



Approved Standard for Earthen IRC Structures

Earthen Wall Structures

Section R614.1 General. Earthen wall structures in Seismic Design Category A, B or C with basic wind speed of 90 mph or less with wind exposure category of A, B, or C may be designed and constructed in accordance with the provisions of this Standard.

This Section shall comply with the seismic requirements of the *International Residential Code*.

Exception: Structures with any site conditions may be designed with accepted engineering practice for earthen wall structures and the provisions of the approved Standard for IBC Earthen Structures.

Section R614.1.1 Earthen materials. This section shall establish minimum standards for safety for construction of earthen materials structures, collectively known as adobe, rammed earth, and hydraulic pressed unit construction.

Section R614.1.2 Professional registration not required. When the empirical design provisions of this standard are used to design wall systems, project drawings, typical details and specifications are not required to bear the seal of an architect or engineer.

Section R614.1.3 Professional registration required. When the earthen structure exceeds the empirical design provisions of this standard, the plans and specifications shall be prepared by an Arizona Registrant. All such projects shall be designed in accordance with the approved Standard for IBC Earthen Structures.

Section R614.2 Dimensions of earth walls. Dimensions of earthen walls shall conform to the requirements of this section.

Section R614.2.1 Thickness and Height. The minimum thickness and maximum height of earthen walls and parapets shall be in accordance with Tables R614.2.1 (1 to 6) based upon the S_d value for the project site. Wall thickness shall be measured from face to face of walls with concave joints. Walls with rake joints shall be measured surface of joint to surface of joint. The thickness of wall sections shall not be combined without full cross bonding of the masonry units throughout the wall.

Exception: Walls supported only at ground level and only supported at the base of the wall shall be limited to a height of $\frac{1}{2}$ that allowed by Tables R614.2.1 (1 to 6).

Table R614.2.1 (1)

Seismic Sites with Sds

0.00 TO 0.25

Assuming zero tension out-of-plane

	10	11	12	Actual Wall thickness (in) 13	14	15	16	18	20	22	24
				Maximum Wall Heights (inches)							
EXTERIOR	NP	83	99	116	135	144	144	144	144	144	144
INTERIOR	127	140	144	144	144	144	144	144	144	144	144
PARAPET	NP	22	24	26	28	30	32	36	40	44	48
				Bond Beam Size and Steel Requirements All Bond Beams 8" Minimum Height							
EXTERIOR WALL NO PARAPET											
TYPE "A"	2 - #4	2 - #4	2 - #5	2 - #5	2 - #5	2 - #5	2 - #4	2 - #4	2 - #4	2 - #4	2 - #4
TYPE "B"	2 - #5	2 - #5	2 - #5	4 - #4	4 - #4	4 - #4	2 - #5	2 - #4	2 - #4	2 - #4	2 - #4
TYPE "C"	NP	NP	NP	NP	NP	4 - #5	4 - #4	2 - #4	2 - #4	2 - #4	2 - #4
EXTERIOR WALL with FULL PARAPET											
TYPE "A"	2 - #4	2 - #4	2 - #5	2 - #5	2 - #5	2 - #5	2 - #4	2 - #4	2 - #4	2 - #4	2 - #4
TYPE "B"	2 - #5	2 - #5	2 - #5	4 - #4	4 - #4	4 - #4	2 - #5	2 - #4	2 - #4	2 - #4	2 - #4
TYPE "C"	NP	NP	NP	NP	NP	4 - #5	4 - #4	2 - #4	2 - #4	2 - #4	2 - #4
INTERIOR WALL with infill between beams											
TYPE "A"	2 - #4	2 - #4	2 - #5	2 - #5	2 - #5	2 - #5	2 - #4	2 - #4	2 - #4	2 - #4	2 - #4
TYPE "B"	2 - #5	2 - #5	2 - #5	4 - #4	4 - #4	4 - #4	2 - #5	2 - #4	2 - #4	2 - #4	2 - #4
TYPE "C"	NP	NP	NP	NP	NP	4 - #5	4 - #4	2 - #4	2 - #4	2 - #4	2 - #4

NP = This wall not permitted.

Table R614.2.1 (2)

Seismic Sites with Sds

0.25 TO 0.30

Assuming zero tension out-of-plane

	10	11	12	Actual Wall thickness (in) 13	14	15	16	18	20	22	24
				Maximum Wall Heights (inches)							
EXTERIOR	NP	83	99	116	135	144	144	144	144	144	144
INTERIOR	106	116	127	137	144	144	144	144	144	144	144
PARAPET	NP	22	24	26	28	30	32	36	40	44	48
				Bond Beam Size and Steel Requirements							
				All Bond Beams 8" Minimum Height							
EXTERIOR WALL											
NO PARAPET											
TYPE "A"	2 - #4	2 - #5	2 - #5	2 - #5	4 - #4	4 - #4	2 - #5	2 - #4	2 - #4	2 - #4	2 - #4
TYPE "B"	2 - #5	4 - #4	4 - #4	4 - #5	4 - #5	4 - #5	4 - #4	2 - #5	2 - #4	2 - #4	2 - #4
TYPE "C"	NP	NP	NP	NP	NP	4 - #5	4 - #5	2 - #5	2 - #4	2 - #4	2 - #4
EXTERIOR WALL											
with FULL PARAPET											
TYPE "A"	2 - #4	2 - #5	2 - #5	2 - #5	4 - #4	4 - #4	2 - #5	2 - #4	2 - #4	2 - #4	2 - #4
TYPE "B"	2 - #5	4 - #4	4 - #4	4 - #5	4 - #5	4 - #5	4 - #4	2 - #5	2 - #4	2 - #4	2 - #4
TYPE "C"	NP	NP	NP	NP	NP	4 - #5	4 - #5	2 - #5	2 - #4	2 - #4	2 - #4
INTERIOR WALL											
with infill between beams											
TYPE "A"	2 - #4	2 - #5	2 - #5	2 - #5	4 - #4	4 - #4	2 - #5	2 - #4	2 - #4	2 - #4	2 - #4
TYPE "B"	2 - #5	4 - #4	4 - #4	4 - #5	4 - #5	4 - #5	4 - #4	2 - #5	2 - #4	2 - #4	2 - #4
TYPE "C"	NP	NP	NP	NP	NP	4 - #5	4 - #5	2 - #5	2 - #4	2 - #4	2 - #4

NP = This wall not permitted.

BOND BEAM LOAD	46	61	79	100	125	125	108	80	42	0	0
BOND BEAM LOAD	81	103	130	160	194	204	198	194	183	171	203
BOND BEAM LOAD	84	100	118	137	150	151	152	155	158	161	164

Table R614.2.1 (3)

Seismic Sites with Sds

0.30 TO 0.35

Assuming zero tension out-of-plane

	10	11	12	Actual Wall thickness (in) 13	14	15	16	18	20	22	24
				Maximum Wall Heights (inches)							
EXTERIOR	NP	83	99	116	127	136	144	144	144	144	144
INTERIOR	91	100	109	118	127	136	144	144	144	144	144
PARAPET	NP	22	24	26	28	30	32	36	40	44	48
				Bond Beam Size and Steel Requirements All Bond Beams 8" Minimum Height							
EXTERIOR WALL NO PARAPET											
TYPE "A"	2 - #5	2 - #5	2 - #5	4 - #4	4 - #4	4 - #5	4 - #5	4 - #4	2 - #5	2 - #4	2 - #4
TYPE "B"	4 - #4	4 - #4	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #4	2 - #5	2 - #4	2 - #4
TYPE "C"	NP	NP	NP	NP	NP	4 - #6	4 - #6	4 - #5	4 - #4	2 - #5	2 - #4
EXTERIOR WALL with FULL PARAPET											
TYPE "A"	2 - #5	2 - #5	2 - #5	4 - #4	4 - #4	4 - #5	4 - #5	4 - #4	2 - #5	2 - #4	2 - #4
TYPE "B"	4 - #4	4 - #4	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #4	2 - #5	2 - #4	2 - #4
TYPE "C"	NP	NP	NP	NP	NP	4 - #6	4 - #6	4 - #5	4 - #4	2 - #5	2 - #4
INTERIOR WALL with infill between beams											
TYPE "A"	2 - #5	2 - #5	2 - #5	4 - #4	4 - #4	4 - #5	4 - #5	4 - #4	2 - #5	2 - #4	2 - #4
TYPE "B"	4 - #4	4 - #4	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #4	2 - #5	2 - #4	2 - #4
TYPE "C"	NP	NP	NP	NP	NP	4 - #6	4 - #6	4 - #5	4 - #4	2 - #5	2 - #4

NP = This wall not permitted.

BOND BEAM LOAD	53	71	92	117	137	157	176	156	127	88	40
BOND BEAM LOAD	94	121	151	186	218	250	281	289	291	287	277
BOND BEAM LOAD	86	103	120	140	160	182	203	206	210	213	216

Table R614.2.1 (4)

Seismic Sites with Sds

0.35 TO 0.40

Assuming zero tension out-of-plane

	10	11	12	Actual Wall thickness (in) 13	14	15	16	18	20	22	24
				Maximum Wall Heights (inches)							
EXTERIOR	NP	83	95	103	111	119	127	143	144	144	144
INTERIOR	79	87	95	103	111	119	127	143	144	144	144
PARAPET	NP	22	24	26	28	30	32	36	40	44	48
				Bond Beam Size and Steel Requirements All Bond Beams 8" Minimum Height							
EXTERIOR WALL NO PARAPET											
TYPE "A"	2 - #5	2 - #5	4 - #4	4 - #4	4 - #4	4 - #5	4 - #5	4 - #5	4 - #4	2 - #5	2 - #5
TYPE "B"	4 - #4	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #4	2 - #5
TYPE "C"	NP	NP	NP	NP	NP	4 - #6	4 - #6	4 - #6	4 - #5	4 - #5	2 - #5
EXTERIOR WALL with FULL PARAPET											
TYPE "A"	2 - #5	2 - #5	4 - #4	4 - #4	4 - #4	4 - #5	4 - #5	4 - #5	4 - #4	2 - #5	2 - #5
TYPE "B"	4 - #4	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #4	2 - #5
TYPE "C"	NP	NP	NP	NP	NP	4 - #6	4 - #6	4 - #6	4 - #5	4 - #5	2 - #5
INTERIOR WALL with infill between beams											
TYPE "A"	2 - #5	2 - #5	4 - #4	4 - #4	4 - #4	4 - #5	4 - #5	4 - #5	4 - #4	2 - #5	2 - #5
TYPE "B"	4 - #4	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #4	2 - #5
TYPE "C"	NP	NP	NP	NP	NP	4 - #6	4 - #6	4 - #6	4 - #5	4 - #5	2 - #5

NP = This wall not permitted.

BOND BEAM LOAD	61	81	101	118	137	157	179	227	211	181	142
BOND BEAM LOAD	108	138	168	198	229	263	299	379	399	409	412
BOND BEAM LOAD	89	105	123	143	163	186	209	260	268	272	276

Table R614.2.1 (5)

Seismic Sites with Sds

0.40 TO 0.45

Assuming zero tension out-of-plane

	10	11	12	Actual Wall thickness (in) 13	14	15	16	18	20	22	24
				Maximum Wall Heights (inches)							
EXTERIOR	NP	78	85	92	99	106	113	127	141	144	144
INTERIOR	70	78	85	92	99	106	113	127	141	144	144
PARAPET	NP	22	24	26	28	30	32	36	40	44	48
				Bond Beam Size and Steel Requirements							
				All Bond Beams 8" Minimum Height							
EXTERIOR WALL											
NO PARAPET											
TYPE "A"	2 - #5	2 - #5	4 - #4	4 - #4	4 - #4	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #4
TYPE "B"	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #6	4 - #5	4 - #5
TYPE "C"	NP	NP	NP	NP	NP	4 - #6	4 - #6	4 - #6	4 - #6	4 - #6	4 - #5
EXTERIOR WALL											
with FULL PARAPET											
TYPE "A"	2 - #5	2 - #5	4 - #4	4 - #4	4 - #4	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #4
TYPE "B"	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #6	4 - #5	4 - #5
TYPE "C"	NP	NP	NP	NP	NP	4 - #6	4 - #6	4 - #6	4 - #6	4 - #6	4 - #5
INTERIOR WALL											
with infill between beams											
TYPE "A"	2 - #5	2 - #5	4 - #4	4 - #4	4 - #4	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #4
TYPE "B"	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #6	4 - #5	4 - #5
TYPE "C"	NP	NP	NP	NP	NP	4 - #6	4 - #6	4 - #6	4 - #6	4 - #6	4 - #5

NP = This wall not permitted.

BOND BEAM LOAD	68	85	101	118	137	157	179	227	280	274	243
BOND BEAM LOAD	121	149	177	208	241	276	314	398	491	530	548
BOND BEAM LOAD	91	108	126	146	167	189	213	265	322	339	343

Table R614.2.1 (6)

Seismic Sites with Sds

0.45 TO 0.50

Assuming zero tension out-of-plane

	10	11	12	Actual Wall thickness (in) 13	14	15	16	18	20	22	24		
				Maximum Wall Heights (inches)									
EXTERIOR	NP	70	76	82	89	95	101	114	127	140	144		
INTERIOR	63	70	76	82	89	95	101	114	127	140	144		
PARAPET	NP	22	24	26	28	30	32	36	40	44	48		
				Bond Beam Size and Steel Requirements All Bond Beams 8" Minimum Height									
EXTERIOR WALL NO PARAPET													
TYPE "A"	2 - #5	2 - #5	4 - #4	4 - #4	4 - #4	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5		
TYPE "B"	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #6	4 - #6	4 - #5		
TYPE "C"	NP	NP	NP	NP	NP	4 - #6	4 - #6	4 - #6	4 - #6	4 - #6	4 - #6		
EXTERIOR WALL with FULL PARAPET													
TYPE "A"	2 - #5	2 - #5	4 - #4	4 - #4	4 - #4	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5		
TYPE "B"	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #6	4 - #6	4 - #5		
TYPE "C"	NP	NP	NP	NP	NP	4 - #6	4 - #6	4 - #6	4 - #6	4 - #6	4 - #6		
INTERIOR WALL with infill between beams													
TYPE "A"	2 - #5	2 - #5	4 - #4	4 - #4	4 - #4	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5		
TYPE "B"	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #5	4 - #6	4 - #6	4 - #5		
TYPE "C"	NP	NP	NP	NP	NP	4 - #6	4 - #6	4 - #6	4 - #6	4 - #6	4 - #6		

NP = This wall not permitted.

BOND BEAM LOAD	70	85	101	118	137	157	179	227	280	338	345
BOND BEAM LOAD	129	156	185	218	252	290	330	417	515	623	683
BOND BEAM LOAD	93	110	129	149	170	193	217	269	327	390	417

Section R614.2.2 Maximum length. The maximum length of any earthen wall laterally braced by Bond Beams per Section R614.5.2 shall be 20 feet between perpendicular bracing walls. Any wall in excess of 20 feet shall be designed in accordance with the approved Standard for IBC Earthen Structures.

Section R614.3 Support conditions. Earthen walls shall be supported on a solid concrete, solid masonry foundation system the width of which shall be not be less than 1/2 inch narrower than the earthen wall which it supports. Earthen structures shall not be less than 6 inches above adjacent grade.

Section R614.3.1 Moisture barrier. A moisture barrier equal to 30 lb asphalt impregnated building paper, or equivalent moisture resistant barrier, shall be installed between the supporting foundation and the earthen wall material.

Section R614.4 Allowable stresses. Allowable compressive, tensile and shear stresses in earthen walls shall not exceed the values prescribed in Table R614.4. In determining the stresses in masonry, the effects of all loads and conditions of loading and the influence of all forces affecting the design and strength of the several parts shall be taken into account. Bolts in shear shall be limited to those values in *International Building Code* Table 2109.3.3.1.

Section R614.4.1 Combined units. In walls composed of different kinds or grades of units, materials or mortars, the maximum stress shall not exceed the allowable stress for the weakest of the combination of units, materials and mortars of which the wall is composed. The net thickness of any facing unit of earthen materials used to resist stress shall not be less than 3 inches.

When dissimilar materials, (e.g. concrete masonry or steel) are used to support earth wall construction, such elements shall be structurally isolated from other earth wall elements. The design shall recognize, with specific detailing, the effects shrinkage of the earth wall construction may have on the structural integrity of the structure.

**TABLE R614.4
ALLOWABLE STRESSES FOR EMPIRICAL DESIGN OF EARTHEN WALL STRUCTURES**

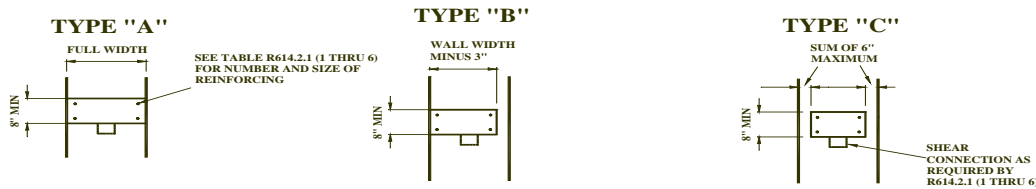
Strength of Unit, Gross Area		Allowable Stresses, Gross Sectional Area ¹	
Compression:	300 psi	Compressive Stress:	30 psi
Modulus of rupture:	50 psi	Allowable tension w/o tensile reinforcing:	0 psi
Shear:	N/A	Shear with Special Inspection:	8 psi
		Shear w/o Special Inspection:	4 psi
Modulus of Elasticity:	60,000 psi	Allowable Deflection:	Less than 0.5%

¹ Gross cross-sectional are shall be calculated on the actual rather than the nominal dimensions

Section R614.5 Lateral support. Earthen walls constructed of earthen units shall be bonded and tied to intersecting earthen walls and laterally supported in the vertical direction in accordance with one of the methods in Section R614.5.2 or Section R614.5.3.

Section R614.5.2 Bond Beams. A continuous concrete bond beam system embedded in the earthen walls, designed to provide lateral support for the walls without the aid of additional bracing elements such as roof diaphragm. Bond beams shall be not less than the width of the wall minus 6 and a height of not less than 8 inches. Bond beams shall be reinforced as required by Tables R614.2.1 (1 to 6). Bars shall be placed not more than 1 1/2" from the inside face of the form or veneer block as indicated in Figure R614.5.2.1.

Figure R614.5.2.1



Section R614.5.2.2.1 Bond beam anchorage. Bond beams shall be anchored to earthen walls at intervals of not over 48 inches (1219 mm) by a connection with shear strength of not less than 200 lbs per lineal foot plus an additional 25 lbs per lineal foot for every inch of thickness in excess of 16" thick.

Section R614.5.3 Roof diaphragm. A roof diaphragm complying with the *International Residential Code* adequate to provide not less than 200 lbs per lineal foot of lateral support may be used to brace earthen walls. Earthen walls shall be anchored to roof diaphragms with connections to resist loads of not less than 200 lbs per lineal foot plus an additional 25 lbs per lineal foot for every inch of thickness in excess of 16" thick. This anchorage shall be tie beams as specified in Section R614.5.3.2 or other anchorage methods of equal strength.

Section R614.5.3.1 Tie beams. A tie beam is a concrete or masonry beam built into the earthen wall for the purpose of anchoring the roof diaphragm and transferring the lateral perpendicular and parallel forces. Tie beams shall be provided for all earthen walls laterally braced by a roof diaphragm. Tie beams shall be anchored to the roof diaphragm system at intervals not exceeding 4 feet.

Tie beams shall be not less than 1/2 the width of the earthen wall, a minimum of 8 inches high and reinforced with 2 - #4 reinforcing bars.

Section R614.5.3.2 Tie beam anchorage. Tie beams shall be anchored to earthen walls at intervals of not over 48 inches by a connection with shear strength of not less than 200 lbs per lineal foot plus an additional 25 lbs per lineal foot for every inch of thickness in excess of 16" thick.

Section R614.6 Lintels. Earthen walls over openings shall be supported by steel lintels, reinforced concrete or masonry lintels or earthen arches designed to support load imposed. Lintels shall not be supported by rigid structural columns, frames or posts with rigidities greater than the earthen wall unless the design allows for the potential for differential settlements.

Small openings less than 12" may be constructed without structural lintels.

Section R614.7 Shear walls. Earthen walls subject to in-plane loads shall be designed with at least one earthen wall shear panel, at least 4 feet long, free of openings, with a length as computed by formula R614.7-1.

$$L = (\text{Sqrt } PL \times Sds \times 4) \text{ Equation R614.7-1}$$

Where:

L = Length of shear panel

PL = Sum of overall length of walls perpendicular to the panel.

Sds = Sds factor as determined by the *International Building Code*.

Section R614.8 Jambs at openings. Portions of walls between openings or corner shall be constructed with lengths of not less than 1 ½ times the thickness of the wall in which they occur.

Section R614.9 Piers. The thickness of isolated earthen piers shall be not less than 1 ½ times those wall thickness values indicated in Table R614.2.1(1 to 6). When structural posts or columns are provided within the pier ties, attachments shall be provided to the earthen wall system to laterally secure it.

Section R614.9.1 Pier Cap. A solid concrete cap shall be provided at the top of load bearing piers under all concentrated loads. The cap shall cover not less than 50% of the top of the pier.

Section R614.10 Chases. Chases and recesses in earthen walls shall not be deeper than one-half the thickness of the wall. The maximum length of a horizontal chase or horizontal projection shall not exceed 4 feet and shall have at least 8 inches of masonry in back of the chases and recesses and between adjacent chases or recesses and the jambs of openings. Chases and recesses in earthen walls shall be designed and constructed so as not to reduce the required strength or required fire resistance of the wall and in no case shall a chase or recess be permitted within the required area of a pier. Masonry directly above chases or recesses wider than 12 inches shall be supported on noncombustible lintels.

Section R614.11 Stack bond. When the earthen wall is constructed of units (e.g. adobe brick), units shall not be laid in stack bond. Units shall, in all locations throughout the wall system, overlap the courses below by not less than one-third the dimension of the units.

Section R614.12 Metal reinforcement. In addition to bonding earthen walls shall be anchored at their intersections, all walls shall be reinforced with joint reinforcement at vertical intervals of not more than 16 inches. Horizontal reinforcement shall be continuous at the intersections. Reinforcement shall be not more than 4 inches narrower than the wall thickness.

Section R614.13 Veneer. All veneers using earthen materials shall be installed in accordance with this section. Such veneers shall be installed with a noncombustible foundation, over concrete masonry, a backing of wood or cold-formed steel and shall be limited to the first story above grade and be not less than 4 inches or greater than 8 inches in thickness. Veneers shall not exceed a height of over 20 times their thickness without structural vertical support.

Section R614.13.1 Anchorage. Earth units shall be anchored to the supporting wall with a corrosion-resistant veneer tie system mechanically attached to continuous horizontal joint reinforcement continuously installed in the veneer bed joint not less than 16 inches on center vertically. When earth mortar systems are used the tie system shall prevent the accumulation of mortar at the base of the veneer. Conventional brick ties shall not be used to anchor earth units.

Section R614.13.2 Air space. The veneer shall be separated from the sheathing by an air space of a minimum of 1 inch but not more than 2 inches. A moisture-resistant barrier or 15 lb asphalt-saturated felt shall be provided except when veneer is applied over concrete masonry or concrete backing.

Section R614.13.3 Flashing. Approved corrosion-resistive flashing shall be provided in the exterior wall envelope in such a manner as to prevent entry of water into the wall cavity or penetration of water into the building structural framing components. The flashing shall extend to the surface of the exterior wall finish and shall be installed to prevent water from reentering the exterior wall envelope. Flashing shall be located beneath the first course of veneer, and at other points of support, including structural floors, shelf angles and lintels. Approved corrosion-resisting flashing shall be installed at all of the following locations:

1. At top of all exterior window and door openings in such a manner as to be leak proof.
2. At the intersection of chimneys or other masonry construction with frame or stucco walls, with projecting lips on both sides under stucco copings.

3. Under and at the ends of masonry, wood or metal copings and sills.
4. Where exterior porches, decks or stairs attach to a wall or floor assembly of wood-frame construction.
5. At wall and roof intersections.

Section R614.13.4 Weep holes. Weep holes shall be provided in the outside width of masonry walls at a maximum spacing of 33 inches on center. Weep holes shall not be less than 3/16 inches in diameter. Weep holes shall be located immediately above the flashing.

Section R614.13.5 Plaster veneer. Both interior and exterior faces of earthen walls which are to be plastered with cement plaster shall be lathed and plastered in accordance with the *International Residential Code*.

Section R614.14 Buttresses. Earthen walls used as buttresses shall not extend beyond an average length perpendicular to the wall to be braced a distance of 6 feet without consideration to out-of-plane bending of the buttress.

Section R614.15 Gable end walls. Gable end walls shall be constructed using veneer construction or shall be provided with lateral bracing to prevent overturning designed in accordance with the approved Standard for IBC Earthen Structures.

Section R614.16 Ledgers. Ledgers shall not be used to support vertical live and dead loads in excess of 75 lbs per lineal foot.

Section R614.17 Construction documents. Drawings for earthen structures shall include the following:

1. The Sds number of the site.
2. The wind speed and site exposure coefficient of the site.
3. The material standard to which the earthen materials will comply.
4. The foundation supporting system and moisture barrier material.
5. The length, height and thickness in the actual dimensions of all earthen walls and parapets.
6. The bond beam or tie beam construction and attachment method to the earthen wall.
7. Lintel design, construction and end bearing area.
8. Veneer dimensions, attachment methods, moisture barrier and supporting structure.
9. Flashing materials and installation.
10. Metal reinforcement type and location.

Section R614.18 Corbeled wall elements. The maximum corbeled projection beyond the face of the wall shall not be more than one fourth of the wall thickness.

Section R614.19 Material standards. The materials used in earthen wall structures shall comply with the following material standards. For each of the tests prescribed in these standards, five full size sample units shall be selected at random from each lot of units of fraction thereof produced. Mass wall systems such as rammed earth shall provide at least five tests for each required standard test series.

Section R614.19.1 Manufacturers of earthen materials. Established manufacturers of earthen materials shall certify compliance with these standards. Copies of their periodic testing shall be supplied to the building official when requested. Literature, advertising and other information supplied by the manufacturer to designers and users of earthen materials shall include the actual dimensions of units, not nominal dimensions.

Section R614.19.2 Onsite earthen materials. Earthen units, mortar, rammed earth wall materials mined, mixed, formulated, and or molded on site shall be tested for compliance with these standards. For individual structures, a set of tests shall be provided for the first 2500 square feet of wall and an additional test for each additional 2500 square feet or portion thereof in the structure. At least one set of tests shall be made for each structure and for

each 2500 square feet of patio wall. The fabricator of the materials used in the project shall certify in writing to the building official compliance with these standards. The certification shall include the number of units site molded, size of the units, volume of material used as mortar, dates of fabrication, and results of testing of the material. If materials from established manufacturers and onsite materials are used in the project, copies of records including sources, quantities, and location of use within the structure shall be provided to the building official upon request.

Section R614.19.3 Categories of earthen materials. Type I, II, III, and IV earthen materials are approved for use.

Exception: Type I adobe shall only be used for repairs and small additions in which new walls do not exceed 10% of the surface area of existing walls of Type I construction and for structures constructed of a similar material system and for projects requiring this class of materials to meet historic guidelines.

Required plaster veneer. Adobe of Type I and II shall be protected on the exterior with exterior plaster meeting the requirements of *International Residential Code* applied over wire lath. Type I and II adobe shall not be used within 4 inches of the floor or at the top of parapet walls or near potential sources of water which may affect the stability of the earth wall system. Other Types of adobe may be left unplastered and may be used without separation from the floor.

Adobe units and mortar. Moisture resistant stabilized adobe units and mortar shall meet the following testing standards as indicated in Table. Type S Portland cement mortar may be used for Type II, III, and IV adobe in lieu of earth mortar.

Table R614.19.3 Required Tests by Material Type

<i>Material Type</i>	Dry Compression	Wet Compression	Modulus of Rupture	Absorption <2.5%	Absorption <5.0%	Moisture Content
I	X		X			X
II	X		X		X	X
III	X		X	X		X
IV		X	X			X

X Indicates that material must pass the test standards prescribed in this Section.

Section R614.19.3.1 Dry compression strength. Determine the compressive strength of the required number of samples in accordance with the following:

1. Dry the specimen. Dry the specimen at a temperature of 85° F+-15° F in an atmosphere having relative humidity of not more than 50 percent. Weigh the specimen at one-day intervals until constant weight is attained.
2. Cap the specimen. The specimen may be suitably capped with calcined gypsum mortar or the bearing surfaces may be rubbed smooth and true. Then calcined gypsum is used for capping, conduct the test after the capping has set and the specimen has been dried to constant weight in accordance with item 1 of this section.
3. Test the Specimen. Test the specimens in the position in which the earthen unit is designed to be used. And bed on and cap with a felt pad not less than 1/8 inch or more than ¼ inch in thickness.

4. Testing equipment. The loading head shall completely cover the bearing area of the specimen and the applied load shall be transmitted through a spherical bearing block of proper design. The speed of the moving head of the testing machine shall not be more than 0.05 inch per minute.
5. Reporting results. Calculate the average compressive strength of the specimens tested and report this as the compressive strength of the block. Units shall have an average dry compressive strength of 300 psi and no individual unit may have a strength of less than 250 psi.

Section R614.19.3.2 Wet compression strength. Determine the compressive strength of the required number of specimen in accordance with the following:

1. Wetting the specimen. Submerge the specimen under water for not less than 8 hours or longer as required until fully saturated.
2. Test the specimen. Immediately test the specimen in the position in which the earthen unit is designed to be used. And bed on and cap with a felt pad not less than 1/8 inch or more than 1/4 inch in thickness.
3. Testing equipment. The loading head shall completely cover the bearing area of the specimen and the applied load shall be transmitted through a spherical bearing block of proper design. The speed of the moving head of the testing machine shall not be more than 0.05 inch per minute.
4. Reporting results. Calculate the average compressive strength of the specimens tested and report this as the compressive strength of the block. Adobe units shall have an average wet compressive strength of 300 psi. Five samples shall be tested and no individual unit may have a wet compressive strength of less than 250 psi.

Section R614.19.3.3 Modulus of rupture. Adobe units shall have an average modulus of rupture of 50 psi when tested in accordance with the following procedure. Five samples shall be tested and no individual unit shall have a modulus of rupture of less than 35 psi.

Section R614.19.3.3.1 Support conditions. A cured unit shall be simply supported by 2-inch-diameter cylindrical supports located 2 inches in from each end and extending the full width of the unit.

Section R614.19.3.3.2 Loading conditions. A 2-inch-diameter cylinder shall be placed at mid-span parallel to the supports.

Section R614.19.3.3.3 Testing procedure. A vertical load shall be applied to the cylinder at the rate of 500 pounds per minute until failure occurs.

Section R614.19.3.3.4 Modulus of rupture determination. The modulus of rupture shall be determined by the formula:

$$F_r = 3WL_s/2bt^2 \quad \text{Equation 2116.3.3.4-1}$$

Where, for the purposes of this section only:

- b = Width of the test specimen measured parallel to the loading cylinder, inches.
- f_r = Modulus of rupture, psi.
- L_s = Distance between supports, inches.
- T = Thickness of the text specimen measured parallel to the direction of load, inches.
- W = The applied load at failure, pounds.

Section R614.19.3.4 Absorption less than 2.5%. A 4-inch cube, cut from an adobe unit fired to a constant weight in a ventilated oven at 212 degrees F to 239 degrees F, shall not absorb more than 2 1/2 percent moisture by weight when placed upon a constantly water-saturated, porous surface for 7 days. A minimum of five specimens shall be tested and each specimen shall be cut from a separate unit.

Section R614.19.3.5 Absorption less than 5.0%. A 4-inch cube, cut from an adobe unit fired to a constant weight in a ventilated oven at 212 degrees F to 239 degrees F, shall not absorb more than 5 percent moisture by weight when placed upon a constantly water-saturated, porous surface for 7 days. A minimum of five specimens shall be tested and each specimen shall be cut from a separate unit.

Section R614.19.3.6 Additional Requirements. All earthen units shall meet the following requirements:

1. Moisture content requirements. Earthen units shall have a moisture content not exceeding 4 percent by weight at the time of use.
2. Shrinkage cracks. All earthen units shall not contain more than three shrinkage cracks and any single shrinkage crack shall not exceed 3 inches in length or 1/8 inch in width.
3. Soil requirements. Soil used for moisture resisting adobe units and mortar shall be chemically compatible with the stabilizing material. The soil shall contain sufficient clay to bind the particles together without the aid of stabilizers. The soil shall contain not more than 0.2 percent of water-soluble salts.

Section R614.19.3.7 Cement Stabilized Rammed Earth. Cement stabilized Rammed Earth shall meet the following standards:

1. Testing before Construction. The installer of cement stabilized Rammed Earth shall provide the following testing before issuance of a building permit.
2. Materials from a Licensed Sand and Gravel Producer. A copy of Proctor ASTM D 698 shall be provided for each soil type and source or combination of sources. Periodic testing as provided by the supplier may be supplied to meet this requirement. The soil shall contain not more than 0.2 percent of water-soluble salts.
3. Material Mined and Mixed on Site. A copy of ASTM D 698, ASTM C 117, ASTM C 136, and ASTM D 4318 shall be provided for each soil type and source or combination of sources. Such tests shall be repeated as required to assure that all materials to be used have been tested and are represented by the tests. The soil shall contain not more than 0.2 percent of water-soluble salts.
4. Testing required during Construction. The installer of cement stabilized Rammed Earth shall provide the following tests made during the construction process. A certified testing laboratory shall provide field density tests for comparison to the pre-construction Proctor ASTM D 698, percent moisture ASTM D 2216, dry density ASTM D 698, and percent moisture ASTM D 1556. Cement Stabilized Rammed Earth walls shall meet or exceed 95% maximum dry density (ASTM D 698). Samples taken from the wall shall exceed 300 psi compression (ASTM D 1633) 14 days after placement.