# Concrete Building Inventories: Implications for Retrofit Policies for Nonductile Concrete Buildings

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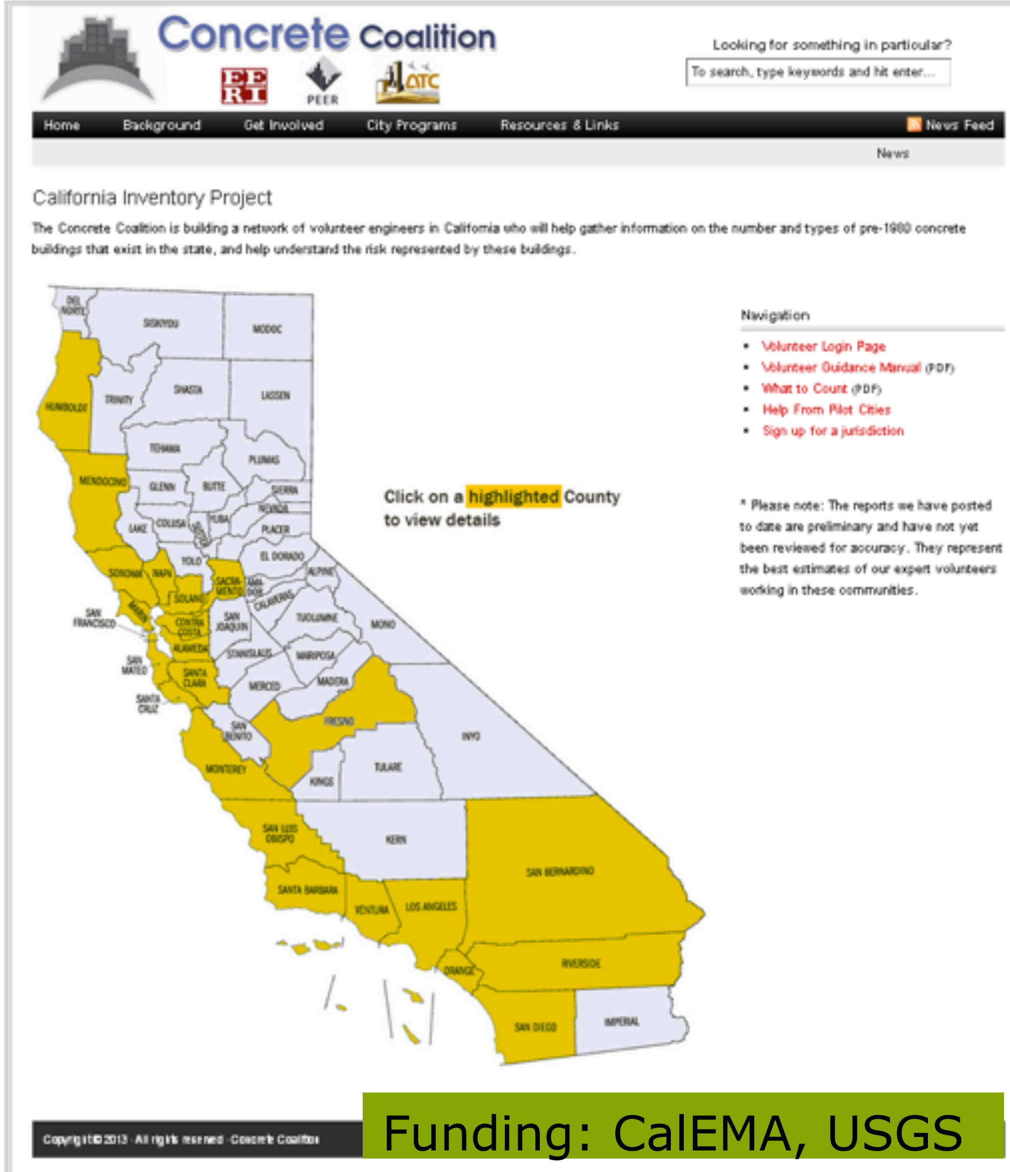
# Reaching a Broader Audience

Concrete Coalition advocates

- the identification of **older concrete buildings**
- the development of sensible solutions

- Inventory 23 highest seismicity counties
- Engage engineers, cities, agencies, policy makers

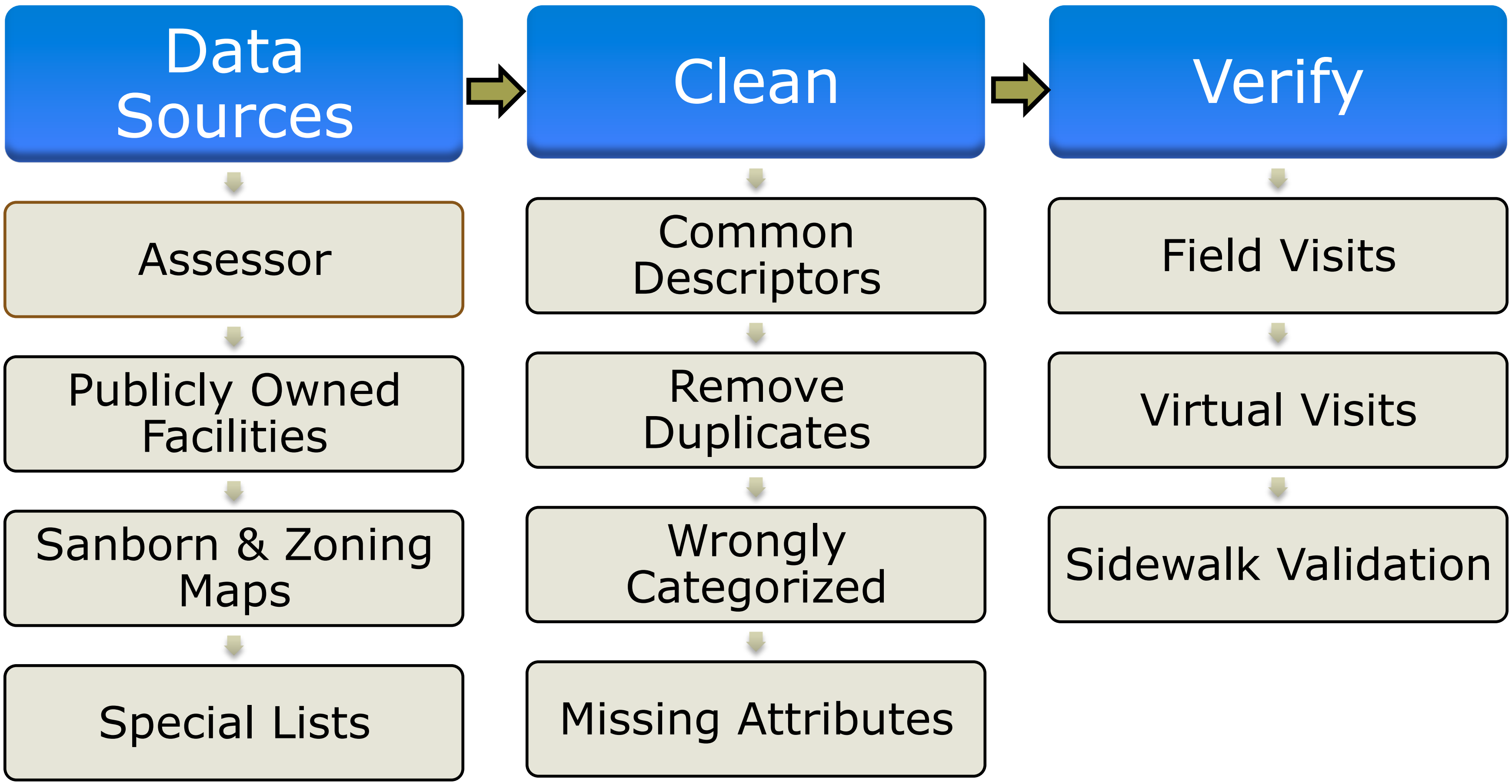



Funding: CalEMA, USGS

# Counting older concrete buildings

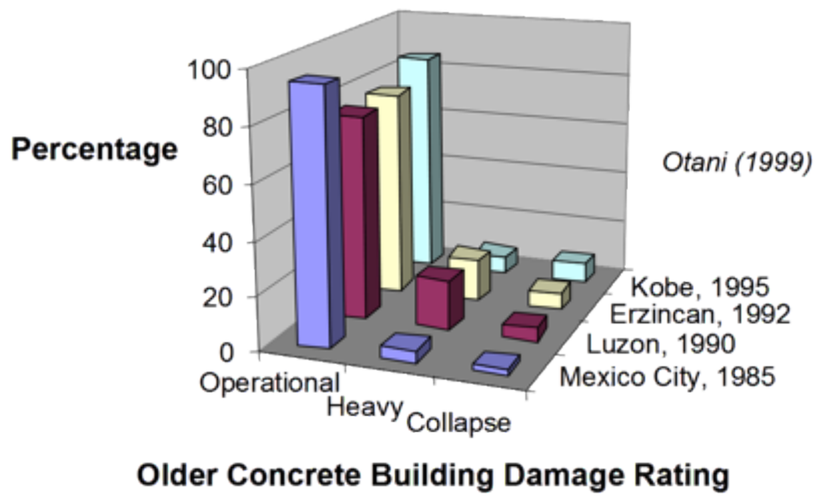
- What
  - Pre-1976 UBC ≈ 1980 construction
- How
  - Volunteers for ~ 40 cities
  - Walk the city
  - Talk to building officials
  - Assessor data
  - Zoning maps
  - Sanborn maps
  - Drawing files
  - Google Earth
  - Sanity checks
  - Regression analyses

# Collecting Inventory



# California inventory estimate

- City of Los Angeles – 1500 buildings
- San Francisco – 3200 buildings
- For 22 CA counties – 22,000 buildings

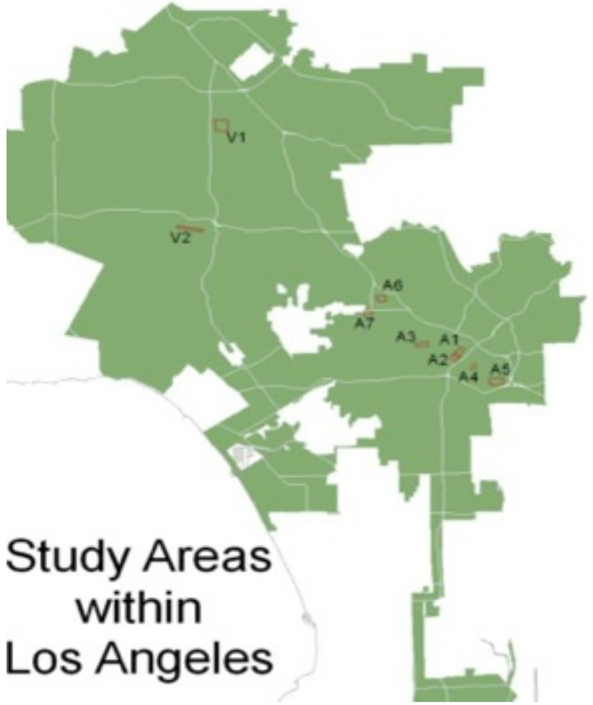


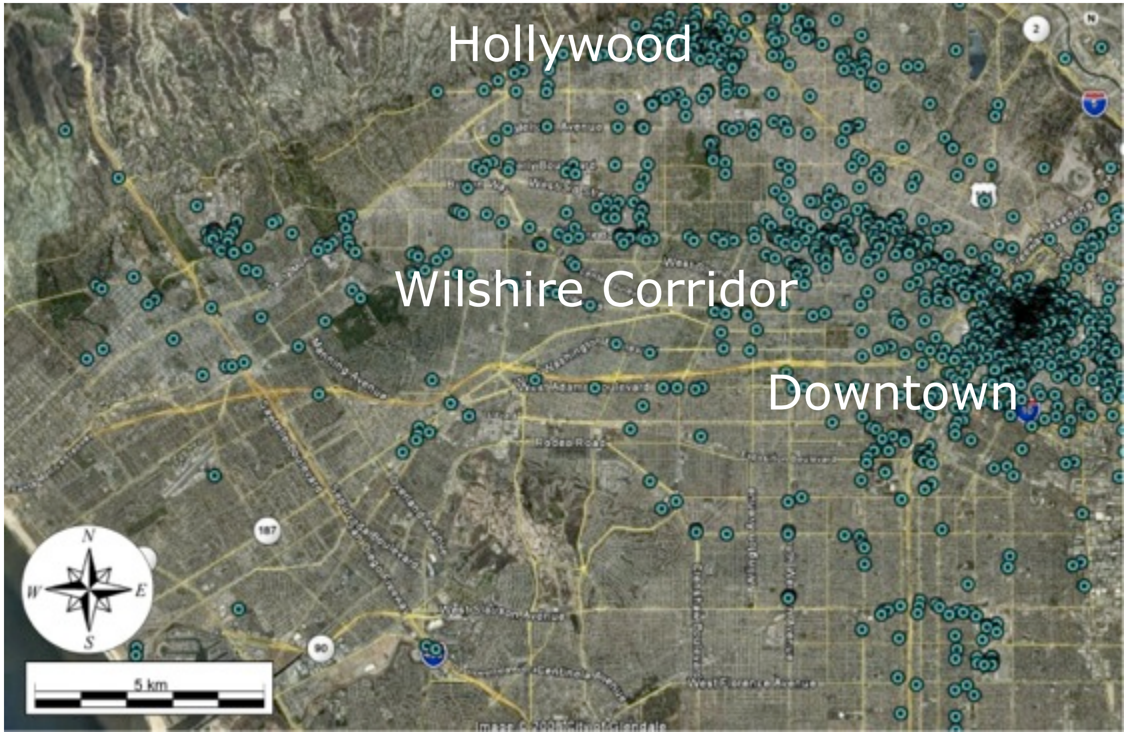
# NSF NEES Grand Challenge Project

- Understand the scale of the problem
- Increase awareness
- Improve modeling and simulation
  - components
  - soil-foundation-structural systems
- Facilitate identification of critical deficiencies
- Demonstrate cost-effective retrofit
- Identify mitigation policy alternatives

# LA Inventory: Implications for Policy

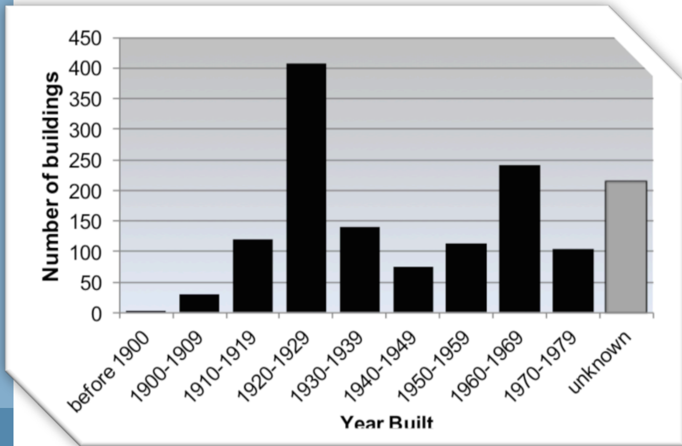
- 470 sq. miles
- 1500 Buildings
- 88 mil. sq ft older concrete
- Geocoded database - Public Sources



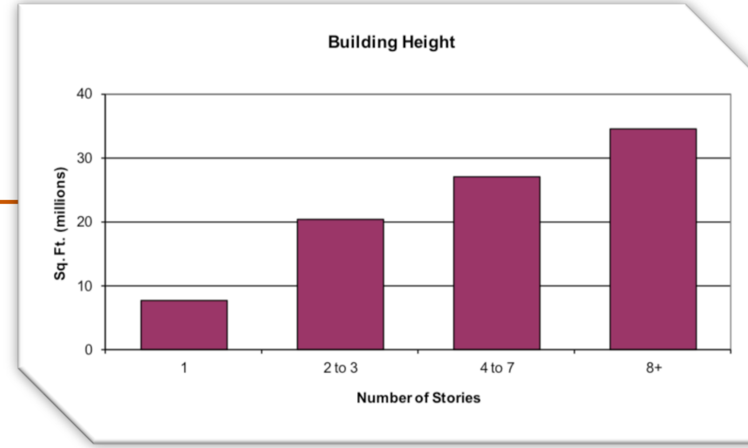



# Understand the Inventory

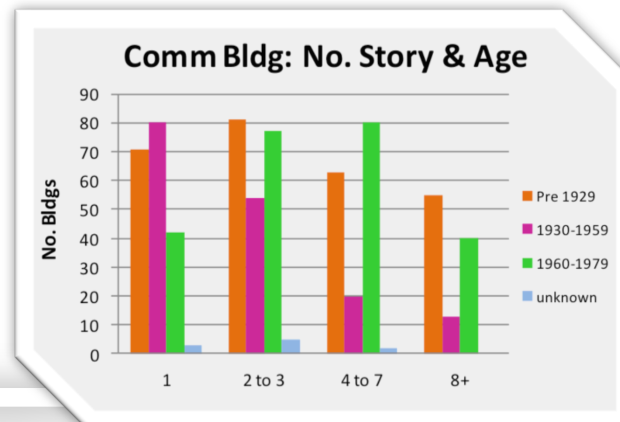
Age

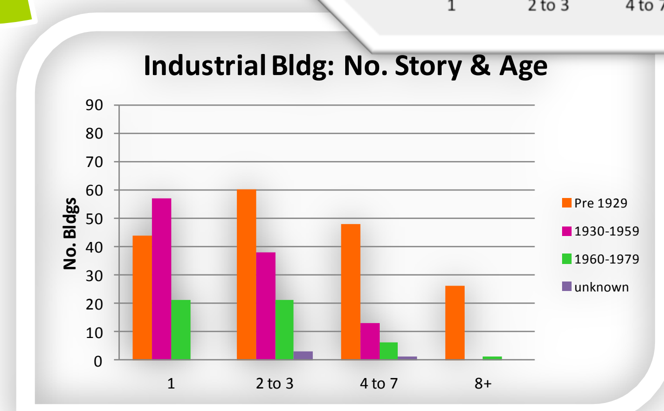



Height

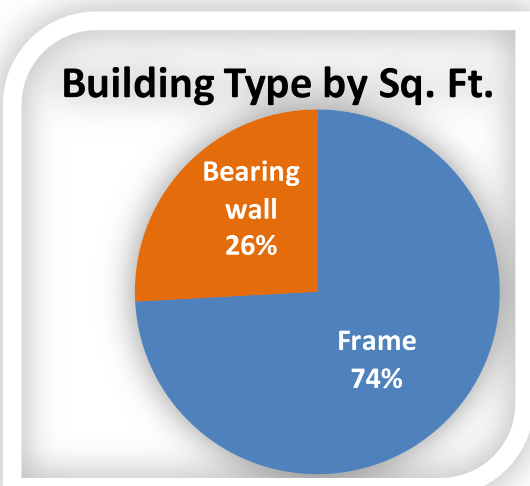



Occupancy



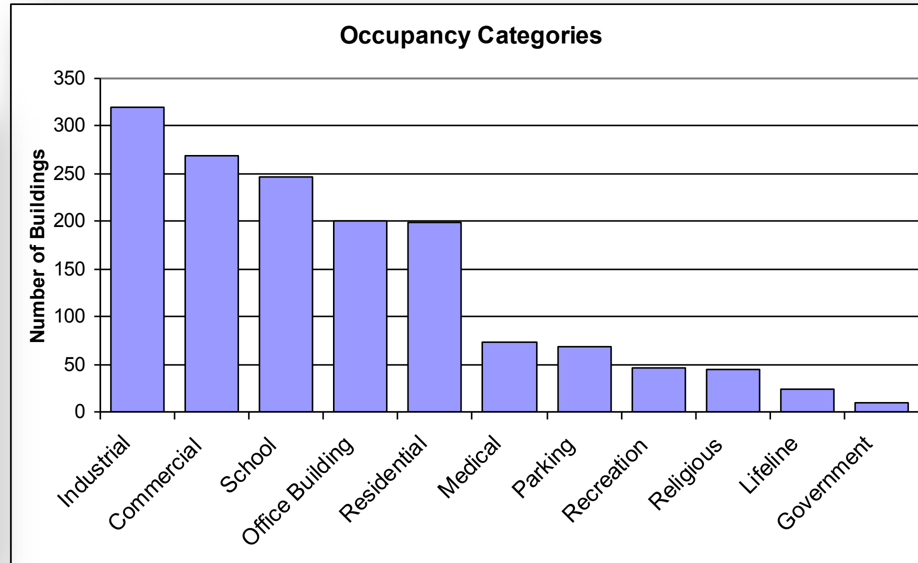

Structure

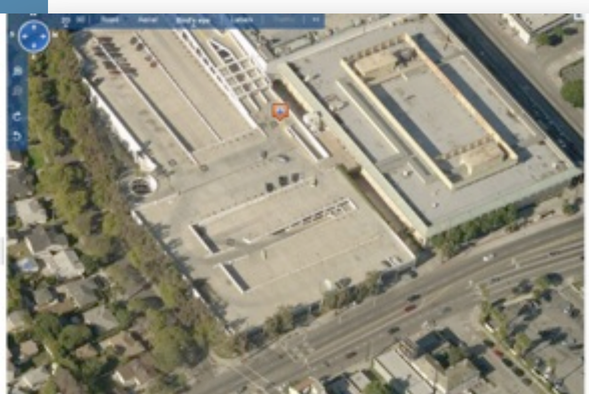


# Inventory Characteristics

Industrial


Office



Commercial

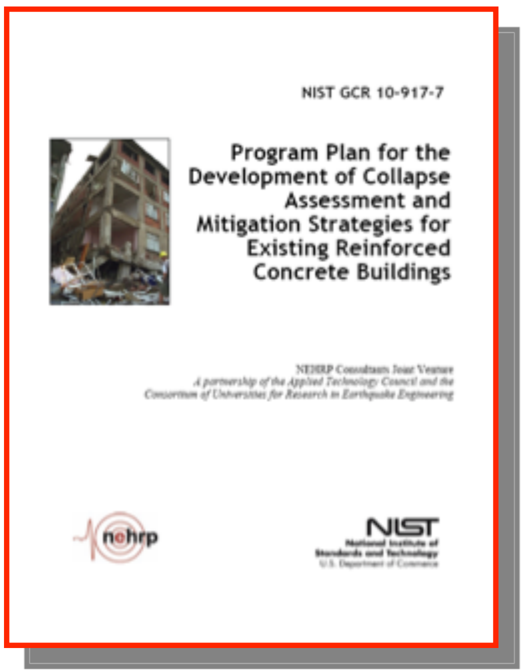
Residential

School

# Critical Deficiencies

ATC/CUREE Joint Venture
7-year project

8 recommended guidelines for assessment, modeling, mitigation


NIST GCR 10-917-7

Program Plan for the Development of Collapse Assessment and Mitigation Strategies for Existing Reinforced Concrete Buildings

NEHRP Consultants Joint Venture
*A partnership of the Applied Technology Council and the Consortium of Universities for Research in Earthquake Engineering*

nehrp

NIST
National Institute of Standards and Technology
U.S. Department of Commerce

| Deficiency A: Shear-critical columns | Deficiency F: Overall weak frames |
|---|---|
|  Shear and axial failure of columns in a moment frame or gravity frame system. |  Overall deficient system strength and stiffness, leading to inadequacy of an otherwise reasonbably configured building. |
| **Deficiency B: Unconfined beam-column Joints** | **Deficiency G: Overturning mechanisms** |
|  Shear and axial failure of unconfined beam-column joints, particularly corner joints. |  Columns prone to crushing from overturning of discontinuous concrete or masonry infill wall. |
| **Deficiency C: Slab-column connections** | **Deficiency H: Severe plan irregularity** |
|  Punching of slab-column connections under imposed lateral drifts. |  Conditions (including some corner buildings) leading to large torsional-induced demands. |
| **Deficiency D: Splice and connectivity weakness** | **Deficiency I: Severe vertical irregularity** |
|  Inadequate splices in plastic hinge regions and weak connectivity between members. |  Setbacks causing concentration of damage and collapse where stiffness and strength changes. Can also be caused by change in material or seismic-force-resisting-system. |
| **Deficiency E: Weak-story mechanism** | **Deficiency J: Pounding** |
|  Weak-column, strong-beam moment frame or similar system prone to story collapse from failure of weak columns subjected to large lateral deformation demands. |  Collapse caused by pounding of adjacent buildings with different story heights and non-coincident floors. |

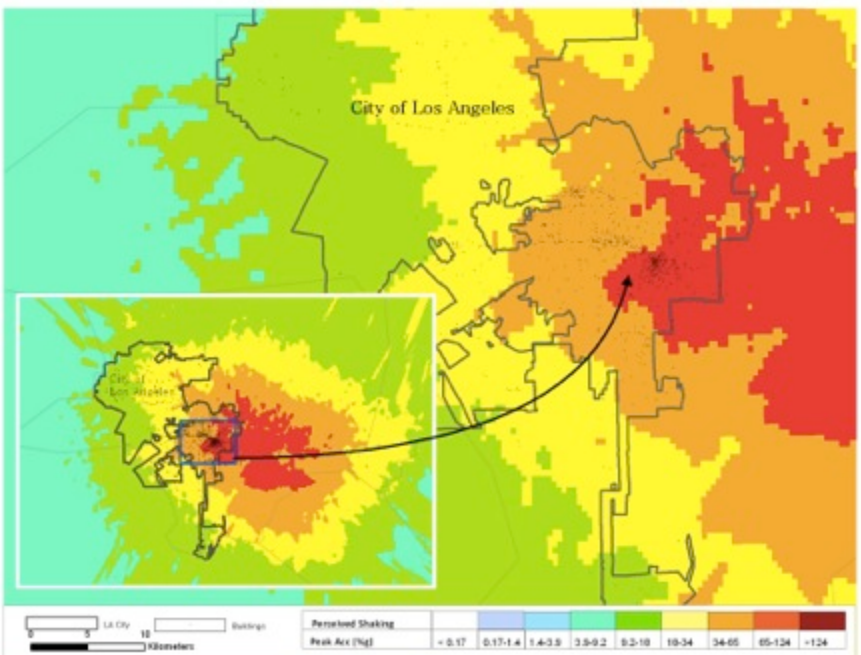
# Deficiencies in Inventory Groups For Loss Estimation and Simulation

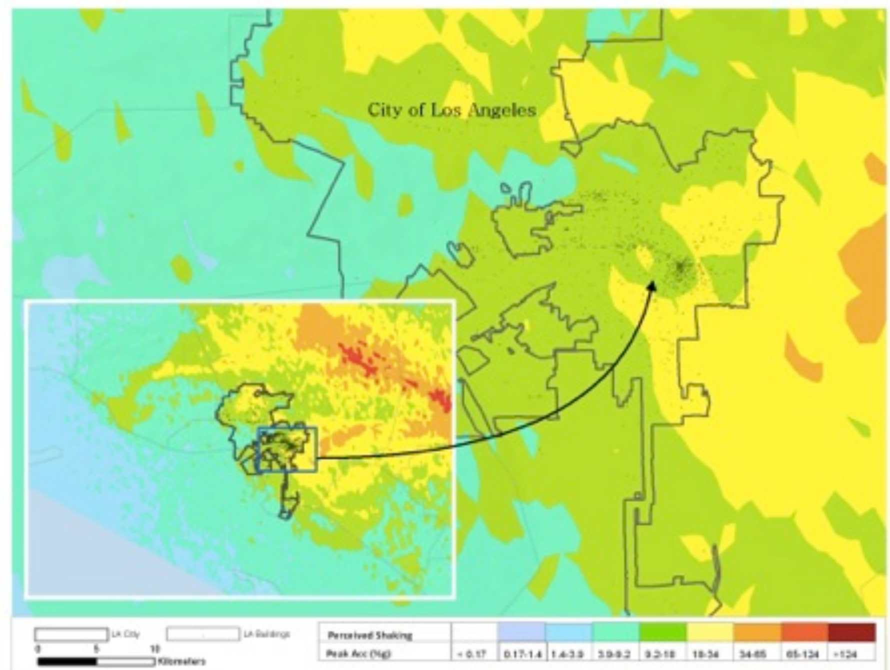
- 1: Short, pre-1929, various occupancies.
- 2: 4+ story, pre-1929 warehouses.
- 3: 4+ story, pre-1959 apartments.
- 4: 8+ story, apartments.
- 5: 8+ story, hotels.
- 6: 4+ story, 1960-79 commercial/office.
- 7: 8+ story, pre 1929 commercial/office.
- 8: 8+ story, 1960-79 modern office.
- 9: 1-3 story, 1960-79 non-office commercial.
- 10: 4-7 story, pre-1929 non-office commercial.
- Parking structures.
- Education structures.

# Two Scenarios for Loss Models

PEAK GROUND ACCELERATIONS

M 7.15 Puente Hills    M 7.8 S. San Andreas



# Estimates of Losses

| | Baseline | | Retrofitted | |
|---|---|---|---|---|
| | Losses w/ closure & business Interruption | Deaths | Losses w/ closure & business Interruption | Deaths |
| San Andreas | $1.9 Billion | 0-25 | $350 million | <10 |
| Puente Hills | $19.6 Billion | 300-2000 | $5.8 Billion | 5-50 |

# Policy Example

- Hypothetically retrofit only high rise
- 15% of buildings
- 38% of value

| | **Reduction in Losses** | **Reduction in Deaths** |
|---|---|---|
| San Andreas | 83% (high rise) | Close to 100% (high rise) |
| | 54% (overall) | 48% or more (overall) |
| Puente Hills | 64% (high rise) | 90 to 95% (overall) |
| | 26% (overall) | 17 to 34% (overall) |

# Mitigation & Policy Implications

- An inventory guides policy approaches
  - Targeted retrofits of categories with high loss estimates is cost effective and influence how cities plan for mitigation
  - Voluntary and mandatory programs can be quite effective in mitigating risk
- NSF NEES Grand Challenge research is available on on the NEEShub
  - https://nees.org/data/download/NEES-2008-0637/Documentation/Older_Concrete_Building_Modeling_Inventory.pdf
- Researchers working with City and sharing data with the City of Los Angeles

# How Cities Develop Inventories 1

- 1. A city holds a hearing to establish criteria for inclusion of collapse-risk buildings in an the inventory.
- 2. City prepares a draft inventory.
- 3. City notifies owners that their building is a candidate to be placed on the yet-to-be published draft inventory and provide them ample time and opportunity to produce evidence that would demonstrate that their building does not meet criteria.
- 4. City receives owner comments and take actions to revise the draft inventory based on input from owners.

# How Cities Develop Inventories 2

- 5. City publishes the draft inventory and allow time and opportunity for the general public to comment on the draft.
- 6. City receives public comments and take actions to revise the draft inventory based on input from the public.
- 7. City holds a public hearing to discuss the draft inventory.
- 8. City takes an action to publish a final inventory, and allows the building department to periodically make further changes to the inventory as additional information becomes available.

# The San Francisco Experience

- The Community Action Plan for Seismic Safety (CAPSS) Program begun in 1998 and the study completed 2010
- SPUR Disaster Planning 2001-present
- The Earthquake Safety Implementation Program (ESIP) began in early 2012 as a 30 year program.
- April, 2013, Mayor Ed Lee signed into law the Mandatory Soft Story Retrofit Ordinance.

# Incremental Policy Approach

- Learn from experience with retroactive ordinances for masonry and soft-story buildings
- Engage civic groups, owners and tenants in discussion of policy options, retrofit finance and time-lines
- Build coalitions of support for community seismic safety
- Creative incentives are essential
- Expect long planning and implementation timelines