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BUILDING A VOLUNTEER ENGINEERING NETWORK: THE EXPERIENCE OF THE CONCRETE COALITION

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ABSTRACT

The Concrete Coalition is a network of individuals, governments, institutions, and agencies with a shared interest in assessing the risk associated with dangerous non-ductile concrete buildings and developing strategies for fixing them. It is a program of the Earthquake Engineering Research Institute, the Pacific Earthquake Engineering Center (PEER) at UC Berkeley, the Applied Technology Council and their partners, including the Structural Engineering Association of California, The American Concrete Institute, BOMA of Greater Los Angeles and the U.S. Geological Survey. With funding from the California Emergency Management Agency, the Concrete Coalition is helping the state of California understand the dimensions of the problem posed by these buildings. How many are there? What kinds of strategies might be appropriate to address this problem? In tandem with the work of the Coalition, PEER is identifying the most serious deficiencies associated with older concrete buildings, to guide the discussion about what can be done about the most dangerous buildings in this class.

This paper will discuss the network and its efforts to accurately estimate how many of these buildings exist in California. Using volunteer engineers in southern northern and northern southern California, the Concrete Coalition project has developed a network where volunteers are encouraged to use various combinations of estimation techniques to come up with best estimates. In addition to volunteers providing expert judgment estimates, the Concrete Coalition is also gathering and incorporating statewide databases of buildings that will be combined with the city estimates to provide a better picture of the size and complexity of the problem associated with these older concrete buildings. Working with the individual jurisdictions, discussing the variety of data collection techniques, recruiting and working with the volunteers, and assembling the numbers will all be explored in this paper.

Introduction

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Poor seismic performance of nonductile concrete buildings has been demonstrated dramatically in recent earthquakes. Buildings designed with insufficient detailing to resist seismic loads (*nonductile)* pose a significant risk in terms of monetary loss, social disruption, and casualties. In particular, loss of life is a highly likely outcome if these buildings collapse, as evidenced in a number of earthquakes including San Fernando, California (1971); Chi Chi, Taiwan (1999); Kocaeli, Turkey (1999); and Sichuan, China (2008). Older concrete buildings without ductile detailing were constructed on California before the late 1970s and are found throughout the United States and the world. In fact, a scenario based on a repeat of the San Francisco 1906 event in the San Francisco Bay Area today confirms that a large proportion of the deaths and serious injuries would be attributable to the collapse of these nonductile concrete buildings. Unfortunately, few building officials in the major metropolitan areas of the western U.S. and Canada know how many of these buildings there are in their jurisdictions—this is an important first step in adequately understanding the potential risks.

The Concrete Coalition is a network of individuals, governments, institutions, and agencies with a shared interest in assessing the risk associated with dangerous non-ductile concrete buildings and developing strategies for fixing them (EERI 2009). It is a program of the Earthquake Engineering Research Institute, the Pacific Earthquake Engineering Center (PEER) at UC Berkeley, the Applied Technology Council and their partners. Currently, the Concrete Coalition is helping the state of California understand the dimensions of the problem posed by these buildings in this state. How many are there? What kinds of strategies might be appropriate to address this problem?

Building On PEER Grand Challenge

The National Science Foundation has funded a NEES Grand Challenge project at PEER entitled "Mitigation of Collapse Risk in Older Concrete Buildings", which aims to develop effective strategies for identifying seismically hazardous older concrete building construction and promoting effective mitigation strategies (PEER 2009). One major component of the Grand Challenge project is to develop a nonductile concrete building inventory for the study region (City of Los Angeles), to estimate collapse risk using the inventory with existing tools (e.g., HAZUS) and the best available ground motion models, to improve risk assessment tools for nonductile concrete buildings through targeted testing and numerical simulation work, and to re-assess the collapse risk with the improved tools. The inventory for the City of Los Angeles is an essential component of the Grand Challenge project.

Identifying the magnitude of the risk associated with existing buildings poses an enormous challenge. Detailed inventories of existing building stock that include appropriate risk attributes do not exist in most communities. For any sizeable city, performing a building by building inventory is prohibitively expensive. As a result, inventories may be estimated using a combination of existing databases, land use data, statistical sampling, and inference rules based on expert opinion.

PEER Grand Challenge participants have been working for more than two years, using a variety of tools, to develop an inventory of these older (pre-1976) concrete buildings in the City of Los Angeles. They are using several databases and tools, including county assessors' data, publicly available databases and Google Earth.

In parallel to the Los Angeles inventory effort, the Concrete Coalition is building a network of volunteer engineers in California who are helping gather information on the number and types of pre-1980 concrete buildings that exist in the state, and help understand the risk represented by these buildings. 1980 was selected as the cut-off date to account for those jurisdictions that may not have immediately adopted the changes in concrete design that were incorporated in the 1976 building code. This project is supported by a FEMA Hazard Mitigation Grant which is administered through the California Emergency Management Agency. The focus of this project is the 22 highest seismic risk counties in the state, primarily those counties along the coast. These counties represent 32 million people. See Figure 1.

Figure 1. Focus of the project is to collect estimates from 350+ cities in 22 high seismic risk counties (shown in yellow)

The Approach

Volunteer engineers have signed up for a city or cities in the high seismic risk counties in the state. Using a variety of techniques (see Table 1), the volunteer gathers data that he or she uses in formulating a reliable estimate of the number of pre-1980 buildings. These estimates exclude tilt-up buildings, as well as K-12 public schools, universities and hospitals, the counts for which are being imported from statewide databases.

Several guidance documents are available to help the volunteers through the process and are all available at the project website at: http://www.concretecoalition.org/ ?page_id=260&page=california_counties including:

- Presentations on the approaches used by the pilot cities

- Volunteer Guidance Manual which explains the project, provides tips from a few cities, and explains how to upload data online
- A file called WHAT TO COUNT, which explicitly identifies what types of buildings should be included in the count, a portion which is included in Figure 2.

Concrete Building Types	Count Data	Optional – Other Databases Available	Do Not Count Data
Concrete Frame with Masonry Infill	X		
Wood-frame Residential on Conc. Podium	X		
1-story Cast-in-Place Concrete with Wood Roof (including walls with pilasters)	X		
Concrete Shear Wall with Steel Gravity Frame	X		
Mixed Construction[2]	X		
Tilt-ups			X
Dual System with Concrete Shear Wall[3]			X
Parking Garages	X		
Buildings Whose Concrete Elements are Limited to Fire Walls Between Sections			X
Buildings Whose Concrete Elements are Limited to Basement or Retaining Walls			X

[2] Includes horizontal additions of concrete as well as buildings with concrete lateral load systems in one direction only.
[3] Do not need to make exceptional efforts to verify whether a building has a dual system or not, but if you know, don't count it.

Figure 2. A segment from WHAT TO COUNT instructions

Different cities require different approaches (see Table 1), which is one reason why it is important to have volunteers who are familiar with the cities participate in developing these estimates. Knowledge of local development patterns and history can be very useful. Such knowledge can also explain variations in the estimates. For example, the city of Alameda contains an old naval base, which is one reason why the estimate is so much higher than it might otherwise be for a city of a similar size (McCormick 2009). In addition, some techniques, such as using Sanborn maps, which may work in one jurisdiction, may not be appropriate in another (because the maps could be too old and outdated, for example). Sanborn maps were originally created for assessing fire risk in the urbanized U.S., and indicate the construction material on the maps. They are color-coded, so it is possible to look at Sanborn maps and count the blue buildings to get a rough estimate of the number of concrete buildings as of a certain date.

Table 1. Techniques used by volunteers in California cities (as of August 2009)

CITY	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Alameda	X	X	X	X	X			X			
Albany	X		X	X	X						
Berkeley	X			X	X	X				X	
Burlingame			X	X			X				
Calabasas				X							X [illegible]
Daly City	X		X	X			X				[illegible]
El Cerrito	X		X	X	X						
Emeryville	X			X							
Eureka		X		X	X						
Fortuna		X		X	X						
Fullerton		X	X	X	X				X		X [illegible]
Glendale	X	X	X	X	X						X [illegible]
Long Beach		X	X	X	X						
Mill Valley	X		X		X				X		
Millbrae			X	X	X						
Napa	X		X	X							
Novato		X	X	X			X				
Oakland	X		X								
Piedmont			X	X	X		X				
San Anselmo				X	X						
San Francisco	X		X	X							
San Leandro	X	X		X	X						
San Rafael	X		X		X						
Santa Monica		X	X	X	X	X					
Santa Rosa	X	X	X	X							
Solana Beach		X		X			X				X [illegible]

Volunteers enter their information online, and once approved, the reports are visible on the website by clicking in one of the high seismic risk counties (see Figure 3).

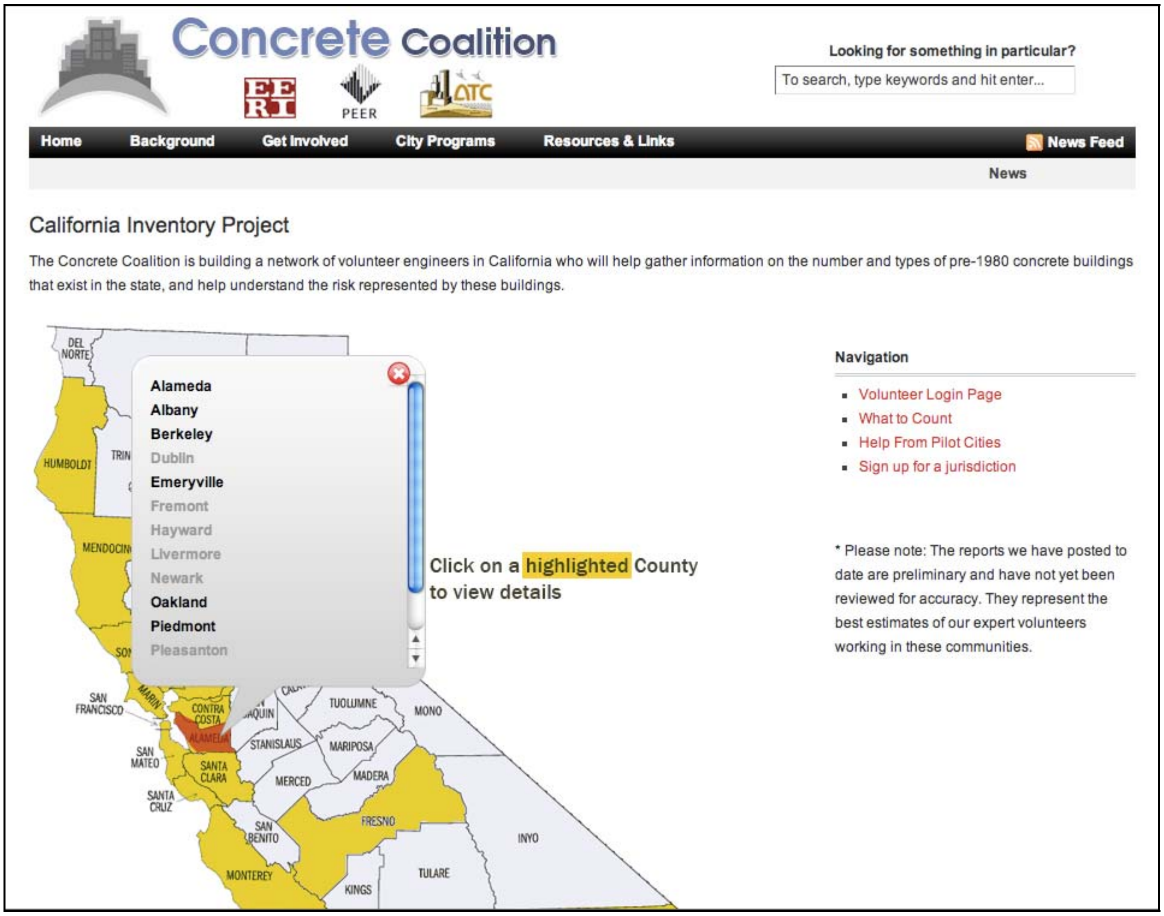

Figure 3. Map of the state with highlighted counties. User clicks on county and a list of cities pops up—cities in black are ones for which a report is available.

The project is using an online database to store the data as it comes in from volunteers. In addition to providing an estimate of the number of pre-1980 buildings, volunteers also attach files showing their field work or what tools they used to come up with their estimates. These files are being used both for quality control (to verify that estimates seem reasonable) and for future documentation, so that it will be possible to go back and understand the counts in more detail. This may end up being particularly important in the next phase of the project, when the Concrete Coalition hopes to work with individual jurisdictions to determine which of these buildings are the most vulnerable, and what mitigation strategies might be most appropriate.

Table 2 shows the estimates that have been provided by volunteers as of November 2009. Plans are currently underway to verify the counts in San Francisco and Oakland, and to re-visit cities such as San Bernardino and Riverside, where the counts seem too low for such large cities.

Table 2: Estimates from Volunteers as of November 2009

COUNTY	CITY or TOWN	REPORTED PRE-80 CONCRETE BUILDINGS
Alameda	Alameda	140 180
	Albany	35
	Berkeley	275
	Emeryville	44
	Fremont	10
	Oakland	1300
	Piedmont	8
	San Leandro	67
Contra Costa	El Cerrito	22
	Richmond	35-45
	San Ramon	0
Humboldt	Eureka	10
Los Angeles	Calabasas	2
	Glendale	160
	Long Beach	400
	Los Angeles	1500
	Pasadena	14
	Santa Monica	70
Marin	Fairfax	18
	Mill Valley	13
	Novato	18
	San Rafael	63
Napa	Napa	14
Orange	Fullerton	60
Riverside	Riverside	5
Sacramento	Elk Grove	0
San Bernardino	San Bernardino	5
San Diego	Solana Beach	3
San Francisco	San Francisco	3000
San Mateo	Burlingame	240
	Daly City	30
	Millbrae	62
	Redwood City	180
	San Mateo	180
Santa Clara	San Jose	363
Sonoma	Santa Rosa	85

Regression Model

In addition to the field estimates provided by volunteers, project staff and volunteers have also collected census data for all of the 350 cities in these higher risk counties. Professor Peter May at the University of Washington developed a regression model that can be used to estimate the number of pre-1980 concrete buildings for the remainder of the 350 cities in the high risk counties. Building from initial estimates coming in from the volunteers, and using census data that exists for each of these cities, May ultimately worked out a model that is based on the number of housing units in a city, the percentage of these units that are in buildings with 20 units or more, and the percentage of these units that were built prior to 1939 (May 2009). While this model doesn't provide numbers that are as accurate as the volunteer estimates, they appear to be in the same "ball park" (May 2009). See Table 3.

Table 3: Sample of the predictions made by regression model:

COUNTY	CITY or TOWN	VOLUNTEER ESTIMATES PRE-80 CONCRETE BUILDINGS	REGRESSION MODEL PREDICTION PRE-80 CONCRETE BUILDINGS
Alameda	Alameda	140-160	294
	Albany	36	37
	Berkeley	275	451
	Dublin		2
	Emeryville	44	53
	Fremont	10	66
	Hayward		97
	Livermore		24
	Newark		16
	Oakland	1300	1246
	Piedmont	8	0
	Pleasanton		16
	San Leandro	67	113
	Union City		12
Contra Costa	Antioch		34
	Brentwood		4
	Clayton		0
	Concord		48
	Danville		1
Contra Costa	El Cerrito	22	27
	Hercules		0
	Lafayette		9
	Martinez		31
	Moraga		1
	Oakley		3
	Orinda		9
	Pinole		8
	Pittsburg		24
	Pleasant Hill		10
	Richmond	35-45	109
	San Pablo		36
	San Ramon	0	5
	Walnut Creek		27
Humboldt	Arcata		26

Statewide Databases

In addition to the volunteer estimates, and the regression model which is based on these estimates, there are additional numbers that are currently being factored into the total estimate from various statewide databases. These include numbers of concrete buildings from public K-12 schools, hospitals, and some government buildings. In addition, numbers are being developed for the University of California and California State University systems. It is anticipated that these statewide databases will add between 1,000 and 5,000 buildings to the estimate of pre-1980 concrete buildings in the 22 counties currently part of the study.

Next Steps

The next steps will be to revise and run the regression model (as data come in from additional cities), factor in data from the statewide databases, and come up with a reliable estimate (or range) for the number of these buildings in the higher seismic risk counties of California. Then the difficult task of figuring out which of these buildings are most vulnerable and what to do about them begins.

The challenge of older concrete building extends beyond technical evaluation, design, and construction issues. These buildings impact the life safety and economic viability of the broader community. The concrete coalition is developing several initiatives to facilitate community action, building on the estimates that are coming in from volunteers.

First comes awareness. Most engineers and building officials are familiar to some degree with a potential life safety problems posed by older concrete buildings. Many building owners and community leaders are not. To best communicate with key stakeholders, the Concrete Coalition has been working to quantify the impacts. How many buildings are there? How many are dangerous? What would happen in a large earthquake? How much will it cost to fix? Past experience with unreinforced masonry buildings (URMs) and other public and private retrofit programs indicates that knowledge of the size of the problem is effective in stimulating community action.

After awareness, education is critical. What does a building owner need to do to assess the condition of a property? What will happen to the building in an earthquake? What measures can the owner and community take to avoid catastrophic losses? How will the owner or the community pay for it? The education and communication process is a two-way street. Architects and engineers need to hear from building owners and community leaders to gain insight into their perspectives and problems. Critically needed, for example, are economical evaluation techniques to identify truly dangerous buildings. The broader community cannot afford to invest blindly in mitigation that may not be necessary or efficient. The Coalition intends to extend the network developed for fostering awareness to include meetings, workshops, and seminars to exchange information among all stakeholders.

Just as innovation is needed to meet design and construction issues, creative programs for implementing and funding mitigation are essential. Seismic sustainability can be most effectively viewed in the context of building and community renewal. It needs to be incorporated into this broader context. This means effective and broadly-based public-policy initiatives implemented over reasonable time periods. These must also include financing programs to assist in funding construction. This is not without precedent. For example, the city of Los Angeles used its bonding capability to provide low-interest loans to building owners after Northridge to investigate and repair damaged steel frame buildings. It is hoped that concentrated work on these initiatives will begin in 2010.

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