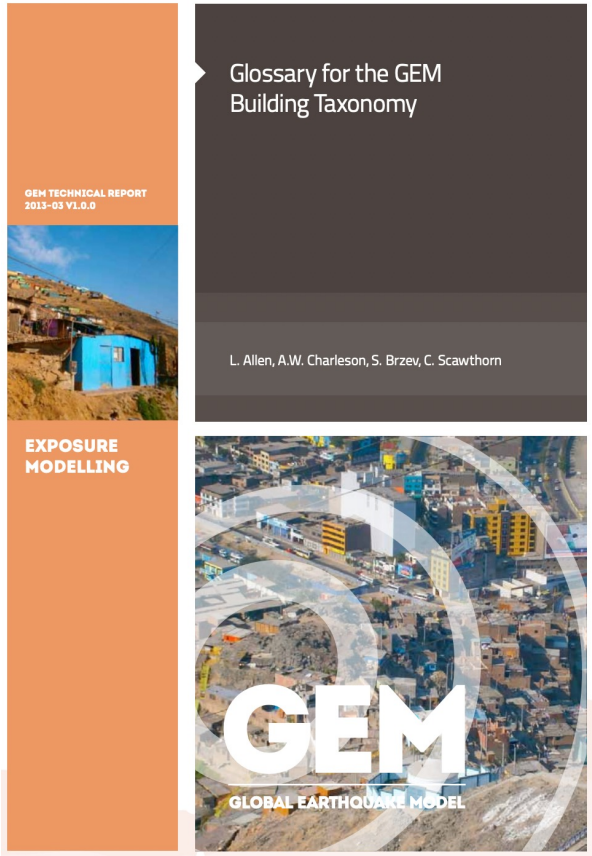
- For example, the global vulnerability model of GEM contains a comprehensive set of functions associated with 1400+ building types derived using the GEM Taxonomy
- The Building Taxonomy is accompanied by supplementary resources





GEM Building Glossary

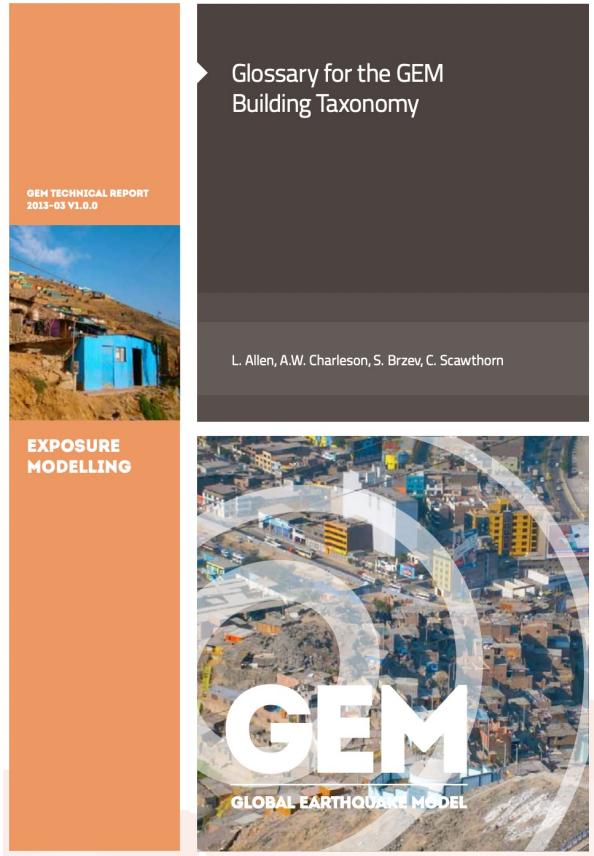
- The GEM Building Glossary was developed in 2013 thanks to contributions from 13 organizations and 69 individuals



Scan me to access report

GEM Building Glossary

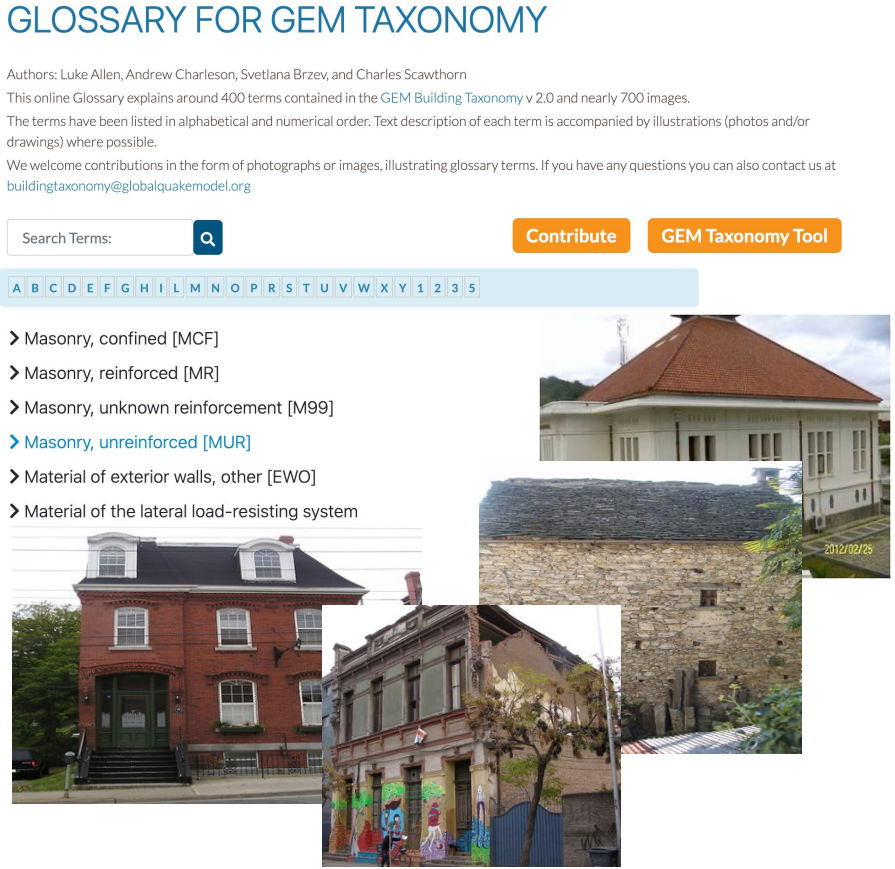
- The Glossary is intended to be referred to in conjunction with the GEM Taxonomy
- Graphical illustrations are critical for the effectiveness of the Glossary keeping in mind its diverse global audience
- Graphical explanation and clarification on the meaning of attributes and their details for users



GEM Building Glossary

- Each Glossary term contains a text description, and most terms contain one or more illustrations (photos and/or drawings).
- The Glossary includes more than **370** terms and **760** illustrations

Scan me to access online glossary



GEM Building Glossary

- Each Glossary term contains a text description, and most terms contain one or more illustrations (photos and/or drawings).
- The Glossary includes more than **370** terms and **760** illustrations

Scan me to access online glossary

GLOSSARY FOR GEM TAXONOMY

Authors: Luke Allen, Andrew Charleson, Svetlana Brzev, and Charles Scawthorn

This online Glossary explains around 400 terms contained in the GEM Building Taxonomy v 2.0 and nearly 700 images.

The terms have been listed in alphabetical and numerical order. Text description of each term is accompanied by illustrations (photos and/or drawings) where possible.

We welcome contributions in the form of photographs or images, illustrating glossary terms. If you have any questions you can also contact us at buildingtaxonomy@globalquakemodel.org

Search Terms:

Contribute | GEM Taxonomy Tool

A B C D E F G H I L M N O P R S T U V W X Y 1 2 3 5

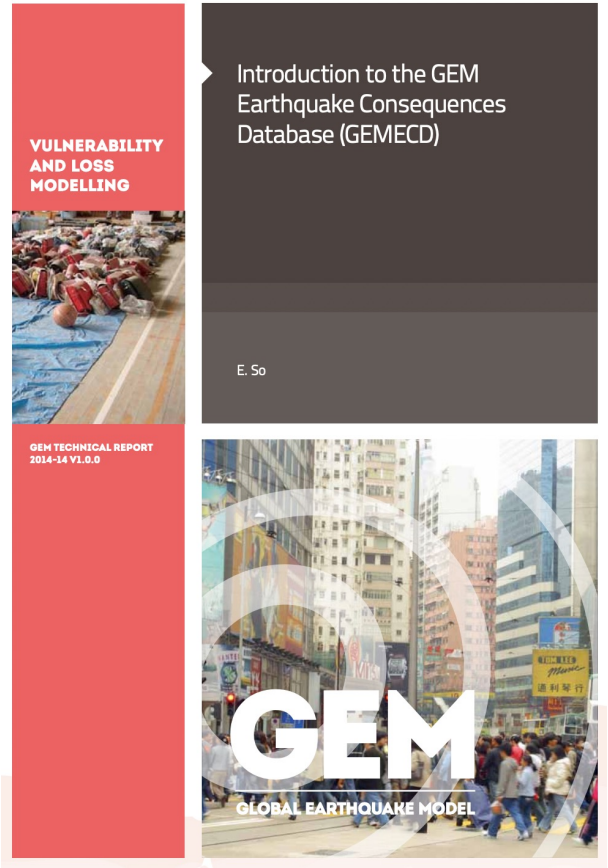
- Masonry, confined [MCF]
- Masonry, reinforced [MR]
- Masonry, unknown reinforcement [M99]
- Masonry, unreinforced [MUR]
- Material of exterior walls, other [EWO]
- Material of the lateral load-resisting system



Earthquake Consequence Database: GEMECD

- GEMECD project initiated in November 2010
- Collaboration between 10 international partners
- The report (So *et al,* 2014) includes:
  - Description of the database (contents and framework)
  - Development of a set of guidelines for data collection and templates to populate the database
  - GEMECD examples

Scan me to access report



Earthquake Consequence Database: GEMECD

- GEMECD is a GIS relational database integrated into the GEM OpenQuake Web Portal
- GEMECD creates a global database of standardised information of consequences on **inventory classes** following significant events
- Benchmarking tool for analytical loss models and to support the development of tools to create vulnerability data appropriate to specific countries, structures, or building classes



Earthquake Consequence Database: GEMECD

- **GEMECD Statistics**
  - **68** Events
  - **228** Reports
    - **121** on building damage
    - **44** on casualties
    - **63** on critical infrastructure
    - **23** on socio-economic impact
    - **4** on secondary geohazards (i.e., slope failure)
  - Survey locations: **3760**
  - Survey value record: **39629**
  - Photographs: **14000+**



Earthquake Consequence Database: GEMECD

- **GEMECD Metadata**

  - Photo ID
  - Event ID
  - Event and Inspection Coordinates
  - Asset Class
  - Soil Conditions
  - Material and Technology Type
  - Occupancy
  - Design Code
  - Damage Scale and Assigned Grade

Earthquake Consequence Database: GEMECD

- **GEMECD Metadata (Examples)**

  - Photo ID: **11411**
  - Event ID: **Banda-Aceh Sumatra 2004**
  - Event Coordinates: **95.97, 13.29**
  - Investigation Coordinates: **100.547, 13.753**
  - Soil Conditions: **NA**
  - Material and Technology Type: **RC**
  - Occupancy: **RES**
  - Design Code: **NO-CODE**
  - Damage Scale and Assigned Grade: **D2 (EMS-98)**



Earthquake Consequence Database: GEMECD

- **GEMECD Metadata (Examples)**

  - Photo ID: **11411**
  - Event ID: **Kocaeli-Golcuk 1999**
  - Event Coordinates: **29.91, 40.7**
  - Investigation Coordinates: **29.938, 40.712**
  - Soil Conditions: **NA**
  - Material and Technology Type: **MUR**
  - Occupancy: **EDU**
  - Design Code: **NO-CODE**
  - Damage Scale and Assigned Grade: **D5 (IMS-14)**



Earthquake Consequence Database: GEMECD

- **GEMECD Metadata (Examples)**

  - Photo ID: **13078**
  - Event ID: **Wenchuan 2008**
  - Event Coordinates: **103.364, 30.959**
  - Investigation Coordinates: **103.486, 31.057**
  - Soil Conditions: **Diluvial or Alluvial Fan of the Yuzixi River**
  - Material and Technology Type: **RC (PC) / LFINF**
  - Occupancy: **EDU**
  - Design Code: **GB 50011-2001 & GB50223-2004 (Chinese intensity zone VII)**
  - Damage Scale and Assigned Grade: **D5 (IMS-14)**



Earthquake Consequence Database: GEMECD

- **Non-structural damage observations**



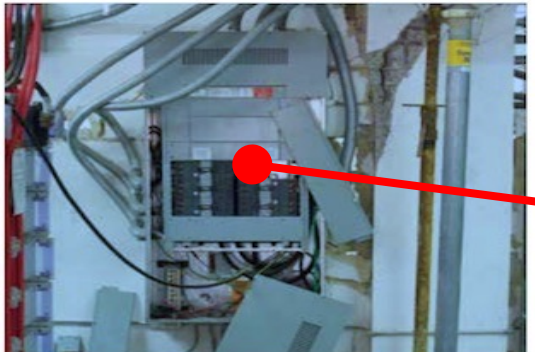
Slight Damage to Piping Systems



Complete Damage to HVAC Ducts

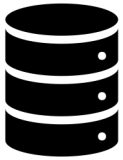


Heavy Damage to Suspended Ceilings



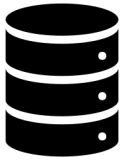
Complete Damage to Distribution Panels

Interconnected System for Post-Earthquake Reconaissance



GEM Glossary

- Facilitates the identification of inspected buildings



GEMECD

- Harmonisation of damage scales
- Eases the identification of damage patterns
- Accurately associate damage patterns to IMS-compatible damage grades
- Promote uniform damage classification



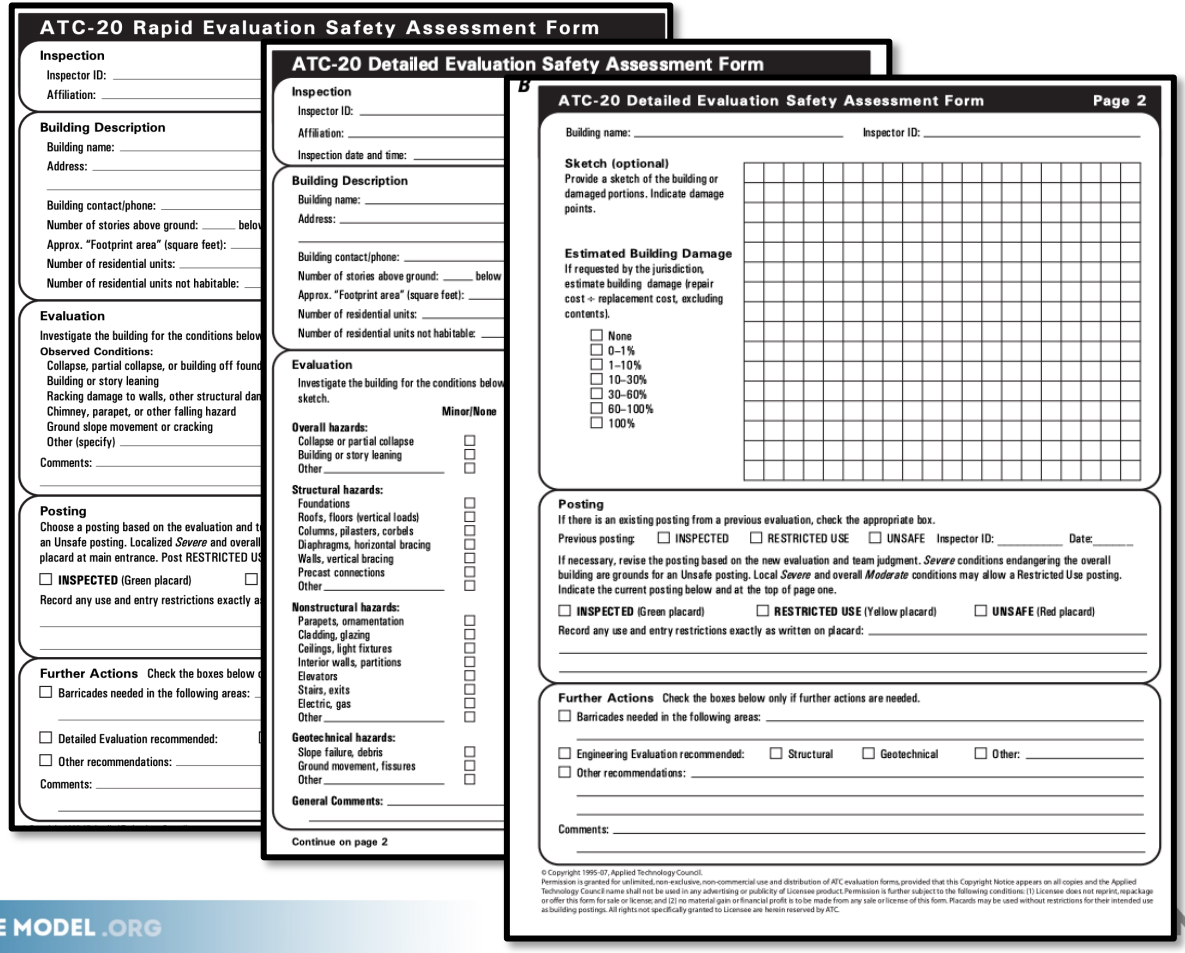
Digital Evaluation Form

- Collection of damage data and identification of damage patterns
- Associates damage patterns to IMS-compatible damage grades

Interconnected System for Post-Earthquake Reconaissance

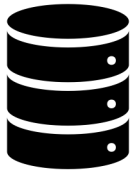
Digital Evaluation Form

- Harmonisation of damage scales
- Eases the identification of damage patterns
- Associates damage patterns to IMS-compatible damage grades



Damage Data Collection

The experience of DaDO: Database of Observed Damage









- The platform is divided into two sections:
  - Ordinary buildings, includes 12 databases relating to events: Friuli 1976, Irpinia 1980, Abruzzo 1984, Umbria-Marche 1997, Pollino 1998, Molise-Puglia 2002, Emilia 2003, L'Aquila 2009, Emilia 2012, Garfagnana-Lunigiana 2013, Central Italy 2016 - 2017 and Mugello 2019
  - Churches, includes 8 databases relating to Umbria-Marche 1997, Molise-Puglia 2002, Piedmont 2003, Salò 2004, L'Aquila 2009, Emilia 2012, Central Italy 2016 - 2017 and Ischia 2017 events

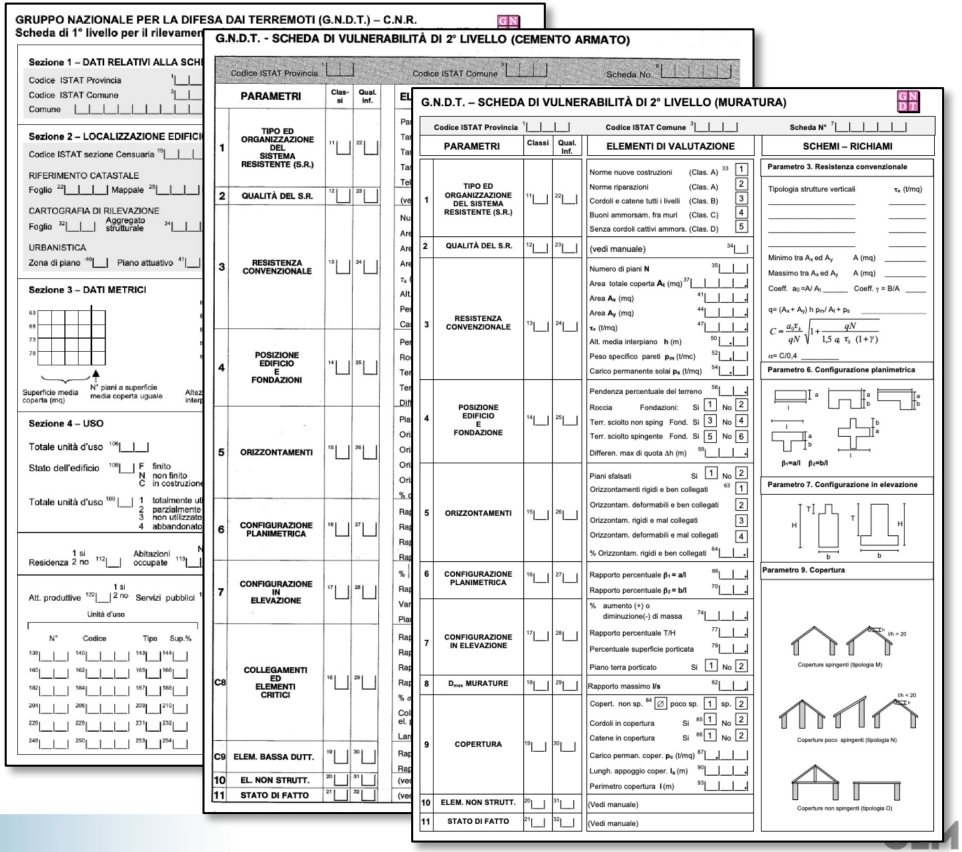
Damage Data Collection

The experience of DaDO: Database of Observed Damage

Prior to 1997

- 1st and 2nd level vulnerability forms prepared by the National Group for the Defense against Earthquake (GNDT)
- Simple detection of RC and Masonry structures vulnerability and damage using general building properties

https://emidius.mi.ingv.it/GNDT2/



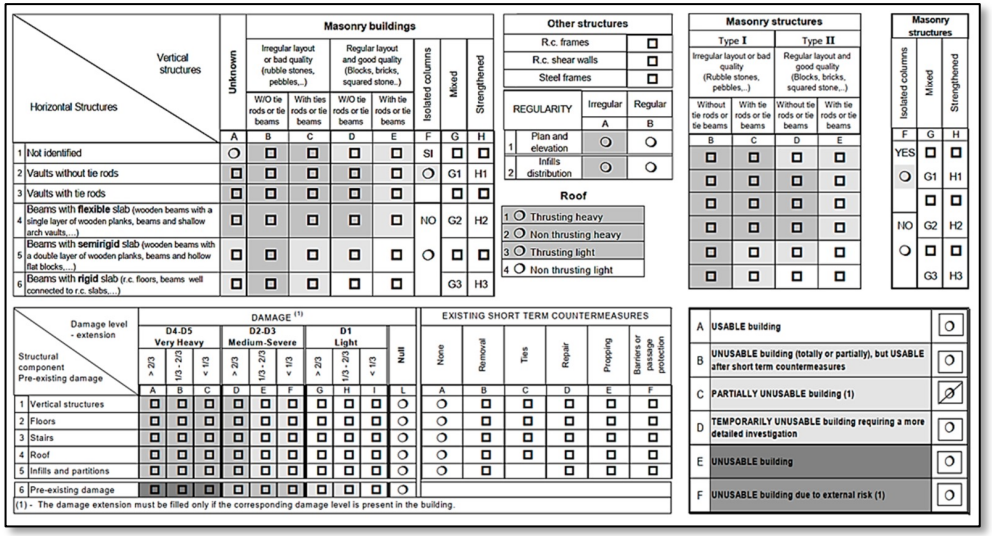
Damage Data Collection

The experience of DaDO: Database of Observed Damage

After Umbria-Marche 1997 Event

- Building Identification
- Building Description
- Building Typology
- Damage to Structural Elements (e.g., vertical structures, floors, stairs, etc.)
- Damage to Non-Structural Elements (e.g., plaster, tiles, HVAC systems, electrical systems, etc.)

https://emidius.mi.ingv.it/GNDT2/



AeDES Short-Form (2002)

Damage Data Collection

The experience of DaDO: Database of Observed Damage



International Journal of Disaster Risk Reduction
Volume 87, March 2023, 103595

Damage survey
Observed Dam
earthquakes (D

Antonella Di Meo [a], Marc
Chiara Calderini [b], Romina Si

Show more

Add to Mendeley Shar

https://doi.org/10.1016/j.ijdrr.2023.10

Abstract

Da.D.O. (Database of Observe
international scientific comm
structural characteristics and
relevant seismic events occur
platform was conceived by th
Eucentre (European Centre fo
as a part of a wider project ai
damage scenario of the Italia
Initially, the Da.D.O. platform

Observed damage datab
earthquakes: the Da.D.O.

M. Dolce, E. Speranza, F.
Pascale

Following major seismic e
data relevant to post-ear
today represent an inesti
purposes, including calib
formulation of damage s
tools developed over the
for enhancing the reliabil
decision-making has mov
2014, a specific project w
of Eucentre Foundation,
Database), is meant to st
campaigns occurred in th
members of the scientific
extended in the future to
capabilities of the IT plat
events (or sequences) oc
earthquake).

https://doi.org/10.5194/nhess-23-3199-2
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Research article |

Testing machine
building damage
Database of Obs

Subash Ghimire, Philippe Gué

Abstract

Assessing or forecasting seismic
explore the efficacy of several m
damage observed after Italian ea
and classification-based machine
The structural features consider
considered to be the most reliab
intensity was also included as an
observed after seven significant
boosting classification is statistically the most efficient method, particularly w
grouping the damage according to the traffic-light-based system used; for ex
and red), 68 % of buildings were correctly classified. The results obtained by t
damage assessment are of the same order of accuracy (error values were less than 17 %) as those obtained by th
UE method. Finally, the machine learning analysis found that the importance of structural features with respect to
conditioned by the level of damage considered.

How to cite. Ghimire, S., Guéguen, P., Pothon, A., and Schorlemmer, D.: Testing machine learning models for heur
damage assessment applied to the Italian Database of Observed Damage (DaDO), Nat. Hazards Earth Syst. Sci., 23,
https://doi.org/10.5194/nhess-23-3199-2023, 2023.

Empirical fragility curves for Italian residential RC buildings

S.I. : Seismic Risk Assessment in Italy | Open acces
Volume 19, pages 3165–3183, (2021) Cite this ar

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A. Rosti, C. Del Gaudio, M. Rota, P. Ricci,

5506 Accesses 89 Citations Exp

Abstract

In this paper, empirical fragility curve
on post-earthquake damage data colle
Italy in the period 1976–2012. These d
called Da.D.O., provide information on
damage detected on different structur
of data is carried out to guarantee the
Then, an in-depth analysis of the degr
aiming at the identification of the Mur

com/article/10.1007/s10518-020-00971-4#Sec3

Empirical fragility curves for masonry buildings after the 2009 L'Aquila, Italy, earthquake

Original Research | Published: 19 July
Volume 17, pages 6301–6330, (2019)

Download PDF Acc

Carlo Del Gaudio, Giuseppina
Ricci & Gerardo Mario Verderame

1288 Accesses 77 Citat

Abstract

This study focuses on the seis
L'Aquila earthquake. A geo-re
was compiled in the aftermat
Department of Civil Protectio
enormous amount of data pro
damage data and their correla
earthquake survey. The origi

Empirical fragility curves for Italian URM buildings

S.I. : Seismic Risk Assessment in Italy |
Volume 19, pages 3057–3076, (2021)

Download PDF Acce

Annalisa Rosti, Maria Rota & A

1834 Accesses 93 Citati

Abstract

This paper illustrates the deri
unreinforced masonry (URM)
data and compatible with the
Seismic vulnerability is descri
refined based on the building
merge predefined building ty
the observed seismic fragility

Fragility functions for non-ductile infilled reinforced concrete buildings using next-generation intensity measures based on analytical models and empirical data from past earthquakes

Original Article | Published: 21 June 2024
Volume 22, pages 4983–5021, (2024) Cite this article

Download PDF Access provided by CARE-CRUI COMPACT

Al Mouayed Bellah Nafeh & Gerard J. O'Reilly

267 Accesses Explore all metrics

Abstract

The regional seismic risk assessment of reinforced concrete (RC) building portfolios is a critical issue in earthquake engineering due to their high vulnerability and widespread distribution in seismic prone areas. A pertinent aspect in regional seismic risk applications is the ability to accurately quantify the exceedance of any damage state, generally via fragility functions. To this end, this study derives analytical fragility functions for large-scale seismic risk applications of non-ductile RC buildings with masonry infills characteristic of the Italian peninsula and Southern Europe in general. These were derived

Interconnected System for Post-Earthquake Reconaissance

Event Occurrence



Interconnected System for Post-Earthquake Reconaissance

Event Occurrence → Post-Sequence Inspection





Interconnected System for Post-Earthquake Reconaissance

Event Occurrence → Post-Sequence Inspection → Building Class Identification











GEM Glossary

Building Class Identification

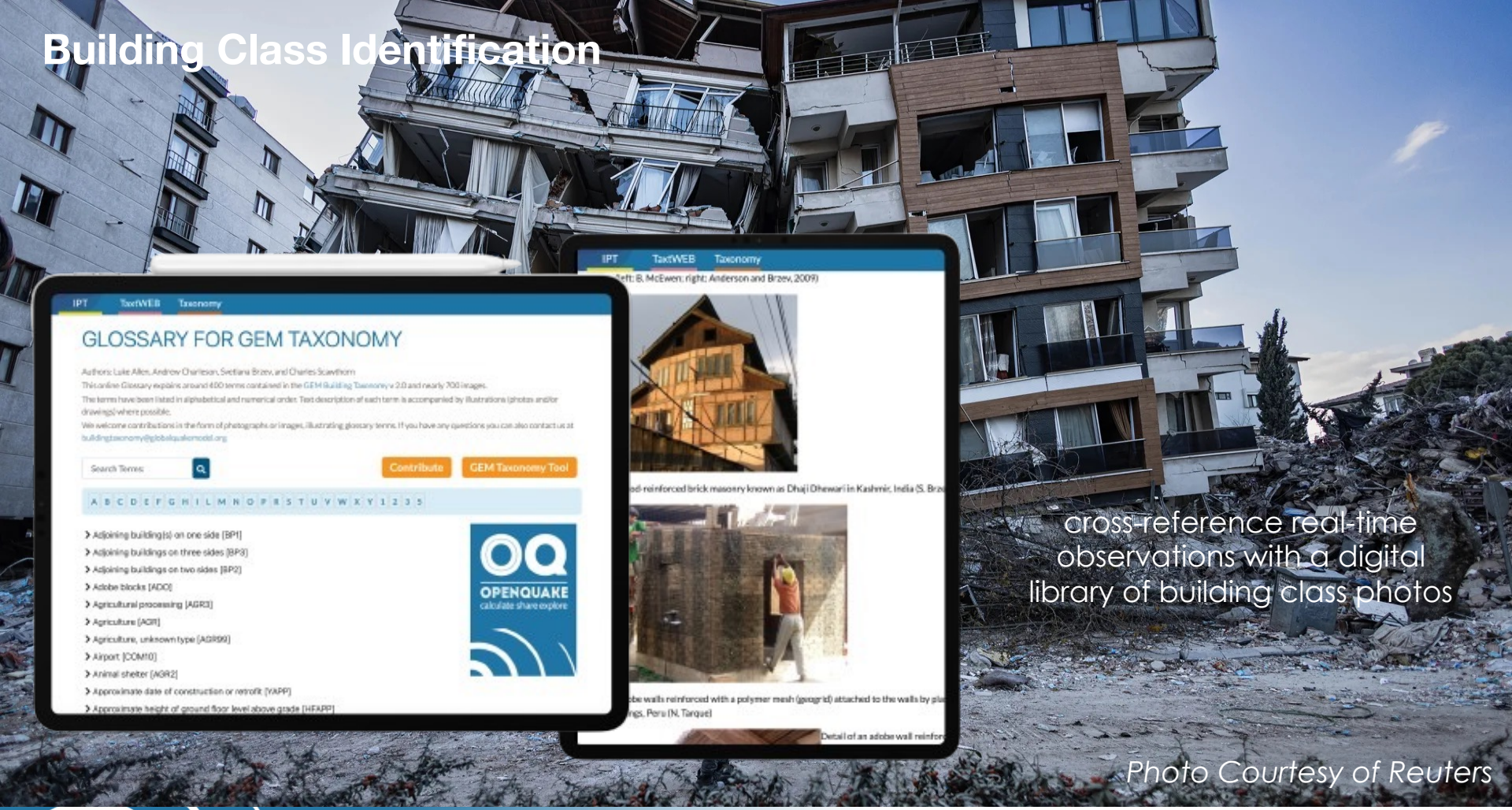


Photo Courtesy of Reuters

Interconnected System for Post-Earthquake Reconaissance

Event Occurrence → Post-Sequence Inspection → Building Class Identification → VC and DG Identification







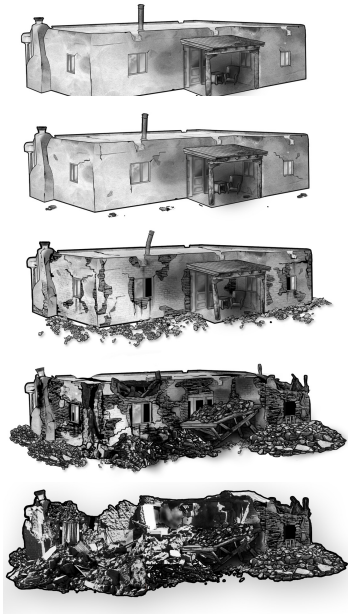


GEM Glossary





GEMECD + Form



Damage Inspection



compare observed damage against previously documented earthquake impacts

Photo Courtesy of Reuters

Damage Inspection



compare observed damage against previously documented earthquake impacts

Photo Courtesy of USGS

Building Damage Data Collection



ATC-20 Rapid Evaluation Safety Assessment Form

Inspection

Inspector ID: _____ Inspection date and time: _____ ☐ AM ☐ PM

Affiliation: _____ Areas inspected: ☐ Exterior only ☐ Exterior and interior

Building Description

Building name: _____

Address: _____

_____

Building contact/phone: _____

Number of stories above ground: _____ below ground: _____

Approx. "Footprint area" (square feet): _____

Number of residential units: _____

Number of residential units not habitable: _____

Type of Construction

☐ Wood frame ☐ Concrete shear wall

☐ Steel frame ☐ Unreinforced masonry

☐ Tilt-up concrete ☐ Reinforced masonry

☐ Concrete frame ☐ Other: _____

Primary Occupancy

☐ Dwelling ☐ Commercial ☐ Government

☐ Other residential ☐ Offices ☐ Historic

☐ Public assembly ☐ Industrial ☐ School

☐ Emergency services ☐ Other: _____

Evaluation

Investigate the building for the conditions below and check the appropriate column.

Observed Conditions:	Minor/None	Moderate	Severe	Estimated Building Damage (excluding contents)
Collapse, partial collapse, or building off foundation	☐	☐	☐	☐ None
Building or story leaning	☐	☐	☐	☐ 0–1%
Racking damage to walls, other structural damage	☐	☐	☐	☐ 1–10%
Chimney, parapet, or other falling hazard	☐	☐	☐	☐ 10–30%
Ground slope movement or cracking	☐	☐	☐	☐ 30–60%
Other (specify) _____	☐	☐	☐	☐ 60–100%
				☐ 100%

Comments: _____

Collect building damage data using forms tailored to IMS

Photo Courtesy of Daily Sabah

Interconnected System for Post-Earthquake Reconaissance

Event Occurrence → Post-Sequence Inspection → Building Class Identification → VC and DG Identification → Intensity Assignment













GEM Glossary

GEMECD + Form

Statistical Methods



Extreme
X+

Moderate
V

Not Felt
I

GEM GLOBAL EARTHQUAKE MODEL working together to assess risk

USGS science for a changing world

ATC Applied Technology Council

Future Endeavour

GEM GLOBAL EARTHQUAKE MODEL working together to assess risk

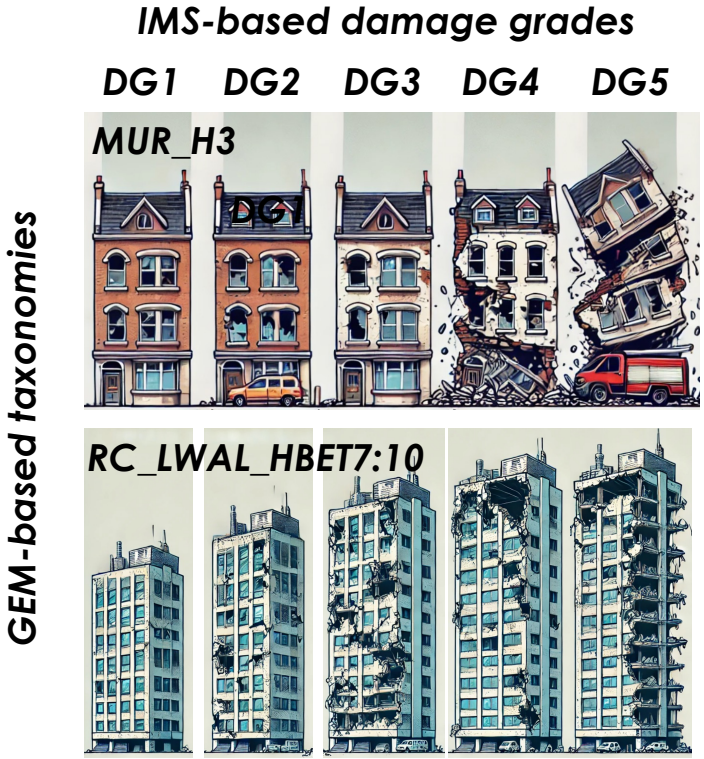


GEM Damage Taxonomy

- Joint effort between 6 international institutions
- GEM Damage Taxonomy brings several key benefits in improving earthquake risk assessment via a unified system for categorizing damage based on:
  - Comprehensive and standardized taxonomy definition enabling cross-comparability and inclusive representation of global building classes
  - Simplicity, efficiency and practicality of IMS damage grades

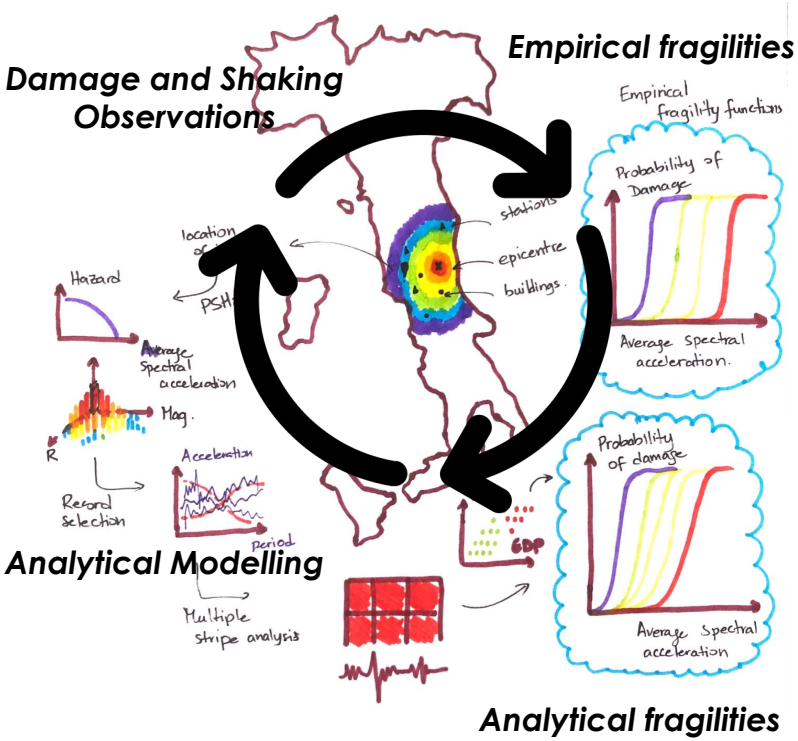
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GEM Damage Taxonomy

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  - Comprehensive and standardized taxonomy definition enabling cross-comparability and inclusive representation of global building classes
  - Simplicity, efficiency and practicality of IMS damage grades
- Benefits include:
  - Improved derivation of fragility and vulnerability functions for earthquake risk assessment application
  - Validation with consistent, well-categorized empirical data improving the analytical predicting capacity



Conclusions

Objective

- To communicate a **universal**, **efficient** and **simple** intensity scale, damage to buildings of a particular type should be grouped **consistently** irrespective of the strength of the building damaged
- To present tools that adequately map the output from rapid evaluation forms (**ATC-20-like digital forms**) to IMS VCs and DGs and—with sufficient observations—automatically assign IMS intensities:
  - Comprehensive building taxonomy and illustrative resources for facilitating building type identification
  - Extensive and photographic consequence database to ease inspect and building damage data collection
  - With sufficient observations, these tools will be able to **automatically assign IMS intensities** for more efficient post-event analysis to ensure more reliable, standardized results

Conclusions

Direct Benefits of Database Integration in Earthquake Response:

- Streamlining Identification of Building Classes:
  - Inspectors can quickly cross-reference real-time observations with a digital library of building class photos
  - Reduces ambiguity in identifying structural types, leading to more accurate vulnerability assessments
- Improving Damage Classification:
  - Databases of historical damage data allow inspectors to compare observed damage against previously documented earthquake impacts
  - This helps to standardize damage classifications and improve the consistency of assessments
- Openly accessible BDD will facilitate consistent macroseismic intensity assignments and ShakeMaps

Conclusions

Future Benefits of Integrating Digital Tools with IMS

- Such efforts would facilitate significantly the development of IMS-based global vulnerability database
- This consistency translates into earthquake engineering applications for better understanding of building behavior, improved fragility curves, and refined prediction equations
- BDD data assist with societal needs for response, recovery, and long-term mitigation of vulnerable structures

Thank you!

Please attribute to the GEM Foundation with a link to:
https://www.globalquakemodel.org



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