A Brief History of Confined Masonry and the Development of Guidelines

Dr. Svetlana Brzev
BCIT, Vancouver, Canada
IIT Gandhinagar, India
Why Confined Masonry?

- Poor performance of unreinforced masonry and nonductile reinforced concrete (RC) frame construction caused unacceptably high human and economic losses in past earthquakes.
- This prompted a need for developing and/or promoting alternative building technologies.

The goal is to achieve enhanced seismic performance using technologies which require similar (preferably lower) level of construction skills and are economically viable.
an opportunity for improved seismic performance both for unreinforced masonry and reinforced concrete frame construction in low- and medium-rise buildings
Confined Masonry Construction: An Alternative to RC Frame Construction
Confined Masonry Construction: An Alternative to Unreinforced Masonry Construction
Confined Masonry: Beginnings

- Evolved though an informal process based on its satisfactory performance in past earthquakes
- The first reported use in the reconstruction after the 1908 Messina, Italy earthquake (M 7.2) - death toll 70,000
- Practiced in Chile and Columbia since 1930’s and in Mexico since 1940’s

Currently practiced in several countries/regions with high seismic risk, including Latin America, Mediterranean Europe, Middle East (Iran), South Asia (Indonesia), and the Far East (China).
Key Components of a Confined Masonry Building:

- **Masonry walls** made either of clay brick or concrete block units
- **Tie-columns** = vertical RC confining elements which resemble columns in reinforced concrete frame construction.
- **Tie-beams** = horizontal RC confining elements which resemble beams in reinforced concrete frame construction.
Components of a Confined Masonry Building:
Key Elements – Layout Rules

tie-column spacing \( \leq 4.0\)m

tie-columns at wall ends and intersections

tie-columns at openings

thickness \( \geq 100\)mm
Reinforced Concrete Frame Construction
Confined Masonry Construction
Confined Masonry versus Infilled RC frames:

- construction sequence
- integrity between masonry and frame

Confined Masonry
- Walls first
- Concrete later

Reinforced Concrete Infilled Frame
- Concrete first
- Walls later

Source: Tom Schacher
Confined Masonry vs RC Frames with Infills – Key Differences
Seismic Performance

- Confined masonry construction is found in countries/regions with very high seismic risk, for example: Latin America (Mexico, Chile, Peru, Argentina), Mediterranean Europe (Italy, Slovenia), South Asia (Indonesia), and the Far East (China).
- In some countries (e.g. Italy) it has been exposed to earthquakes for almost 100 years
- **If properly built**, confined masonry shows satisfactory seismic performance
Notable Earthquakes

**Confined masonry** construction has been exposed to several destructive earthquakes:

- 1985 Lloleo, Chile (magnitude 7.8)
- 1985 Mexico City, Mexico (magnitude 8.0)
- 2001 El Salvador (magnitude 7.7)
- 2003 Tecoman, Mexico (magnitude 7.6)
- 2007 Pisco, Peru (magnitude 8.0)
- 2003 Bam, Iran (magnitude 6.6)
- 2004 The Great Sumatra Earthquake and Tsunami, Indonesia (magnitude 9.0)
- 2007 Pisco, Peru (magnitude 8.0)
- 2010 Maule, Chile earthquake (magnitude 8.8)
- 2010 Haiti earthquake (magnitude 7.0)

*Confined masonry buildings performed very well in these major earthquakes – some buildings were damaged, but no human losses*
Confined Masonry Performed Very Well in Past Earthquakes

A six-storey confined masonry building remained undamaged in the August 2007 Pisco, Peru earthquake (Magnitude 8.0) while many other masonry buildings experienced severe damage or collapse.
Confined Masonry and RC Frame Construction: Performance in Recent Earthquakes

January 2010, Haiti
M 7.0
300,000 deaths

February 2010, Chile
M 8.8 521 deaths
(10 due to confined masonry construction)
Tecomán earthquake, Mexico, January 2003

Oaxaca quake, Mexico, September 1999
Confined Masonry Design Codes

Codes and Standards


Available at www.confinedmasonry.org
Global Confined Masonry Initiative

- An International Strategy Workshop on the Promotion of Confined Masonry organized in January 2008 at Kanpur, India
- Chaired by Dr. Sudhir Jain
- 19 participants from 8 countries
- The group decided to create the Confined Masonry Network
Confined Masonry Network

Main objectives:

- To improve the design and construction quality of confined masonry where it is currently in use; and

- To introduce it in areas where it can reduce seismic risk.
Confined Masonry Network: Activities

- Development of guidelines
- Online repository of resources related to confined masonry technology and its application in various countries
- Research papers, earthquake reconnaissance reports, codes, and guidelines
- Publishing papers at key conferences
- Web site managed by the Earthquake Engineering Research Institute (EERI)

www.confinedmasonry.org
Three guides at different stages of development:


2. Construction guide (under development)

3. Guide for engineered confined masonry buildings - preliminary stage
Seismic Design Guide for Low-Rise Confined Masonry Buildings

- Developed by an international volunteer committee consisting of masonry experts from 13 countries
- Recommendations based on experience from countries and regions where confined masonry construction has been practiced for many decades, including Mexico, Peru, Chile, Argentina, Iran, Indonesia, China, Algeria and Slovenia.
Authors of the Guide

- Maximiliano Astroza, Chile;
- Teddy Boen, Indonesia;
- Francisco Crisafulli, Argentina;
- Junwu Dai, China;
- Mohammed Farsi, Algeria;
- Tim Hart, USA;
- Ahmed Mebarki, France;
- A.S. Moghadam, Iran;
- Daniel Quiun, Peru;
- Miha Tomazevic, Slovenia;
- Luis Yamin, Colombia.
Guideline Development Meeting – Lima, Peru, 2009

14 participants from 10 countries
The Objectives

- To explain the mechanism of seismic response of confined masonry buildings for in- and out-of-plane seismic effects and other relevant seismic response issues;

- To recommend prescriptive design provisions related to low-rise non-engineered buildings (1 and 2-stories high), and

- To provide a summary of the seismic design provisions for confined masonry buildings from relevant international codes.
# Guide in a Nutshell

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Dissemination of Confined Masonry Technology in Engineering Community - Challenges

- Engineering community outside the countries that use confined masonry is not familiar with this technology and its benefits.
- Confined masonry not practiced in the USA and is not addressed by the masonry code (TMJC/ACI).
- Publishing of research papers a challenge in some North American journals.
- Large majority of research papers and reports published in Spanish!
Global Promotion and Recognition of Confined Masonry - Recent Developments

Special sessions on confined masonry at a few North American conferences:

1) 12\textsuperscript{th} Canadian Masonry Symposium held in Vancouver, Canada, June 2013 – paper related to confined masonry by Dr. Durgesh Rai won an award!

2) 10\textsuperscript{th} North American Masonry Conference – to be held in Anchorage, Alaska in July 2014

Initiated by members of the Confined Masonry Network!
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Confined Masonry in India

- Confined masonry in the form used in the rest of the world had not been used in India until the IIT Gandhinagar construction project (2013)
- Tradition of using confining elements in various forms since 19th century (Asam construction)
Confined Masonry in India: Initiated by Engineering Community

Confined masonry first identified as an alternative for RC frames with masonry infills by Dr. Jain in a paper Indian Earthquake Problem published in Current Science in 2005
The Indian earthquake problem

Sudhir K. Jain

After every damaging earthquake in India a lot of coverage is given in newspapers and on TV to the issues of earthquake safety. Different government agencies announce plans towards this. Many experts are interviewed on TV channels to share their wisdom on ways to mitigate such disasters. Numerous conferences are held all over the country. And, the public feels reassured that the problem of earthquake safety will now be taken care of until the next such earthquake when we again realize that not much really got done since the last event. In the backdrop of the tragic Kashmir earthquake, it is time for a sober introspection of the ‘earthquake problem in India’.

The 1931 earthquake in Mach, Baluchistan led to the construction of several earthquake-resistant railway bungalows being added at an unprecedented pace. It is a great opportunity to ensure that all new infrastructures comply with seismic requirements. Unfortunately, this is not happening. For instance:

- We must discourage construction of reinforced concrete frame buildings without competent engineering supervision. Instead, buildings with confined masonry or those with reinforced concrete shear walls are more appropriate when adequate engineering inputs are not available.
1. Published by NICEE in 2007
Author: Svetlana Brzev (Canada)

www.nicee.org
2. Published by NICEE in 2009
Author: Tom Schacher

Confined Masonry
For one and two storey buildings in low-tech environments
A guidebook for technicians

www.nicee.org
3. Published by GSDMA in 2013
Author: C.V.R. Murty and co-authors
Confined Masonry in India – Positive Development

- There is a growing awareness related to confined masonry construction
- Three workshops (2008, 2011, 2014-current) held to discuss approaches to promote confined masonry in India
- Construction of new IIT Gandhinagar campus under way (started in 2013)
- Short course on engineered design of confined masonry construction held Feb 17-21, 2014 at IIT Gandhinagar
Confined Masonry in India – Challenges

- Confined masonry is not covered by Indian codes
- Guidelines currently available in India contain somewhat different provisions – source of confusion for potential users
- There is no document that provides rational basis for analysis and design of confined masonry which would help identify required provisions for different building applications
Future Needs

- Create a consensus document that provides rational basis for seismic design of confined masonry buildings
- The document need to provide material for future code provisions (IS 1905)