CURRENT ARIZONA PRACTICE
and
OBSERVATIONS OF THE WESTMORLAND EARTHQUAKE

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ABSTRACT Overview report of adobe practices and codes in Arizona. Observations and practices of Robert E. Barnes, Architect and Adobe Builder. Photos and observations of The Westmorland Earthquake of April 28, 1981.

Current Arizona Practice

A renaissance of Earth Construction has been occuring in Arizona over the last five years. Stimulated by the need for energy efficiency, high thermal mass structures utilizing earth techniques of adobe and rammed earth are being built by numerous contractors, and owner-builders throughout central and southern Arizona.

Practically all structures now being built are single family residences, most limited to one story, and most are sponsored by owner-builders or adobe oriented small custom builders. No earth structures have been constructed by the large mass builders, who supply 90% of the housing units within the state, or by goverment in public housing projects. Only a church built of rammed earth in Saint David, Arizona has been built for institutional or commercial purposes.

This limited start for earth structures has been stimulated by the nontraditional craft oriented builders and has been widely publicized. Public response to the renaissance has been very high with the founding of several adobe associations.

While current construction volumn is low due to the high interest rates on home mortgages, subcontractors who are currently short of work are becoming more interested in adobe.

Few architects, and fewer engineers, have expressed interest in adobe, and the state of earth building appears to be non industrial, local, and traditional. Few, if any, structures are designed for seismic forces and local codes have been stimulated by political pressure of adobe's historic rather than its technical nature.

Most builders, especially the owner-builders, have tried to avoid involvement of structural analysis professions in their projects beyond simple tabled evaluations of roof structures.

Codes

Local jurisdictions in Arizona are responsible for preparation and adoption of building codes and most have adopted the Uniform Building Code as their basic code. Several counties have no codes at all and there is strong political pressure to avoid them. Several cities and counties within Arizona have adopted local adobe codes to be used in conjunction with the U. B. C., but which are more substantive than the U. B. C. references to adobe. Most of the local code ammendments are derived from the New Mexico Code and all vary in detail. Many do not require

seismic analysis for residential structures despite the U.B.C. designation of Zone 2 for most of Arizona.*

All of the local ammendments are specific codes rather than performance largely due to the nonengineering orientation of the adobe builders.

Most local codes do not require the minimum percentage of steel (UBC Section 2418j3) required for masonry structures in seismic Zone 2 with Maricopa County being the exception.

Construction techniques as required by the local codes are based upon the accepted standards for well built adobe structures but have not been innovative or liberal in allowing design professionals latitude in solving the seismic solution.

Code bodies, although cooperative in allowing adobe, have been resistant to allowing adobe out of the home construction market.

As previously mentioned Maricopa County has required steel reinforcing as specified in UBC Section 2418j3 for adobe construction with the apparent intent to provide ductility for seismic loading. This structural concept of heavy gage steel reinforcing for earth structures is in my opinion without sound engineering logic. Earth structures have few similar properties to concrete and fired brick structural systems. The shock absorbing properties and non brittle properties of earth construction have not been reflected in current codes. Techniques appropriate to concrete masonry such as heavy gage grouted steel reinforcing and anchor bolts are in sharp contrast to earth's lower allowable stresses and higher shock absorbing qualities.

It seems that new conceptual thinking is required for earth construction. Simply applying structural methods from other building materials can be misleading and structurally inadequate.

F. H. A.

F. H. A., H U D, and federal agencies have been mixed in their support for earth construction. While funding an adobe training yard for the Tucson Barrio Association they have offered no assistance in drafting F. H. A. property standards for adobe construction which would provide mortgage loan guarantees. F. H. A. loan

* 1. International Conference of Building Officials, Uniform Building Code, International Conference of Building Officials, Whittier, California (1979)

guarantees now are are used by 75% of the Tucson Homebuilders and it is obvious that without such programs earth construction has and will be restricted.

F. H. A.'s major concern seems to be seismic design of adobe structures and unless the science of such engineering is improved earth building on a large scale will be limited.

The Department of Housing and Urban Development through the Federal Housing Administration has on repeated occasion stated that the adobe industry has not presented sufficient technical data to support guarantees for loans, somehow forgetting the substantial role the federal government had in the 1940's and 1950's testing and encouraging adobe and rammed earth use.

The National Bureau of Standards sponsored testing of Earthen Structures in 1941 and published its findings in a report "Structural, Heat-Transter, and Water Permeability Properties of Five Earthwall Construction."* In this study structural properties of wall specimens under compressive, transverse, concentrated, impact, and racking loads were performed.

In March, 1955 the U. S. Department of Housing and Urban Development published an article "Earth for Homes."* In this publication they state "in the opinion of some authorities well bonded earth will withstand seismic loads of moderate intensity if properly incorporated into a building of low, compact, and regular plan. In this case well bonded bearing walls should have a slenderness ratio not greater than eight. The foundations should be monolithic and a substantial continuous reinforced concrete bond beam should be placed on top of the wall bonded to all wall plates. Lightweight ceilings and roof should be used, with the trusses or rafters and joists tied together and so placed on the plate as to avoid eccentric wall loading. Ceiling and roofs, should be anchored to both side and end walls and constructed to serve as diaphragms to resist distortion."

Earth construction without a technically supported and strong federal lobbying effort will not be able to win over the Federal Agencies.

Current Work by Robert E. Barnes & Associates, Inc.

Our work in earthen structures has involved design and construction of five stabilized adobe homes in Tucson and design of three others not yet constructed

* 2. Herbert L. Whittemore, et al, Structural, Heat-Transfer, and Water Permeability Properties of Five Earthwall Construction, National Bureau of Standards, Washington, D.G.,(1941).

3. U.S. Department of Housing and Urban Development, Earth for Homes, Washington, D.C., (1955).

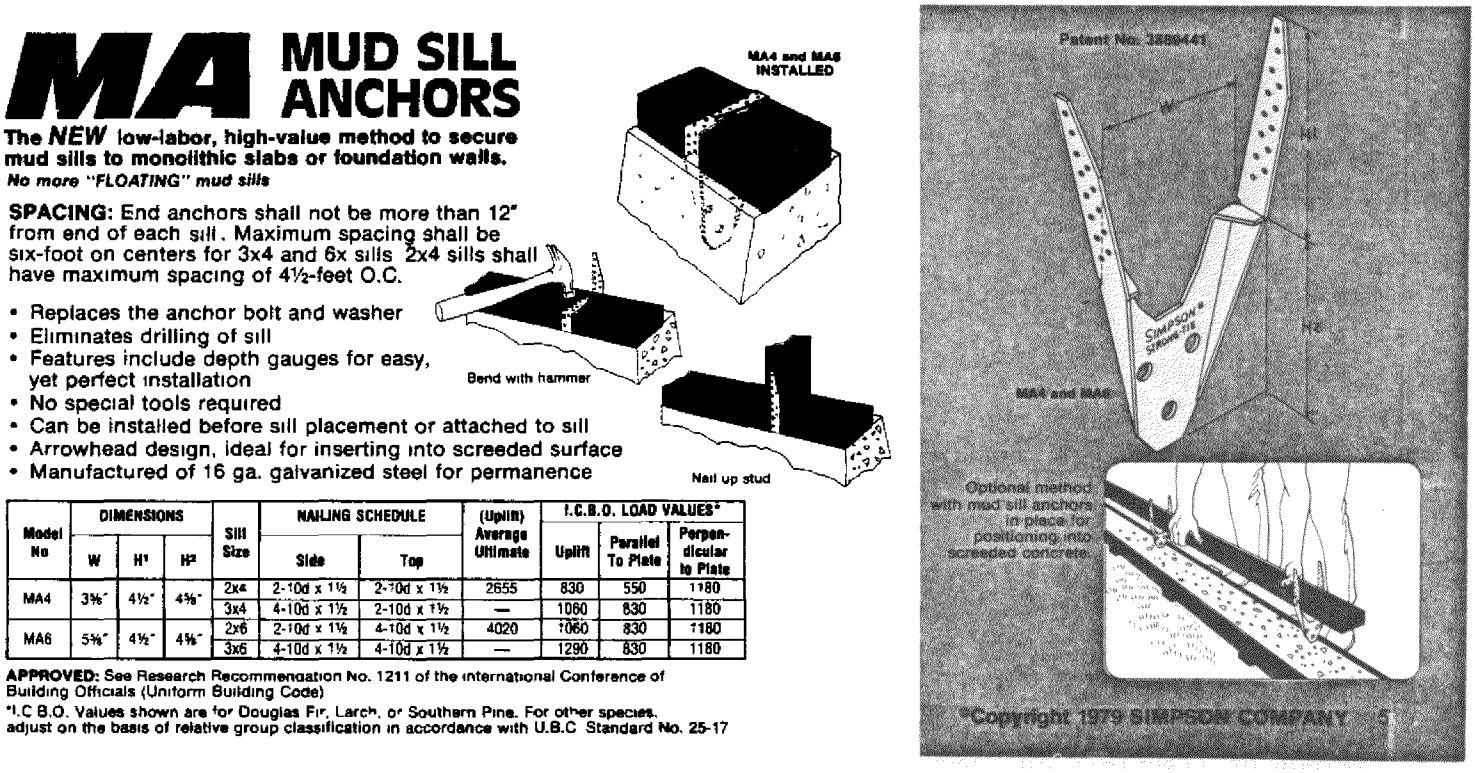
plus a prototype solar adobe rental unit which would be built in multiple groups.

Several structural techniques have emerged from this work. Our homes have been constructed of 14" thick stabilized Adobe Masonry Units (10" x 14" x 3½") laid with full head and bed joints of stabilized adobe mortar. Nine gage by twelve inch wide "Durowall" ladder or truss type joint reinforcing has been placed 16" o.c. horizontally throughout the structures and at every course, five courses thick, at the bond beam. We have used no concrete bond beam but refer to this connection as the "zone of reinforcing." All walls are supported by continuous concrete footing and stem walls.

Several methods of roof attachment have been designed, two have been constructed. Our first two homes were constructed in accordance with local code requirements utilizing 1/2" x 20" anchor bolts. This method of attaching the roof to the wall proved too costly and in retrospect structurally insufficient due to the concentration of forces at the bolts.

Our next three homes utilized roof joists set into the wall, each joist anchored by a "Simpson Mud Sill Anchor".* This device shown in FIG. 1 transfers forces from the joists to the wall.

FIG. 1



MA MUD SILL ANCHORS

The *NEW* low-labor, high-value method to secure mud sills to monolithic slabs or foundation walls.

No more "FLOATING" mud sills

SPACING: End anchors shall not be more than 12" from end of each sill. Maximum spacing shall be six-foot on centers for 3x4 and 6x sills 2x4 sills shall have maximum spacing of 4½-feet O.C.

- Replaces the anchor bolt and washer
- Eliminates drilling of sill
- Features include depth gauges for easy, yet perfect installation
- No special tools required
- Can be installed before sill placement or attached to sill
- Arrowhead design, ideal for inserting into screeded surface
- Manufactured of 16 ga. galvanized steel for permanence

MA4 and MA6 INSTALLED

Bend with hammer

Nail up stud

Model No	DIMENSIONS W	H¹	H²	Sill Size	NAILING SCHEDULE Side	Top	(Uplift) Average Ultimate	I.C.B.O. LOAD VALUES² Uplift	Parallel To Plate	Perpendicular to Plate
MA4	3⅜"	4½"	4⅝"	2x4	2-10d x 1½	2-10d x 1½	2655	830	550	1180
				3x4	4-10d x 1½	2-10d x 1½	—	1060	830	1180
MA6	5⅜"	4½"	4⅝"	2x6	2-10d x 1½	4-10d x 1½	4020	1060	830	1180
				3x6	4-10d x 1½	4-10d x 1½	—	1290	830	1180

APPROVED: See Research Recommendation No. 1211 of the International Conference of Building Officials (Uniform Building Code)

¹I.C.B.O. Values shown are for Douglas Fir, Larch, or Southern Pine. For other species, adjust on the basis of relative group classification in accordance with U.B.C Standard No. 25-17

Patent No. 3889441

W

H1

H2

SIMPSON STRONG-TIE

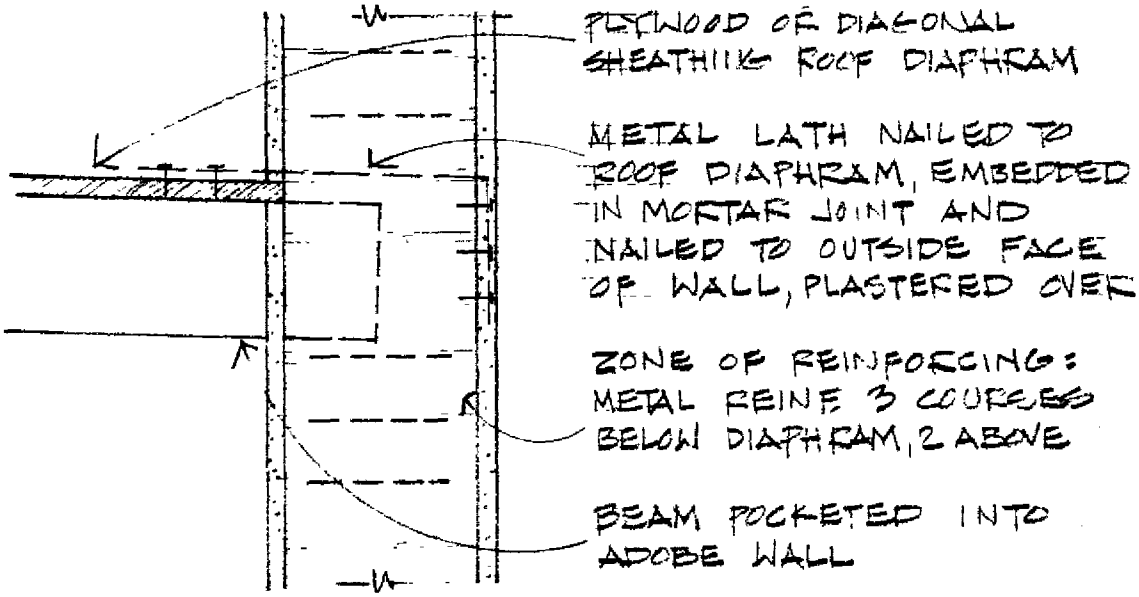
MA4 and MA6

Optional method with mud sill anchors in place for positioning into screeded concrete.

* 4. Handbook of Structural Designs & Load Values, Simpson Company, San Leandro, California, 1979 (Reproduced with their permission).

Current designs utilize "Low Stress" detailing methods. Transverse loads transferred to and from a lightweight wood or plywood roof diaphram are continuously transferred to the wall system utilizing expanded metal lath laid into the wall and attached to the diaphram. No anchors are needed on the joists. No bolts are used (FIG. 2).

FIG. 2



We feel this system to be economical and the most structurally sensible method of transferring loads between the wall and roof system.