

Rammed Earth on the Edge

RE and the North American Building Codes

By

Bly Windstorm

Early 20th Century – North America

**Stateburn, SC. USA
1850**



**King County, Ontario Canada
1937**



Early 20th Century – North America

**Cameron Valley, VA USA
1942**



**Cameron Valley, VA USA
1942**



Late 20th Century

**Vashon Island, WA
1994**



- With the exception of NM, rammed earth is not in the building code.
- Local & National building codes lag behind the current knowledge of materials

Inconsistent Oversight

Art Project

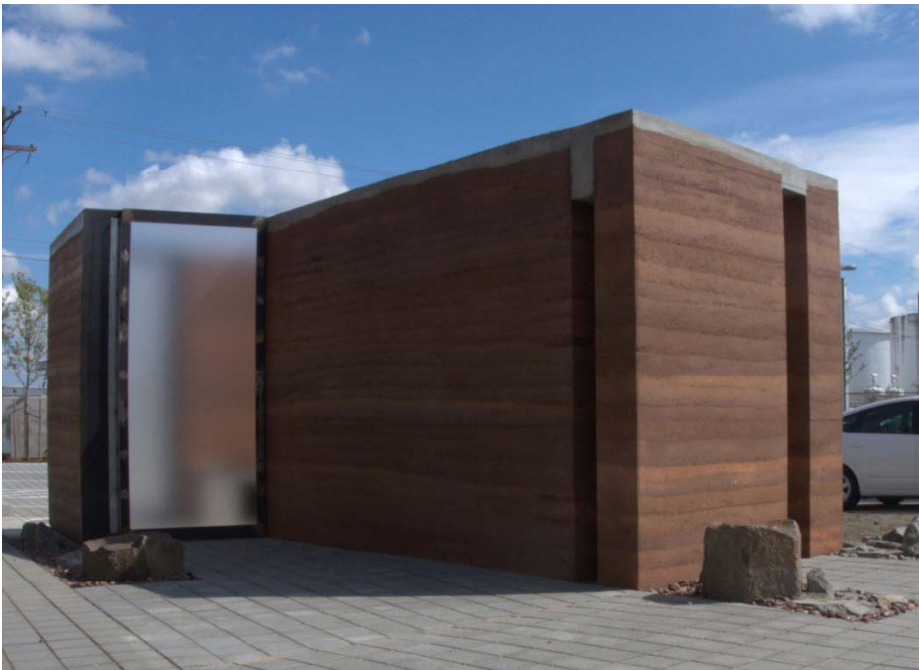
Difficult Permitting Process

Special Inspections

Education Center

Simple Permitting Process

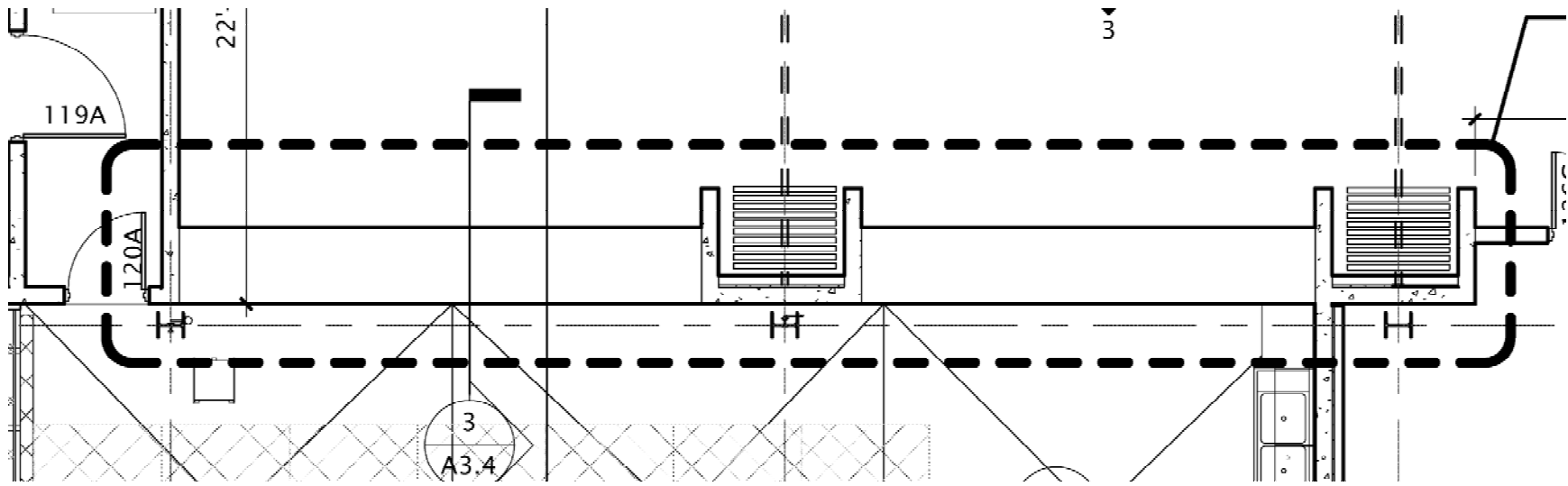
Limited inspections of RE



Design and Engineering Challenges

Plan View of Commercial Project on Bid Set
Engineering T.B.D.

Two RE Walls initially not considered a structural element
Wall Dimensions - 20' long, 14' tall, 2' thick



Permitting Challenges

Single story – Residential

2500 psi. SRE not considered a structural material for roof loads



How did this happen?

Worst Case

- Special preconditions to permit approval
- Special inspections required
- Delayed permitting process
- SRE material not used as structural component of project

Best Case

- Engineered drawings accepted
- Inspection process that accommodates the SRE building process
- Healthy oversight and reasonable Quality Control
- SRE is recognized as a structural component

Documents used to assist with design specifications and permitting

- New Mexico Earthen Building Materials Code
- ASTM E2392/E2392M – Standard Guide for Design of Earthen Wall Building Systems
- NAREBA Rammed Earth Specifications and Standards

New Mexico Earthen Building Materials Code

- Revised in 2009
- Provides a statutory code for RE, SRE, Compressed Block (CEB), and Adobe
- Comprehensive
- Applicable only in NM

RE/SRE in the New Mexico E.B.C.

- Qualifies soil types
 - 300 psi. minimum compression strength
 - 50 psi. modulus of rupture
 - SRE must contain 6% portland cement by weight
 - Maximum aggregate size 1-1/2"
- Provides tables for wall thickness/wall height limits
- Requires exterior stucco for “unqualified” earth mixes
- Specifies requirements for Bond Beam steel reinforcing, size, connections and cold joint placement
- Defines Lintel spans, sizes and reinforcing requirements
- Provides requirements for buttresses, lateral support details, and limitations for voids and nailers.
- Provides limitations for wall openings and connection details

ASTM-Standard Guide for Design of Earthen Wall Building Systems

- Revised in 2010
- Scope includes Adobe, SRE/RE, Cob, and Cast Earth
- Intended “for use in framing decisions for individual projects” and “for use in the development of standards and building codes for earthen building systems”
- Comprehensive
- Contains Appendix X1- Empirical Design and Minimum Detailing Requirements for Earthen Structures

ASTM - Manufacturing Energy Inputs

- Finds that unstabilized earthen building systems are “substantially more energy efficient” to produce than fired clay masonry, concrete masonry and cement stabilized earthen building materials.
- Unstabilized systems are more energy efficient to manufacture than even most wood systems due to the additional energy inputs required for transport and fabrication
- “Stabilized earthen building systems use slightly more embodied energy” in their manufacture

ASTM - Thermal Efficiency

- Earthen building systems (uninsulated) provide thermal storage but little insulation
- Insulation is recommended where maximum and minimum daily temperatures are above or below the desired indoor temperature for several consecutive days at a time
- Buildings generally have good indoor air quality

ASTM - Technical Findings

- “Stabilized earth, especially cement-stabilized earth, belongs more under the purview of existing standards for concrete and concrete masonry construction”
- Engineers have already been using the concrete and masonry code to engineer these structures around the world

ASTM - Technical Findings

- “Design of cement-stabilized RE walls with steel reinforcing bars can make use of established structural design methods for reinforced concrete, except that minimum reinforcing steel requirements can, and usually must, be relaxed to allow access for thorough and dense ramming of the material within the formwork”
- “Material strengths and other key properties should be reliably established”

ASTM - Appendix X1

- This is intended for situations where engineering design is not “feasible or available”
- And where access to cement and reinforcing steel is uneconomical
- The provisions are limited to one story structures where earthquakes pose medium or high risk to inhabitants

ASTM - Appendix X1

- Material selection and simple mix testing is recommended.
- Reinforcing with organic fibers/tensile tests
- “successful” buildings will survive three generations without substantial maintenance
- Bond beams, collar ties, out of plane anchorage, and a limit on the height to thickness ratio are recommended in areas of seismic risk
- Containment reinforcing, lightweight roof frames, and a robust wall layout are also recommended

NAREBA Rammed Earth Specifications and Standards

- Completed in 2008
- Intended to help fill the void created by the lack of uniform standards in the RE industry
- Provides a minimum building standard for SRE construction
- Incorporated into the construction documents for several residential & commercial projects in the US and Canada



NAREBA Rammed Earth Specifications and Standards

- NAREBA certified builders use this as a minimum standard
- Structural RE walls must be engineered and stamped by a registered professional engineer
- Minimum compressive strength is 900 psi
- Establishes a mix design testing protocol
- Requires a mock up test element for each project
- Establishes minimum wall thicknesses



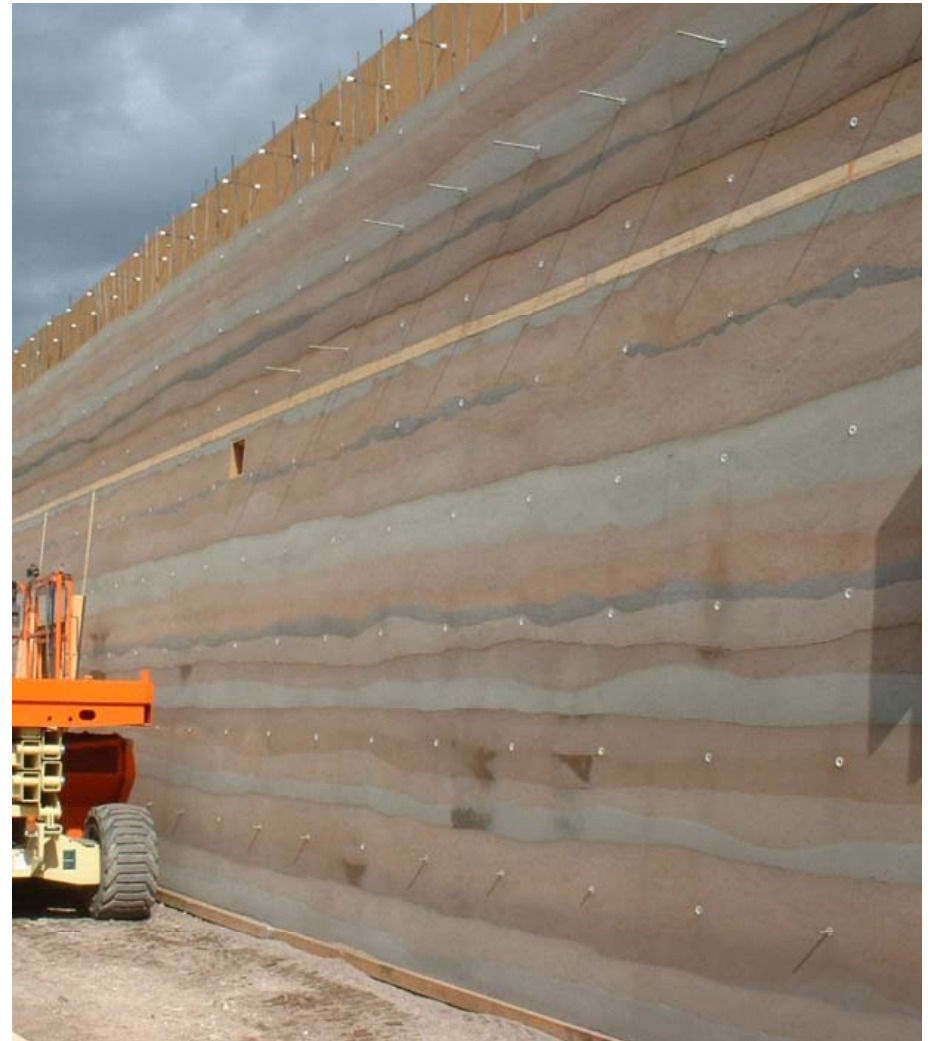
NAREBA Rammed Earth Specifications and Standards

- Describes approved insulation types
- Outlines moisture prevention strategies
- Sealant recommendations
- Guidelines for the mixing, placing, and curing during construction
- Hot and cold weather placement guidelines



NAREBA Rammed Earth Specifications and Standards

- Has helped establish the legitimacy of RE with skeptical building jurisdictions
- Educates permitting jurisdictions with no previous RE experience
- It has limited the consequences from other sources of inaccurate information
- Establishes SRE as a structural component
- Provides a template for mix design and quality control protocols
- Provides design guidance for other professionals



Final Thoughts

- Using the existing concrete code provides a workable, if imperfect, path for SRE projects
- Typically results in a higher compressive strength, which requires more cement than may be necessary to make “successful” structures
- More testing of the SRE material is necessary

Acknowledgements

- Unknown Early 20th Century Photos source
- Rammed Earth Is For Everyone -rammedearth.blogspot.com & LIFE magazine for 1940's RE photos
- Tom Lambe – RE photo of Kappleman Residence
- 2009 New Mexico Earthen Building Materials Code – Title 14, Chapter 7, Part 4, 2009
- ASTM E2392/2392M-10 Standard Guide for Design of Earthen Wall Building Systems, 2010
- NAREBA- www.NAREBA.org – Rammed Earth Specifications & Standards, 2008