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IRC®: Appendix (New), SECTION AU101 (New), AU101.1 (New), AU101.2 (New), AU101.3 (New), AU101.4 (New), FIGURE AU101.4 (New), SECTION AU102 (New), AU102.1 (New), SECTION AU103 (New), AU103.1 (New), AU103.2 (New), AU103.3 (New), AU103.4 (New), AU103.4.1 (New), AU103.5 (New), AU103.6 (New), AU103.7 (New), AU103.8 (New), AU103.9 (New), SECTION AU104 (New), AU104.1 (New), AU104.2 (New), AU104.3 (New), AU104.4 (New), AU104.4.1 (New), AU104.4.2 (New), AU104.4.3 (New), AU104.4.3.1 (New), AU104.4.3.2 (New), AU104.4.4 (New), AU104.4.5 (New), AU104.4.6 (New), AU104.4.7 (New), AU104.4.8 (New), AU104.4.9 (New), SECTION AU105 (New), AU105.1 (New), AU105.2 (New), AU105.3 (New), AU105.3.1 (New), TABLE AU105.3 (New), AU105.3.2 (New), AU105.3.3 (New), AU105.3.4 (New), AU105.3.4.1 (New), AU105.3.4.2 (New), AU105.3.4.3 (New), AU105.3.5 (New), AU105.4 (New), AU105.4.1 (New), AU105.4.2 (New), AU105.4.3 (New), AU105.4.4 (New), AU105.4.5 (New), AU105.5 (New), SECTION AU106 (New), AU106.1 (New), AU106.2 (New), AU106.3 (New), AU106.4 (New), AU106.5 (New), AU106.6 (New), AU106.6.1 (New), AU106.7 (New), AU106.7.1 (New), AU106.8 (New), AU106.8.1 (New), AU106.8.2 (New), AU106.9 (New), AU106.9.1 (New), AU106.9.1.1 (New), AU106.9.1.2 (New), AU106.9.1.3 (New), AU106.9.2 (New), AU106.9.3 (New), AU106.9.4 (New), AU106.9.5 (New), AU106.9.6 (New), AU106.10 (New), TABLE AU106.10 (New), AU106.11 (New), AU106.11.1 (New), AU106.11.2 (New), AU106.11.3 (New), FIGURE AU106.11.3 (New), TABLE AU106.11(1) (New), TABLE AU106.11(2) (New), TABLE AU106.11(3A) (New), AU106.11(3B) (New), AU106.11(3C) (New), AU106.12 (New), TABLE AU106.12 (New), AU106.13 (New), AU106.14 (New), SECTION AU107 (New), AU107.1 (New), SECTION AU108 (New), AU108.1 (New), AU108.2 (New), SECTION AU109 (New), AU109.1 (New), AU109.2 (New), AU109.3 (New), SECTION AU110 (New)

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2018 International Residential Code

Add new text as follows:

APPENDIX U
Cob Construction (Monolithic Adobe)

SECTION AU101
GENERAL

AU101.1 Scope. This appendix provides prescriptive and performance-based requirements for the use of *natural cob* as a building material. *Buildings* using *cob* walls shall comply with this code except as otherwise stated in this appendix.

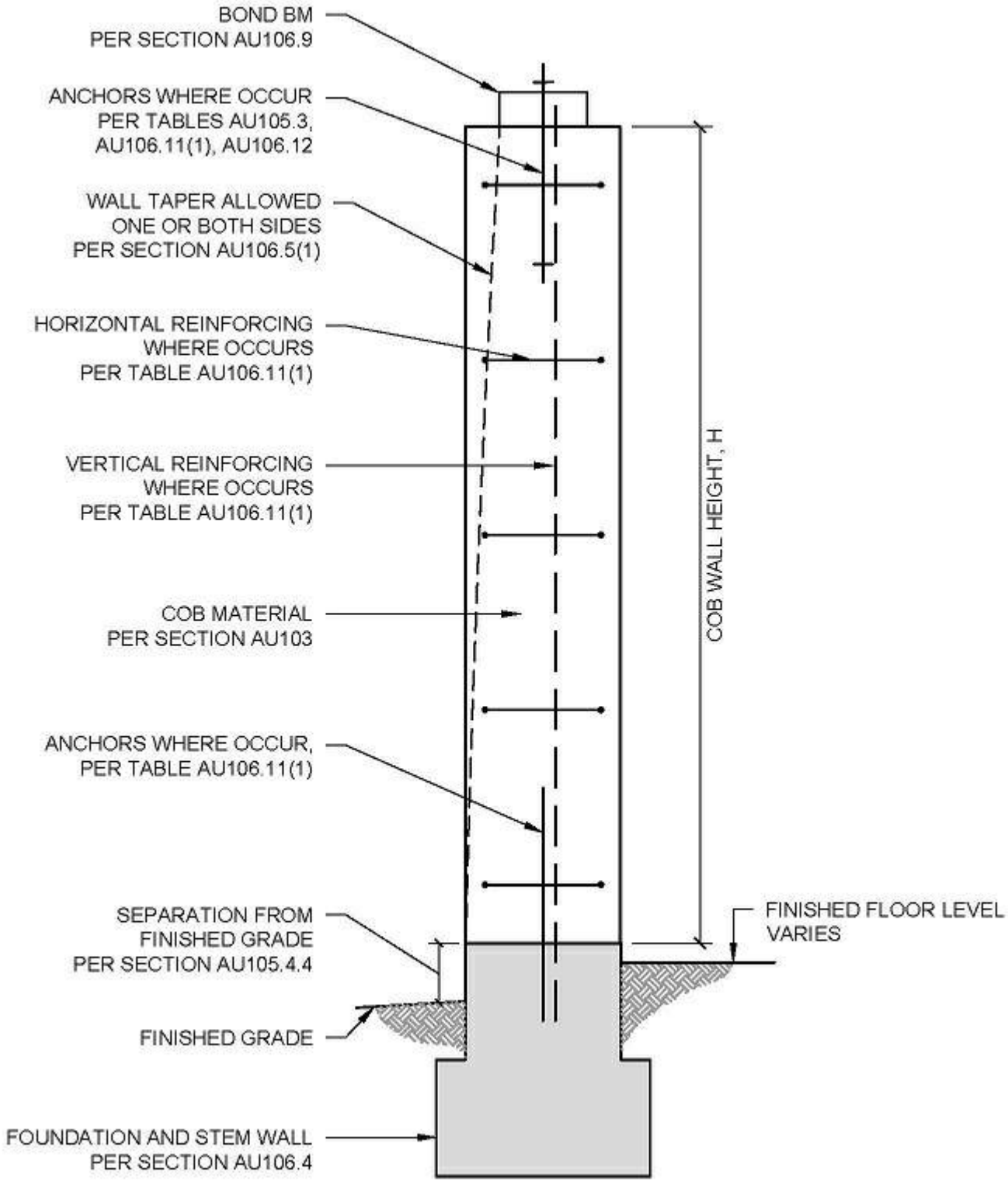
AU101.2 Intent. In addition to the intent described in Section R101.3, the purpose of this appendix is to establish minimum requirements for cob structures that provide flexibility in the application of certain provisions of the code, to permit the use of site-sourced and local materials, and innovative combinations of proven historical and modern techniques that are safe, reduce life-cycle impacts, and increase affordability.

AU101.3 Tests and empirical evidence. Tests for an alternative material, design or method of construction shall be in accordance with Section R104.11.1, and the *building official* shall have the authority to consider

evidence of a history of successful use in lieu of testing.

AU101.4 Cob wall systems. *Cob* wall systems include those shown in Figure AU101.4 and *approved* variations.

FIGURE AU101.4 TYPICAL COB WALL



SECTION AU102
DEFINITIONS

AU102.1 Definitions. The following words and terms shall, for the purposes of this appendix, have the meanings shown herein. Refer to Chapter 2 of the *International Residential Code* for general definitions.

BRACED WALL PANEL. A *cob* wall designed and constructed to resist in-plane shear loads through the interaction of the cob material, its reinforcing and its connections to its bond beam and foundation. The panel's length meets the requirements for the particular wall type and contributes toward the total amount of bracing required along its braced wall line in accordance with Sections AU106.11 and R602.10.1.

BUTTRESS. A mass set at an angle to, or bonded to a wall that it strengthens or supports.

CLAY. Inorganic soil with particle sizes less than 0.00008 inch (0.002 mm) having the characteristics of high to very high dry strength and medium to high plasticity, used as the binder of other component materials in a mix of *cob* or of *clay* plaster.

CLAY SUBSOIL. Subsoil sourced directly from the earth, containing *clay,* sand, and silt, and not more than trace amounts of organic matter.

COB. A composite building material consisting of refined clay or clay subsoil wet-mixed with loose straw and sometimes sand. Also known as *monolithic adobe*.

COB CONSTRUCTION. A wall system of layers or *lifts* of moist *cob* placed to create monolithic walls, typically without formwork.

DRY JOINT. The boundary between a layer of moist cob and a previously laid and significantly drier, non-malleable layer of cob that requires wetting to achieve bonding between the layers.

FINISH. Completed combination of materials on the face of a *cob* wall.

LIFT. A layer of installed *cob*.

LOAD-BEARING WALL. A *cob* wall that supports more than 100 pounds per linear foot (1459 N/m) of vertical load in addition to its own weight.

MONOLITHIC ADOBE. Synonymous with *cob*.

NATURAL COB. Cob not containing admixtures such as Portland cement, lime, asphalt emulsion, or oil. Synonymous with *unstabilized* cob.

NONSTRUCTURAL WALL. Walls other than *load-bearing* walls or *shear walls*.

PLASTER. C*lay*, soil-cement, gypsum, lime, clay-lime, cement-lime, or cement plaster as described in Section AU104.

SHEAR WALL. A *cob* wall designed and constructed to resist in-plane lateral seismic and wind forces in accordance with Section AU106.11. Synonymous with *braced wall panel*.

STABILIZED. *Cob* or other earthen material containing admixtures such as Portland cement, lime, asphalt

emulsion, or oil, that are intended to help limit water absorption, stabilize volume, increase strength, and increase durability.

STRUCTURAL WALL. A wall that meets the definition for a *load-bearing* wall or *shear wall*.

STRAW. The dry stems of cereal grains after the seed heads have been removed.

UNSTABILIZED. A *Cob* or other earthen material that does not contain admixtures such as Portland cement, lime, asphalt emulsion, or oil.

SECTION AU103
MATERIALS, MIXING, AND INSTALLATION

AU103.1 Clay subsoil. *Clay subsoil* for a *cob* mix shall be acceptable if the mix it produces meets the requirements of Section AU103.4.

AU103.2 Sand. Sand or other aggregates such as, but not limited to, gravel, pumice and lava rock, when added to *cob* mixes, shall yield a mix that meets the requirements of Section AU103.4.

AU103.3 Straw. *Straw* for *cob* mixes shall be from wheat, rice, rye, barley or oat, or similar reinforcing fibers with similar performance. Before mixing, the straw or other reinforcing fibers shall be dry to the touch and free of visible decay.

AU103.4 Mix proportions. *Cob* mixes shall be of any proportion of refined *clay* or *clay subsoil*, added sand (if any) and straw that produces a dried mix that passes the shrinkage test in accordance with Section AU103.4.1, complies with the compressive strength requirements of Section AU106.6 and complies with the modulus of rupture requirements of Section AU106.7.

AU103.4.1 Shrinkage test for cob mixes. Each proposed *cob* mix of different mix proportions shall be placed moist to completely fill a 24-inch by 3 1/2-inch by 3 1/2-inch (610 mm by 89 mm by 89 mm) wooden form on a plastic or paper slip sheet and dried to ambient moisture conditions, or oven dried. The total shrinkage of the length shall not exceed 1 inch (25 mm), as measured from the dried edges of the material to the insides of the form. Cracks in the sample > 1/16 inch (1.5 mm) shall first be closed manually. The shrinkage test shall be shown to the building official for approval before placement of the cob mix onto walls.

AU103.5 Mixing. The clay subsoil, sand and straw for *cob* shall be thoroughly mixed by manual or mechanical means with water sufficient to produce a mix of a plastic consistency capable of bonding of successively placed layers or *lifts*.

AU103.6 Installation. *Cob* shall be installed on the wall in *lifts* of a height that supports itself with minimal slumping.

AU103.7 Dry joints. Each layer of cob shall be prevented from drying until the next layer is installed, to ensure bonding of successive layers. The top of each layer shall be kept moist and malleable with one or more of the following methods:

1. Covering with a material that prevents loss of or holds moisture,
2. Covering with a material that shades it from direct sun, or
3. Wetting.

When dry joints are unavoidable, the previous layer shall be wetted prior to application of the next layer.

AU103.8 Drying holes. Where holes to facilitate drying are used, such holes shall be of any depth and not

exceeding 3/4-inch (19 mm) in diameter on the face of *cob* walls. Drying holes shall not be spaced closer than ten hole-diameters. Drying holes shall not be placed in *braced wall panels*. The design load on load-bearing walls with drying holes shall not exceed 90% of the allowable bearing capacity as determined in accordance with Section AU106.8. Drying holes shall be filled with cob before final inspection.

AU103.9 Adding roof loads to walls. Roof and ceiling loads shall not be added until walls are sufficiently dry to support them without compressing.

SECTION AU104
FINISHES

AU104.1 General. *Cob* walls shall not require a *finish*, except as required by Section AU104.2. Finishes applied to *cob* walls shall be plasters in accordance with Section AU104.4, non-plaster exterior wall coverings in accordance with Section R703 or other finish systems in accordance with the following:

1. Specifications and details of the finish system's means of attachment to the wall or its independent support and means of draining or evaporating water that penetrates the exterior finish shall be provided.
2. The vapor permeance of the combination of finish materials shall be 5 perms or greater to allow the transpiration of water vapor from the wall.
3. Finish systems with weights >10 and ≤ 20 pounds per square foot (> 48.9 and ≤ 97.8 kg/m^2) of wall shall require that the minimum total length of braced wall panels in Table AU106.11(3) be multiplied by a factor of 1.2.
4. Finish systems with weights > 20 pounds per square foot (> 97.8 kg/m^2) of wall area shall require an engineered design.

AU104.2 Where required. Cob walls exposed to rain due to local climate, building design and wall orientation shall be finished or clad to provide protection from excessive erosion.

AU104.3 Vapor retarders. Class I and II vapor retarders shall not be used on *cob* walls, except at cob walls surrounding showers or as required or addressed elsewhere in this appendix.

AU104.4 Plaster. *Plaster* applied to *cob* walls shall be any type described in this section. *Plaster* thickness shall not exceed 3 inches (76 mm) on each face except where an approved engineered design is provided.

AU104.4.1 Plaster and membranes. *Plaster* shall be applied directly to *cob* walls to facilitate transpiration of moisture from the walls and to secure a mechanical bond between the *plaster* and the *cob*. A membrane shall not be located between the cob wall and the plaster.

AU104.4.2 Plaster lath. The surface of *cob* walls shall be permitted to function as lath for plaster, with no other lath required. Metal, plastic, and natural fiber lath shall be permitted to be used to limit plaster cracking or increase the plaster bond to the wall, or to bridge dissimilar materials.

AU104.4.3 Clay plaster. *Clay* plaster shall comply with Sections AU104.4.3.1 and AU104.4.3.2.

AU104.4.3.1 General. *Clay* plaster shall be any plaster having a *clay* or *clay subsoil* binder. Such plaster shall contain sufficient clay to fully bind the sand or other aggregate and any reinforcing fibers. Reinforcing fibers shall be chopped straw, sisal, hemp, animal hair or other similar *approved* fibers.

AU104.4.3.2 Clay subsoil requirements. The suitability of *clay subsoil* shall be determined in accordance with the Figure 2 Ribbon Test and the Figure 3 Ball Test in the appendix of ASTM E2392/E2392M.

AU104.4.4 Soil-cement plaster. Soil-cement plaster shall be composed of *clay subsoil*, sand, not more than 7 percent Portland cement by volume and, where provided, reinforcing fibers.

AU104.4.5 Gypsum plaster. Gypsum plaster shall comply with Section R702.2.1 and shall be limited to interior use.

AU104.4.6 Lime plaster. Lime plaster is any plaster with a binder composed of calcium hydroxide including Type N or S hydrated lime, hydraulic lime, natural hydraulic lime or slaked quicklime. Hydrated lime shall comply with ASTM C206. Hydraulic lime shall comply with ASTM C1707. Natural hydraulic lime shall comply with ASTM C141 and EN 459. Quicklime shall comply with ASTM C5.

AU104.4.7 Clay-lime plaster. Clay-lime plaster shall be composed of refined *clay* or *clay subsoil*, sand, lime and, where provided, reinforcing fibers.

AU104.4.8 Cement-lime plaster. Cement-lime plaster shall be plaster mix types CL, F or FL, as described in ASTM C926.

AU104.4.9 Cement plaster. Cement plaster shall have not less than 1 part lime to 4 parts cement and be not thicker than 1-1/2 inches (38 mm), to ensure minimum acceptable vapor permeability

SECTION AU105
COB WALLS—GENERAL

AU105.1 General. *Cob walls* shall be designed and constructed in accordance with this section and Figure AU101.4 or an *approved* alternative design. In addition to the general requirements for c*ob* walls in this section, c*ob structural walls* shall comply with Section AU106.

AU105.2 Building limitations and requirements for cob wall construction. *Cob* walls shall be subject to the following limitations and requirements:

1. Number of stories: not more than one.
2. *Building* height: not more than 25 feet (7620 mm).
3. Seismic design categories: limited to use in Seismic Design Categories A, B and C, except where an *approved* engineered design is provided.
4. Wall height: in accordance with Table AU105.4, and with Table AU106.11(1) for *braced wall panels*.
5. Wall thickness, excluding finish, shall be not less than 10 inches, not greater than 24 inches at the top two-thirds, not limited at the bottom third and, for structural walls, shall comply with Section AU106.2(2). Wall taper is permitted in accordance with Section AU106.5(1).
6. Interior *cob* walls shall require an *approved* engineered design that accounts for the seismic load of the interior *cob* walls, except in Seismic Design Category A for walls with a height to thickness ratio ≤ to 6.

AU105.3 Out-of-plane resistance methods and unrestrained wall height limits. *Cob* walls shall employ a method of out-of-plane load resistance in accordance with Table AU105.3, and comply with its associated height limits and requirements.

AU105.3.1 Determination of out-of-plane loading. Out-of-plane loading for the use of Table AU105.3 shall be in accordance with the ultimate design wind speed and seismic design category requirements of Sections R301.2.1 and R301.2.2 respectively. An *approved* engineered design shall be required where the building is located in a Special Wind Region or a Wind Design Required location in accordance with Figure R301.2(5)B.

TABLE AU105.3 OUT-OF-PLANE RESISTANCE METHODS AND UNRESTRAINED WALL HEIGHT LIMITS

WALL TYPE[a, g, h] and METHOD OF	FOR ULTIMATE DESIGN WIND SPEEDS	FOR SEISMIC DESIGN CATEGORIES	UNRESTRAINED COB WALL HEIGHT H[b, c]		TOP ANCHOR[e] SPACING (inches)	TENSION TIE[f] SPACING (inches)
			Absolute limit in	Limit based on		

OUT-OF-PLANE LOAD RESISTANCE	**(mph)**		**feet**	**wall thickness T^d in feet**		
Wall 1[i]: no anchors, no steel wall reinforcing	≤ 110	A	$H \leq 8$	$H \leq 6T$	none	48
Wall 2: top anchors[j], continuous vertical 6”x6”x6 gage steel mesh in center of wall embedded in foundation 12”	≤ 140	A, B, C	$H \leq 8$	$H \leq 8T$	12	24
Wall A[i]: top anchors, no vertical steel reinforcing	≤ 120	A, B	$H \leq 8$	$H \leq 6T$	12	48
Wall B[i]: top & bottom anchors, no vertical steel reinforcing	≤ 130	A, B	$H \leq 8$	$H \leq 6T$	12	48
Wall C: top and bottom anchors, continuous vertical threaded rod at 4’ oc embedded in foundation and connected to bond beam	≤ 140	A, B, C	$H \leq 8$	$H \leq 8T$	12	24
Wall D: continuous vertical threaded rod at 1’ oc embedded in foundation and connected to bond beam	≤ 140	A, B, C	$H \leq 8$	$H \leq 8T$	NA	24
Wall E: top anchors, continuous vertical 6”x6”x6 gage steel mesh 2” from each face of wall embedded in foundation	≤ 140	A, B, C	$H \leq 8$	$H \leq 8T$	12	24

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s.

N/A = Not Applicable

a. See Table AU106.11(1) for reinforcing and anchorage specifications for wall types A, B, C, D and E.

b. H = height of the cob portion of the wall only. See Figure AU101.4. The maximum H is the absolute limit or the limit based on wall thickness, whichever is more restrictive.

c. Bond beams or other horizontal restraints are capable of separating a wall into more than one unrestrained wall height with an *approved* engineered design.

d. T = Cob wall thickness (in feet) at its minimum, without plaster.

e. 5/8-inch threaded rod anchors at prescribed spacing with 12” embedment in cob, full embedment in concrete bond beams or full penetration in wood bond beam with a nut and washer.

f. Attach rafters to bond beam with 4-inch by 3-inch by 3-inch by 18 gage tension tie angles at prescribed spacing. See Figure R608.9(9). Where rafters are attached to tension ties shall, roof sheathing shall be edge nailed.

g. All walls shall be tested for compressive strength in accordance with Section AU106.6.

h. For curved walls with an arc length:radius ratio of 1.5:1 or greater, the H/T factor shall be increased by 1, and the absolute height limit by 1 foot.

i. Wall type requires a modulus of rupture test in accordance with Section AU106.7.

j. See wall type A in Table AU106.11(1) for top anchor requirements.

AU105.3.2 Bond beams for nonstructural walls. Nonstructural *cob* walls shall be provided with a bond beam at the top of the wall that complies with Section AU106.9, except for requirements relating to roof and/or ceiling loads or *braced wall panels*.

AU105.3.3 Lintels in nonstructural walls. Door, window, and other openings in nonstructural *cob* walls shall require a lintel in accordance with Section AU106.10, except for requirements relating to roof and/or ceiling loads or *braced wall panels*.

AU105.3.4 Reinforcing at wall openings. Reinforcing shall be installed at window, door, and similar wall openings and penetrations greater than 2 feet (610 mm) in width in accordance with this section. Surface voids deeper than 25 percent of the wall thickness shall be considered an opening.

AU105.3.4.1 Opening size limit. Openings shall not exceed 6 feet (1829 mm) in width, and the height of the cob wall below openings shall not exceed 6 feet (1829 mm) above the top of the foundation.

AU105.3.4.2 Horizontal reinforcing. 2-inch by 2-inch (51 mm by 51 mm) 14 gage galvanized steel mesh shall be embedded 4 inches (102 mm) in the cob above the rough opening and below the rough opening for windows, and shall extend 12 inches (305 mm) beyond the sides of the opening. Walls below rough window openings greater than 4 foot 6 inches (1372 mm) in height shall be provided with additional horizontal reinforcing at mid-height.

AU105.3.4.3 Vertical reinforcing. Full-height 5/8-inch (16 mm) threaded rod shall be installed 4 inches (102 mm) from each side of the opening, centered in the thickness of the cob wall. The threaded rods shall be embedded 7 inches (178 mm) in the foundation, and 4 inches (102 mm) in concrete bond beams or shall penetrate through wood bond beams and be secured with a nut and washer. The threaded rods shall be embedded in concrete lintels, or pass through a drilled hole in wood lintels.

AU105.3.5 Minimum length of cob walls. Sections of *cob* walls between openings shall be not less than 2 foot 6 inches (762 mm) in length. Wall sections less than 4 feet (1219 mm) and not less than 2 foot 6 inches (762 mm) in length shall contain vertical reinforcing in accordance with Section AU105.3.4.3

AU105.4 Moisture control. *Cob* walls shall be protected from moisture intrusion and damage in accordance with Sections AU105.4.1 through AU105.4.5.

AU105.4.1 Water-resistant barriers and vapor permeance. *Cob* walls shall be constructed without a membrane barrier between the *cob* wall and *plaster* to facilitate transpiration of water vapor from the wall, and to secure a mechanical bond between the cob and plaster, except as otherwise required elsewhere in this appendix. Where a water-resistant barrier is placed behind an exterior finish, it shall be considered part of the finish system and shall comply with Section AU104.1(2) for the combined vapor permeance rating.

AU105.4.2 Horizontal surfaces. *Cob* walls and other *cob* elements shall be provided with a water-resistant barrier at weather-exposed horizontal surfaces. The water-resistant barrier shall be of a material and installation that will prevent erosion and prevent water from entering the wall system. Horizontal surfaces, including exterior window sills, sills at exterior niches, and exterior buttresses, shall be sloped not less than 1 unit vertical in 12

units horizontal to drain away from *cob* walls or other cob elements.

AU105.4.3 Separation of cob and foundation. A liquid-applied or bituminous Class II *vapor retarder* shall be installed between *cob* and supporting concrete or masonry
Exception: Where local climate, site conditions and foundation design limit ground moisture migration into the base of the *cob* wall, including but not limited to the use of a moisture barrier or capillary break between the supporting concrete or masonry and the earth.

AU105.4.4 Separation of cob and finished grade. *Cob* shall be not less than 8 inches (203 mm) above finished grade.
Exception: The minimum separation shall be 4 inches (102 mm) in Dry climate zones as defined in Table N1101.7.2(1) [R302.3(1)], and shall be 2 inches (51mm) on walls that are not weather-exposed.

AU105.4.5 Installation of windows and doors. Windows and doors shall be installed in accordance with the manufacturer's instructions to a wooden frame of not less than nominal 2x4 (51 mm by 102 mm) wood members anchored into the cob wall with 16d galvanized nails half-driven at a maximum 6-inch (152 mm) spacing, with the protruding half embedded in the cob. The wood frame shall be embedded not less than 1-1/2 inches (38 mm) in the cob and shall be set in from each face of the wall not less than 3 inches (76 mm). Alternative window and door installation methods shall be capable of resisting the wind loads in Table R301.2(2). Windows and doors in cob walls shall be installed so as to mitigate the passage of air or moisture into or through the wall system. Window sills shall comply with Section AU105.4.2.

AU105.5 Inspections. The *building official* shall inspect the following aspects of *cob construction* in addition to the required tests of, and accordance with Section R109.1:

1. Anchors and vertical and horizontal reinforcing in *cob* walls, where required in accordance with Tables AU105.2 and AU106.11(1) and Sections AU105.3.4 and AU105.3.5.
2. Reinforcing in any concrete bond beams or lintels, in accordance with Sections AU106.9.2 and Table AU106.10.

SECTION AU106
COB WALLS—STRUCTURAL

AU106.1 General. *Cob structural walls* shall be in accordance with the prescriptive provisions of this section. Designs or portions of designs not complying with this section shall require an *approved* engineered design.

AU106.2 Requirements for cob structural walls. In addition to the requirements of Section AU105.2, *cob structural walls* shall be subject to the following:

1. Wall height: shall be in accordance with Table AU105.3 for load-bearing cob walls or AU106.11(1) for cob braced wall panels, as applicable and most restrictive.
2. Wall thickness: shall be in accordance with Section AU105.2(5) and Section AU106.8.1 for load-bearing cob walls or AU106.11(1) for cob braced wall panels, as applicable and most restrictive.
3. *Braced wall panel* lengths: for *buildings* using *cob braced wall panels*, the greater of the values determined in accordance with Tables AU106.11(2) for wind loads and AU106.11(3) for seismic loads shall be used.

AU106.3 Loads and other limitations. Live and dead loads and other limitations shall be in accordance with Section R301, except that the dead load for *cob* walls shall be determined with the following equation:
$CW_{DL} = (H \times T_{avg} \times D)$ **(Equation AU-1)**

where:

CW_{DL} = Cob wall dead load (in pounds per lineal foot of wall)

H = Height of cob portion of wall (in feet)

T_{avg}= Average thickness of wall (in feet)

D = Density of cob = 110 (in pcf), unless a lesser value at equilibrium moisture content is demonstrated to the *building official*

AU106.4 Foundations. Foundations for *cob* walls shall be in accordance with Chapter 4. The width of foundations for cob walls shall be not less than the width of the cob at its base, excluding *finish.*

AU106.5 Wall taper, straightness and surface voids for cob walls. *Cob* walls shall be in accordance with the following:

1. *Cob structural* and *nonstructural walls* shall be vertical, or shall taper from bottom to top with the wall thickness in accordance with Section AU105.2(5) and the wall height in accordance with AU105.2(4).
2. *Cob structural* and *nonstructural walls* shall be straight or curved. Curved *braced wall panels* shall be in accordance with Sections AU106.11.2 and AU106.11.3.
3. Niches and other surface voids in *load-bearing walls* are limited to 12 inches (305 mm) in width and height and 25 percent of the wall thickness, and shall be located in the top two-thirds of the wall. Surface voids that exceed these limits shall be considered wall openings, and shall receive a lintel in accordance with Section AU106.10 and be reinforced in accordance with Section AU105.3.4. Surface voids are prohibited in *braced wall panels*.

AU106.6 Compressive strength of cob structural and nonstructural walls. All *cob* walls shall have a minimum compressive strength of 60 psi (414 kPa). *Cob* in walls used as *braced wall panels* shall have a minimum compressive strength of 85 psi (586 kPa).

AU106.6.1 Demonstration of compressive strength. The compressive strength of the *cob* mix to be used in *structural walls* and *nonstructural walls* as required in Section AU106.6 shall be demonstrated to the *building official* before the placement of cob onto walls, with compressive strength tests and an associated report by an *approved* laboratory or with an *approved* on-site test as follows:

1. Five samples of the proposed *cob* mix shall be placed moist to completely fill a 4-inch by 4-inch by 4-inch (102 mm by 102 mm by 102 mm) form and dried to ambient moisture conditions. Samples shall not be oven dried. Any opposite faces shall be faced with plaster of Paris if needed to achieve smooth, parallel faces, after which the sample shall reach ambient moisture conditions before testing. The horizontal cross-section of the dried sample as tested, and the maximum applied load at failure shall be used to calculate the sample's compressive strength. The fourth lowest value shall be used to determine the mix's compressive strength.

AU106.7 Modulus of rupture of cob structural walls. *Cob* in walls used as *braced wall panels* shall have a minimum modulus of rupture of 50 psi (345 kPa).

AU106.7.1 Demonstration of modulus of rupture. The modulus of rupture of *cob* used in structural walls as required in Section AU106.7 shall be demonstrated to the *building official* before the placement of cob onto walls, with modulus of rupture tests and an associated report by an *approved* laboratory or with an *approved* on-site test as follows:

1. Five samples of the proposed *cob* mix shall be placed moist to completely fill a 6-inch by 6-inch by 12-inch (152 mm by 152 mm by 305 mm) form and dried to indoor ambient moisture conditions. Samples shall not be oven dried. Each sample shall be tested with the 12-inch (305 mm) dimension horizontal. The fourth lowest value shall be used to determine if the mix's meets the minimum required modulus of rupture.

AU106.8 Bearing capacity. The allowable bearing capacity for *cob load-bearing walls* supporting vertical roof

and/or ceiling loads imposed in accordance with Section R301 shall be determined with the following equation:
$BC = (C \times T_{min})/3 - (H \times T_{avg} \times D)$ **(Equation AU-2)**

where:

BC = Allowable bearing capacity of wall (in pounds per lineal foot of wall)

C = Compressive strength (in psi) as determined in accordance with Section AU106.6

T_{min} = Thickness of wall (in feet) at its minimum

H = Height of cob portion of wall (in feet)

T_{avg} = Average thickness of wall (in feet)

D = Density of cob = 110 (in pcf), unless a lesser value at equilibrium moisture content is demonstrated

AU106.8.1 Support of uniform loads. Uniform roof and/or ceiling loads shall be supported by *cob load-bearing walls* not exceeding their allowable bearing capacity, as demonstrated in accordance with the following equation:
$BL \leq BC$ **(Equation AU-3)**

where:

BL = Design load on the wall (in pounds per lineal foot) determined in accordance with Sections R301.4 and R301.6

BC = Allowable bearing capacity of wall (in pounds per lineal foot of wall) determined in accordance with Section AU106.8

AU106.8.2 Support of concentrated loads. Concentrated roof and/or ceiling loads shall be distributed by structural elements capable of distributing the loads to the *cob load-bearing wall* and within its allowable bearing capacity as determined in accordance with Section AU106.8. Concentrated loads over lintels or over bond beams spanning openings shall require an *approved* engineered design.

AU106.9 Bond beams. *Cob structural walls* shall require a bond beam at the top of the wall in accordance with Sections AU106.9.1, AU106.9.2 or AU106.9.3, and shall be anchored to the *cob* below in accordance with Tables AU105.3, AU106.11(1) and AU106.12 as applicable and most restrictive. Bond beams spanning openings shall be in accordance with Section AU106.9.4.

AU106.9.1 Wood bond beams. Wood bond beams shall be not less than nominal 4 inches high by 8 inches wide and shall comply with Sections AU106.9.1.1 through AU106.9.1.3.

AU106.9.1.1 Wood species and grade. Wood bond beams shall be of a species with an extreme fiber in bending (F_b) of not less than 850 psi (5.9 MPa), a modulus of elasticity (*E*) of not less than 1,300,000 psi (8964 MPa), and of No. 2 grade or better. Composite lumber bond beams shall have an extreme fiber in bending (F_b) of not less than 850 psi (5.9 MPa), and a modulus of elasticity (*E*) of not less than 1,300,000 psi (8964 MPa).

AU106.9.1.2 Discontinuity. Discontinuous wood bond beams shall be spliced on top with a metal strap with not less than the allowable wind or seismic load tension capacity in accordance with the following, whichever is more restrictive:

1. For seismic design categories: A: 2500 pounds (11 kN). B: 4500 pounds (20 kN). C: 6000 pounds (26.7 kN).
2. For braced wall line lengths, when wind governs: 10 feet: 2500 pounds (11 kN). 20 feet: 3400 pounds (15.1 kN). 30 feet: 5000 pounds (22.2 kN).

AU106.9.1.3 Corners and curved walls. Wood bond beams at corners and discontinuities atop curved walls shall be connected across their exterior faces with a metal strap with a capacity of not less than that determined in in accordance Section AU106.9.2.

AU106.9.2 Concrete bond beams. Concrete bond beams shall be not less than 6 inches (152 mm) high by 8 inches (305 mm) wide. Concrete bond beams shall be reinforced with two # 4 bars, 2 inches (51 mm) clear from the bottom and 2 inches (51 mm) clear from the sides. Lap splices shall comply with Table R608.5.4(1). Reinforcing at corners shall be in accordance with the horizontal reinforcing requirements in Section R608.6.4. The concrete shall have a compressive strength of not less than 2500 psi (17.2 MPa) at 28 days.

AU106.9.3 Other bond beams. Bond beams of other materials, including earthen materials, require an *approved* engineered design.

AU106.9.4 Bond beams spanning openings. Bond beams that support uniform roof and/or ceiling loads and span openings in *cob* walls shall be in accordance with Table AU106.10. Bond beams shall be continuous across the opening and not less than 1 foot (305 mm) beyond each side of the opening.

AU106.9.5 Connection of roof framing to bond beams. Roof and ceiling framing shall be attached to bond beams in accordance with Table R602.3(1), Items 2, 6, 30, 31, and 32. Tension ties shall be provided in accordance with Figure R608.9(9) and Footnote f of Table AU105.3. 10d toe nails at 6 inches (152 mm) on center shall be provided from the rim blocking to top plate for the entirety of braced wall lines, instead of the 43 mil strap shown in Figure R608.9(9). A nominal 2-inch by 6-inch (51 mm by 152 mm) wood plate shall be installed on concrete bond beams with 5/8-inch (16 mm) diameter anchor bolts with 5-inch (127 mm) embedment at 2 feet (610 mm) on center to allow the required fastening of roof and ceiling framing, including tension ties and toe nailing of rim blocking.

AU106.9.6 Bond beams at gable and shed roof end walls. Bond beams at end walls of buildings with gable or shed roofs shall comply with the following:

1. End walls shall not exceed 20 feet (6096 mm) in length.
2. Shall be continuous and straight for the entire wall line.
3. Wood bond beams when used shall comply with the following:
    - 3.1. Not less than nominal 4x8 (102 mm by 203 mm) when wind design governs in accordance with Tables AU106.11(2) and AU106.11(3), and for wall lengths ≤ 20 feet (6096 mm) in Seismic Design Category A, and for wall lengths ≤ 10 feet (3048 mm) in Seismic Design Categories B and C.
    - 3.2. Not less than nominal 4x10 (102 mm by 254 mm) for wall lengths ≤ 20 feet (6096 mm) in Seismic Design Category B.
    - 3.3. Not less than nominal 6x12 (152 mm by 305 mm) or 4x16 (102 mm by 406 mm) for wall lengths ≤ 20 feet (6096 mm) in Seismic Design Category C.
4. Concrete bond beams when used shall be in accordance with Section AU106.9.2 in Seismic Design Categories A, B, and C and for ultimate design wind speeds ≤ 140 mph (63.6 m/s).
5. Walls between the bond beam and roof shall be of wood-framed construction in accordance with Section R602.

AU106.10 Lintels. Door, window, and other openings in *load-bearing cob* walls shall be provided with a lintel of

wood or concrete in accordance with Table AU106.10.

TABLE AU106.10 LINTELS AND BOND BEAMS SPANNING OPENINGS

• GROUND SNOW LOAD ≤ 30 PSF			WOOD: F_b ≥ 850 PSI E ≥ 1,300,000 PSI NO. 2 GRADE OR BETTER ORIENTED FLAT 1 PIECE OR 2 EQUAL-WIDTH PIECES EXTEND 1 FT BEYOND OPENING SIDES		CONCRETE: 2500 PSI COMPRESSIVE STRENGTH HEIGHT = 6” EXTEND 1 FT BEYOND OPENING SIDES REINFORCEMENT: 2 - #4 BARS[a] 2” CLEAR FROM BOTTOM 2” CLEAR FROM SIDES[a]	
Building width (feet)	**Cob above lintel (feet)**	**Total cob wall and plaster thickness (inches)**	**SIZE OF WOOD LINTEL OR BOND BEAM H x W (nominal inches)**		**WIDTH OF CONCRETE LINTEL OR BOND BEAM (inches)**	
			For Span ≤ 4’	**For Span ≤ 6’**	**For Span ≤ 6’**	**For Span ≤ 8’**
10	0	≤ 27	4x8	4x8	8	8
10	1	15	4x12	4x12	12	12
10	1	19	4x16	4x16	16	16
10	1	27	4x24	4x24	24	24
10	2	15	4x12	6x12	12	12
10	2	19	4x16	6x16	16	16
10	2	27	4x24	4x24	24	24
20	0	≤ 27	4x8	6x8	8	8
20	1	15	4x12	6x12	12	12
20	1	19	4x16	6x16	16	16
20	1	27	4x24	4x24	24	24
20	2	15	4x12	6x12	12	NP
20	2	19	4x16	6x16	16	NP
20	2	27	4x24	6x24	24	NP
30	0	≤ 27	4x8	6x8	8	NP
30	1	15	4x12	6x12	12	NP
30	1	19	4x16	6x16	16	NP

30	1	27	4x24	6x24	24	NP
30	2	15	4x12	6x12	12	NP
30	2	19	4x16	6x16	16	NP
30	2	27	4x24	6x24	24	NP

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm

NP = Not Permitted

a. Concrete bond beams spanning openings, and lintels greater than 16 inches in width, shall have an additional #4 bar in the center of their width.

AU106.11 Cob braced wall panels. *Cob braced wall panels* shall be in accordance with Section R602.10 and Tables AU106.11(1), AU106.11(2) and AU106.11(3A), AU106.11(3B) and AU106.11(3C). Wind design criteria shall be in accordance with Section R301.2.1. Seismic design criteria shall be in accordance with Section R301.2.2. An *approved* engineered design shall be required in accordance with Section R301.2.1 where the building is located in a Special Wind Region or a Wind Design Required location in accordance with Figure R301.2(5)B.

AU106.11.1 Non-orthogonal braced wall panels. *Braced wall panels* at an angle to the orthogonal braced wall lines shall be considered to contribute to the minimum total braced wall lengths in Tables AU106.11(2) and AU106.11(3) as follows:

1. A braced wall panel not more than 45 degrees and greater than 30 degrees to an adjacent orthogonal braced wall line shall contribute 50% of its length to that line.
2. A braced wall panel not more than 30 degrees to an orthogonal braced wall line shall contribute 65 percent of its length to that line.
3. A braced wall panel greater than 45 degrees and not more than 60 degrees to an orthogonal braced wall line shall contribute 35 percent of its length to that line.
4. The angle of a curved braced wall panel to a braced wall line shall be determined with the chord of that section of wall, connecting the end points of the arc at the center of the wall.

AU106.11.2 Braced wall lines for buildings with curved walls. Buildings with curved *cob* walls shall contain two braced wall lines in two orthogonal directions. The spacing of the braced wall lines for wind design in Table AU106.11(2) and the spacing and length of the braced wall lines for seismic design in Table AU106.11(3), shall be the maximum widths of the building in the two orthogonal directions.

AU106.11.3 Radius, thickness and length of curved braced wall panels. *Cob* curved *braced wall panels* shall have an inside radius of not less than 5 feet (1524 mm), shall be of the thickness required in Table AU106.11(1) and of the length determined in accordance with Section AU106.11. The curved wall's length shall be considered to be the length of the arc at the center of the wall, in accordance with Figure AU106.11.3 and determined with the following equation:

$ARC_C = .0175\ R_C \times A$ **(Equation AU-4)**

where:

ARC_C = Length of arc at center of wall (in feet)

R_C = Radius at center of wall = $R_I + .5T$ (in feet)

R_I = Inside radius of wall (in feet)

T = Thickness of wall without finish (in feet)

A = Angle of extent of braced wall panel from the center of the arc (in degrees)

FIGURE AU106.11.3 CURVED BRACED WALL PANEL

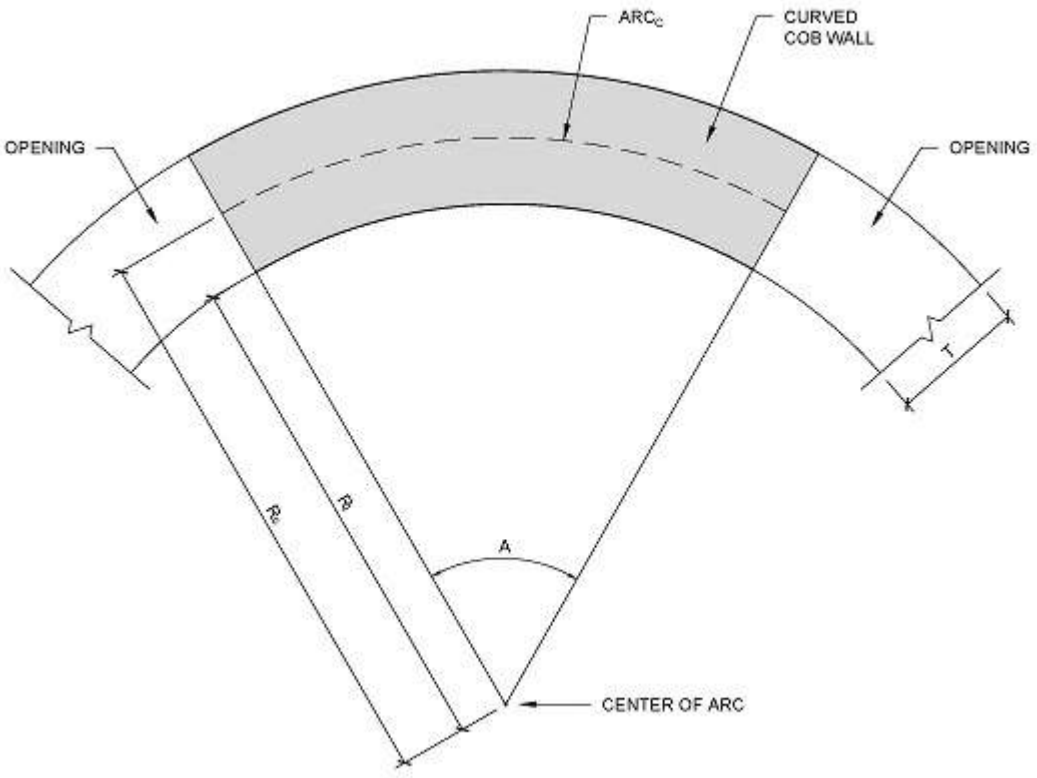


TABLE AU106.11(1) COB BRACED WALL PANEL TYPES

WALL TYPE[a] DESIGNATION	ANCHORS TO FOUNDATION[b]	ANCHORS TO BOND BEAM[c]	VERTICAL STEEL REINFORCING[b, c]	HORIZONTAL STEEL REINFORCING	MAXIMUM HEIGHT H[d] (in feet)	MAXIMUM ASPECT RATIO (H:L)
A	none	5/8" threaded rod @12" 4" from wall ends 12" embedment in cob	none	none	7[e]	1:1
B	#5 bar @ 12" 16" embedment in cob	5/8" threaded rod @12" 4" from wall ends 16"	none	2"x2"x14 gage welded wire mesh[f] @ 18", 6" from foundation and bond beam	7[e]	1:1

		embedment in cob 2”x2”x1/4” washer and nut at cob end				
C	#5 bar @ 12” 16” embedment in cob	5/8” threaded rod @12” 16” embedment in cob	5/8” threaded rod 4” from each end of braced wall panel continuous from foundation to bond beam	2”x2”x14 gage welded wire mesh[f]@ 18”, 6” from foundation and bond beam	7[e]	2:1
D	(see vertical steel reinforcing)	(see vertical steel reinforcing)	5/8” threaded rod 4” from each end of braced wall panel and @12”, continuous from foundation to bond beam	2”x2”x14 gage welded wire mesh[f] @ 18”, 6” from foundation and bond beam	7[e]	2:1
E	6”x6”x6 gage welded wire mesh 12”embedment in foundation	5/8” threaded rod @12” 4” from wall ends 12” embedment in cob	6”x6”x6 gage welded wire mesh 2” from each wall face	none	7.5	1:1

SI: 1 inch = 25.4 mm.

a. *Braced wall panel* types A, B, C, and D shall be not less than 16 inches thick. *Brace wall panel* type E shall be not less than 12 inches thick. All *braced wall panels* shall be not greater than 24 inches thick.

b. Not less than 8” embedment into foundation, unless otherwise stated.

c. Not less than 4” embedment into concrete bond beams. Full penetration through wood bond beam, secured with nut and washer.

d. *H* = height of the cob portion of the wall only. See Figure AU101.4.

e. Maximum height shall be 8 feet when wall thickness is increased to 18”.

f. Galvanized mesh.

TABLE AU106.11(2) BRACING REQUIREMENTS FOR COB BRACED WALL PANELS BASED ON WIND

SPEED

• EXPOSURE CATEGORY B[d] • 25-FOOT MEAN ROOF HEIGHT • 10-FOOT EAVE-TO-RIDGE HEIGHT[d] • 10-FOOT WALL HEIGHT[d] • 2 BRACED WALL LINES[d]			MINIMUM TOTAL LENGTH (FEET) OF COB BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE[a, b, c, d]			
Ultimate Design Wind Speed (mph)	**Story Location**	**Braced Wall Line Spacing (feet)**	**Cob braced wall panel[e] A (aspect ratio H:L ≤ 1:1)**	**Cob braced wall panel[e] B (aspect ratio H:L ≤ 1:1)**	**Cob braced wall panel[e] C, D (aspect ratio H:L ≤ 2:1)**	**Cob braced wall panel[e] E (aspect ratio H:L ≤ 1:1)**
10	6.0	6.0	3.7	NP		
≤ 110	One-story building	20	7.9	7.4	7.4	NP
30	11.8	11.0	11.0	NP		
10	6.0	6.0	4.1	NP		
≤ 115	One-story building	20	8.7	8.1	8.1	NP
30	13.0	12.1	12.1	NP		
10	6.0	6.0	4.4	NP		
≤ 120	One-story building	20	9.4	8.8	8.8	NP
30	14.1	13.1	13.1	NP		
10	6.0	6.0	5.1	NP		
≤ 130	One-story building	20	11.0	10.3	10.3	NP
30	16.5	15.4	15.4	NP		
10	6.0	6.0	5.9	NP		
≤ 140	One-story building	20	12.7	11.9	11.9	NP
30	19.1	17.8	17.8	NP		

For SI: 1 inch = 25.4 mm, 1 foot = 305 mm, 1 mile per hour = 0.447 m/s.

a. Linear interpolation shall be permitted.

b. Braced wall panels shall be without openings.

c. Braced wall panel types A, B and E shall have an aspect ratio (H:L) ≤ 1:1. Braced wall panel types C and D shall have an aspect ratio (H:L) ≤ 2:1.

d. Subject to applicable wind adjustment factors associated with Items 1 and 2 of Table R602.10.3(2)

e. *Cob* braced panel types indicated shall comply with Sections AU106.11.1, AU106.11.2 and Table AU106.11(1).

TABLE AU106.11(3A) BRACING REQUIREMENTS FOR COB-BRACED WALL PANELS BASED ON SEISMIC DESIGN CATEGORY A

• **SOIL CLASS D**[e] • **TOTAL WALL HEIGHT = 10 FEET (INCLUDING STEM WALL AND BOND BEAM)** • **COB WALL HEIGHT PER TABLE AS106.11(1)** • **15 PSF ROOF-CEILING DEAD LOAD**[d] • **STORY LOCATION: ONE-STORY BUILDING** • **SEISMIC DESIGN CATEGORY A** • **1.5" PLASTER THICKNESS EACH SIDE**[h]				**MINIMUM TOTAL LENGTH (FEET) OF COB-BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE**[a, b, c, d]		
Braced wall line spacing (feet)	**Braced wall line length (feet)**	**Braced wall line % openings**	**Perpendicular braced wall line % openings**	**Cob-braced wall panel**[e] **A, B**	**Cob-braced wall panel**[e] **C, D**	**Cob-braced wall panel**[e] **E**
10	30	Any %[g]	Any %[g]	Wind[i]	Wind[i]	NP
20	20	Any %[g]	Any %[g]	Wind[i]	Wind[i]	NP
20	30	Any %[g]	Any %[g]	Wind[i]	4.5	NP
30	30	Any %[g]	Any %[g]	Wind[i]	Wind[i]	NP

For SI: 1 inch = 25.4 mm, 1 foot = 305 mm, 1 pound per square foot = 0.0479 kPa.

a. Interpolation is not permitted.

b. Braced wall panels shall be without openings.

c. Braced wall panel types A, B and E shall have an aspect ratio (H:L) ≤ 1:1. Braced wall panel types C and D shall have an aspect ratio (H:L) ≤ 2:1.

d. Subject to applicable seismic adjustment factors associated with item 5 in Table R602.10.3(4).

e. Cob braced panel types indicated shall comply with Sections AU106.11.1 and AU106.11.2 and Table AU106.11(1).

f. Wall bracing lengths are based on a soil site class “D.” Interpolation of bracing lengths between S_{ds} values associated with the seismic design categories is allowable where a site-specific S_{ds} value is determined in accordance with Section 1613.3 of the *International Building Code*.

g. Openings in the braced wall line shall not be limited, except that the minimum total braced wall panel length shall be as determined by Tables AU106.11(3A) and AU106.11(2).

h. For total plaster thickness between 3-inches and 6-inches, the minimum total length of braced wall panels shall be mulitplied by 1.2.

i. The minimum total braced wall panel length shall be governed by Table AU106.11(2).

AU106.11(3B) BRACING REQUIREMENTS FOR COB-BRACED WALL PANELS BASED ON SEISMIC DESIGN CATEGORY B

• **SOIL CLASS D**[e] • **TOTAL WALL HEIGHT = 10 FEET (INCLUDING STEM WALL AND BOND BEAM)** • **COB WALL HEIGHT PER TABLE AS106.11(1)** • **15 PSF ROOF-CEILING DEAD LOAD**[d] • **STORY LOCATION: ONE-STORY BUILDING** • **SESIMIC DESIGN CATEGORY B** • **1.5” PLASTER THICKNESS EACH SIDE**[h]				**MINIMUM TOTAL LENGTH (FEET) OF COB-BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE**[a, b, c, d]		
Braced wall line spacing (feet)	**Braced wall line length (feet)**	**Braced wall line % openings**	**Perpendicular braced wall lines % openings**	**Cob-braced wall panel**[e] **A, B**	**Cob-braced wall panel**[e] **C, D**	**Cob-braced wall panel**[e] **E**
10	10	Any %[g]	Any %[g]	Wind[i]	Wind[i]	NP
10	20	0	Any %[g]	6.0	4.9	NP
10	20	50	Any %[g]	6.0	Wind[i]	NP
10	30	0	Any %[g]	7.1	6.6	NP
10	30	50	Any %[g]	6.0	4.5	NP
20	10	0	0	6.0[j]	4.9[j]	NP
20	10	0	50	6.0	Wind[i]	NP
20	10	50	Any %[g]	6.0	4.2	NP
20	10	50	50	6.0	4.2	NP
20	20	0	0	7.4	6.9	NP
20	20	0	50	6.0	5.5	NP
20	20	50	0	6.0	5.5	NP
20	20	50	50	6.0	4.1	NP
20	30	0	0	9.4	8.8	NP

20	30	0	50	7.9	7.4	NP
20	30	50	0	7.2	6.7	NP
20	30	50	50	6.0	5.3	NP
30	10	Any %[g]	Any %[g]	Wind[i]	Wind[i]	NP
30	20	0	0	9.4	8.8	NP
30	20	0	50	Wind[i]	Wind[i]	NP
30	20	50	Any %[g]	7.9	Wind	NP
30	30	0	0	11.8	11.0	NP
30	30	0	50	9.5	8.9	NP
30	30	50	0	9.5	8.9	NP
30	30	50	50	Wind[i]	Wind[i]	NP

For SI: 1 inch = 25.4 mm, 1 foot = 305 mm, 1 pound per square foot = 0.0479 kPa.

NP = Not Permitted

a. Interpolation is not permitted.

b. Braced wall panels shall be without openings.

c. Braced wall panel types A, B and E shall have an aspect ratio (H:L) ≤ 1:1. Braced wall panel types C and D shall have an aspect ratio (H:L) ≤ 2:1.

d. Subject to applicable seismic adjustment factors associated with Item 5 in Table R602.10.3(4)

e. Cob braced panel types indicated shall comply with Sections AU106.11.1, AU106.11.2 and Table AU106.11(1).

f. Wall bracing lengths are based on a soil site class “D.” Interpolation of bracing lengths between *Sds* values associated with the seismic design categories is allowable where a site-specific *Sds* value is determined in accordance with Section 1613.3 of the *International Building Code*.

g. Openings in the braced wall line shall not be limited, except that the minimum total braced wall panel length shall be as determined by Tables AU106.11(3A) and AU106.11(2).

h. For total plaster thicknesses 3-inches to 6-inches, the minimum total length of braced wall panels shall be multiplied by 1.2.

i. The minimum total braced wall panel length shall be governed by Table AU106.11(2).

j. Total plaster thicknesses shall be not greater than 3-inches. Substitute 15/32” roof sheathing and 10d at 6” edge nailing for requirements in Table R602.3(1).

AU106.11(3C) BRACING REQUIREMENTS FOR COB-BRACED WALL PANELS BASED ON SEISMIC DESIGN CATEGORY C

• **SOIL CLASS D[e]**	**MINIMUM TOTAL LENGTH (FEET) OF COB-BRACED WALL PANELS REQUIRED ALONG**

• TOTAL WALL HEIGHT = 10 FEET (INCLUDING STEM WALL AND BOND BEAM) • COB WALL HEIGHT PER TABLE AS106.11(1) • 15 PSF ROOF-CEILING DEAD LOAD[d] • STORY LOCATION: ONE-STORY BUILDING • SESIMIC DESIGN CATEGORY C • 1.5" PLASTER THICKNESS EACH SIDE[h]				EACH BRACED WALL LINE[a, b, c, d]		
Braced wall line spacing (feet)	**Braced wall line length (feet)**	**Braced wall line % openings**	**Perpendicular braced wall lines % openings**	**Cob-braced wall panel[e] A, B**	**Cob-braced wall panel[e] C, D**	**Cob-braced wall panel[e] E**
10	10	0	0	8.3[i]	7.8[i]	NP
10	10	0	50	6.5	6.1	NP
10	10	25	0	7.4[i]	6.9[i]	NP
10	10	50	50	4.7	4.4	NP
10	15	0	0	10.6	9.9	NP
10	15	0	50	8.7	8.2	NP
10	15	50	0	7.8	7.3	NP
10	15	50	50	6.0	5.6	NP
10	20	0	0	12.8	11.9	NP
10	20	0	50	11.0	10.2	NP
10	20	50	0	9.1	8.5	NP
10	20	50	50	7.3	6.8	NP
15	10	25	0	9.6	9.0	NP
15	10	0	50	7.8	7.3	NP
15	10	50	0	8.7	8.2	NP
15	10	50	50	6.0	5.6	NP
15	15	0	0	12.9	12.1	NP
15	15	0	50	10.2	9.5	NP
15	15	50	0	10.2	9.5	NP
15	15	50	50	7.5	7.0	NP
15	20	0	0	15.3	14.3	NP
15	20	0	50	12.6	11.7	NP
15	20	50	0	11.7	10.9	NP
15	20	50	50	8.9	8.3	NP
20	10	25	0	NP	NP	NP
20	10	0	50	9.1	8.5	NP
20	10	50	Any %[g]	NP	NP	NP

20	10	50	50	7.3	6.8	NP
20	15	0	0	NP	NP	NP
20	15	0	50	11.7[i]	10.9[i]	NP
20	15	50	0	NP	NP	NP
20	15	50	50	8.9[i]	8.3[i]	NP
20	20	0	0	NP	NP	NP
20	20	0	50	14.2	13.3	NP
20	20	50	0	NP	NP	NP
20	20	50	50	NP	9.9	NP

For SI: 1 inch = 25.4 mm, 1 foot = 305 mm, 1 pound per square foot = 0.0479 kPa.

NP = Not Permitted

a. Interpolation is not permitted.

b. Braced wall panels shall be without openings.

c. Braced wall panel types A, B and E shall have an aspect ratio (H:L) ≤ 1:1. Braced wall panel types C and D shall have an aspect ratio (H:L) ≤ 2:1.

d. Subject to applicable seismic adjustment factors associated with item 5 in Table R602.10.3(4).

e. Cob braced panel types indicated shall comply with Sections AU106.11.1, AU106.11.2 and Table AU106.11(1).

f. Wall bracing lengths are based on a soil site class “D.” Interpolation of bracing lengths between *Sds* values associated with the seismic design categories is allowable where a site-specific *Sds* value is determined in accordance with Section 1613.3 of the *International Building Code*.

g. Openings in the braced wall line shall not be limited, except that the minimum total braced wall panel length shall be as determined by Tables AU106.11(3A) and AU106.11(2).

h. For total plaster thicknesses 3” to 6”, multiply the minimum total length of braced wall panels by 1.2.

i. Total plaster thickness > 3” is not permitted. Substitute 15/32” roof sheathing and 10d at 6” edge nailing for requirements in Table R602.3(1).

AU106.12 Resistance to wind uplift forces. *Cob* walls that resist uplift forces from the roof assembly, as determined in accordance with Section R802.11, shall be in accordance with Table AU106.12.

TABLE AU106.12 ANCHORAGE OF BOND BEAMS FOR WIND UPLIFT

· **ANCHORS: 5/8” ALL THREAD AT 12” O.C. [a, b]**
· **2”x2”x1/4” WASHERS AND NUT AT END IN COB**
· **4” EMBEDMENT IN CONCRETE BOND BEAMS**

· FULL PENETRATION THROUGH WOOD BOND BEAMS WITH 2”X2”X1/4” WASHER AND NUT			
ANCHORAGE DEPTH IN INCHES, PER WALL WIDTH AND WIND UPLIFT FORCE			
WIND UPLIFT FORCE FROM TABLE R802.11 (PLF)	**≤ 12” wall width[c]**	**≤ 16” wall width[c]**	**≤ 24” wall width[c]**
< 75	16	12	12
< 100	24	16	12
< 150	4’ o.c. continuous from foundation to bond beam[d]	24	16
< 200	4’ o.c. continuous from foundation to bond beam[d]	4’ o.c. continuous from foundation to bond beam[d]	24

a. For wood bond beams a maximum of 6” from bond beam ends.

b. For min. 6”x8” concrete bond beams, at 18” o.c. for wind uplift forces < 75 plf., and at 16” o..c for wind uplift forces < 100 plf.

c. Excluding finishes.

d. With 7-inch embedment in foundation, 4-inch embedment in concrete bond beam or full penetration through wood bond beam with 2”x2”x1/4” washer and nut.

AU106.13 Post-and-beam with cob infill. Post-and-beam with *cob* infill wall systems shall be in accordance with an *approved* engineered design.

AU106.14 Buttresses. *Cob* buttresses that are intended to provide out-of-plane wall bracing, or additional capacity for *braced wall panels* shall be in accordance with an *approved* engineered design.

SECTION AU107
COB FLOORS

AU107.1 Cob floors. *Cob* floors supported by grade shall be in accordance with an *approved* specification. Straw shall not be required in the material mix.

SECTION AU108
FIRE RESISTANCE

AU108.1 Fire-resistance rating. *Cob* walls shall be considered to exhibit a 1-hour fire-resistance rating in accordance with the following:

1. Wall thickness shall be 10 inches (254 mm) or greater.
2. Density shall be 70 pcf (1121 kg/m^3) or greater.
3. When used as a *load-bearing wall*, the maximum design load shall be 1000 pounds per lineal foot (14,590 N/m) in accordance with Section AS106.8.
4. When used as a *braced wall panel*, the wall shall be in accordance with Section AS106.11.

AU108.2 Clearance to fireplaces and chimneys. *Cob* walls or other *cob* surfaces shall not require clearance to fireplaces and chimneys, except where clearance to non-combustibles is required by the manufacturer’s instructions.

SECTION AU109

THERMAL PERFORMANCE

AU109.1 Thermal characteristics. *Cob walls* shall be classified as mass walls in accordance with Section N1102.2.5 (R402.2.5) and shall meet the R-value requirements for mass walls in Table N1102.1.2 (R402.1.2).

AU109.2 Thermal resistance. The unit R-value for *cob* walls with a density of 110 pcf (1762 kg/m^3) shall be R-0.22 per inch of *cob* thickness. Walls that vary in thickness along their height or length shall use the average thickness of the wall to determine its R-value. The thermal resistance values of air films and finish materials or additional insulation shall be added to the cob wall's thermal resistance value to determine the R-value of the wall assembly.

AU109.3 Additional insulation. When insulating materials are added to the face of a *cob* wall, the combination of additional insulation and any associated connecting, weather-resisting, or protective materials shall comply with Section AU104.1, Items 1-4.

SECTION AU110 REFERENCED STANDARDS ASTM C5—10 Standard Specification for Quicklime for Structural Purposes - AU104.4.6.1
ASTM C141/C141M—14 Standard Specification for Hydrated Hydraulic Lime for Structural Purposes - AU104.4.6.1

ASTM C206—14 Standard Specification for Finishing Hydrated Lime - AU104.4.6.1

ASTM C1707—11 Standard Specification for Pozzolanic Hydraulic Lime for Structural Purposes - AU104.4.6.1

ASTM E2392/ E2392M—10 Standard Guide for Design of Earthen Wall Building Systems - AU104.4.3.2

ASTM BS1, ASTM BS EN 459—2015 Part 1: Building Lime. Definitions, Specifications and Conformity Criteria; Part 2: Test Methods - AU104.4.6.1

Reason: Cob is an earthen material mix of clay-soil, sand, straw, and water, placed onto a wall in layers to create a monolithic wall. Because the material mix and density of cob are very similar to those of adobe bricks, cob is sometimes known as “monolithic adobe.”
Cob has been used for thousands of years around the world, notably in England and Northern Europe, the Middle East, West Africa, China, and the Southwestern United States. An estimated 20,000 cob homes are still inhabited in the English county of Devon alone, some dating from the 15th century. The term “cob” derives from an Old English word for “lump,” since historical structures were often constructed one handful at a time.

Today, cob is often mixed mechanically using a tractor or mortar mixer, but the wall construction is still generally manual. Cob buildings typically feature raised impermeable foundations and extended roof eaves to protect the walls from moisture and weather. Walls are often plastered with clay, lime or gypsum plasters which protect and beautify the cob without leading to the moisture problems associated with less vapor-permeable finishes such as cement stucco on historic adobe structures.

Since the 1990's, there has been increasing interest in cob construction in the United States and much of the world. Like other earthen construction methods, cob can greatly reduce embodied energy and life-cycle CO2 emissions of buildings. Cob is highly recyclable, and with good design, construction and maintenance, can withstand centuries of use. The constituent materials are inexpensive compared with lumber, steel, concrete and other commonly used building materials. Cob is non-combustible and non-toxic in all stages of construction and use. Cob's thermal mass and moisture management properties modulate interior temperature and humidity, creating healthful building.

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While adobe is included in the masonry chapter of the IBC, and cob building codes or guidelines exist in England and New Zealand, there is currently no cob building code in the United States. As a result, permitting of cob buildings has been left to individual building officials on a case-by-case basis. Designers, builders and officials may be unaware of proper practices to make cob buildings safe and durable. Nevertheless, the desire to utilize cob construction continues, and promises to accelerate in response to economic and environmental pressures. These include the need for non-combustible construction systems that can withstand the increased frequency and intensity of wildfires in the western U.S. The lack of a cob building code has been an impediment to the proper and broader use of cob construction.

The proposed Cob Construction appendix for the IRC was created in response to this need. It is based on New Zealand's earthen building standards, on US codes for the closely-related earthen building systems of adobe and straw-clay, and on the experience and the testing of cob buildings over the past 25 years by architects, engineers, builders, and academics throughout the U.S. and the world. It has received review and input from over 25 experts including 4 architects and 6 civil engineers, including the architect and chair of the Committee that developed the New Zealand Standard for Earth Buildings. Much of the recent testing and research has been compiled or performed by the California-based Cob Research Institute, a non-profit organization founded in 2008 to remove legal barriers to cob construction and promote its safe use. If adopted, the proposed appendix will serve designers, builders, owners, inhabitants, and building officials alike in the design and construction of safe and durable cob buildings.

Supporting documents for the proposed Cob Construction appendix is available at:
https://www.cobcode.org/cobcode-documents

Rationale for Specific Sections of Proposed Appendix U – Cob Construction

GENERAL:

Cob construction can help address the increasing need to reduce our buildings' negative impacts on the environment, including the global climate, and address the impacts of a changing climate on buildings, including increased firestorms. Like other earthen wall systems, cob is among the most fire-resistant building materials available, while also having a low environmental impact. The ability to build with site- or locally-sourced materials further reduces processing and transportation impacts as well as costs.

Though cob construction is not an industrialized building system, its centuries of continuous use in many parts of the world provide empirical evidence and guidance for good practice. This appendix gives the building official greater flexibility to consider empirical evidence and lifecycle impacts in meeting the intent of the code while not abridging health and life-safety requirements.

DEFINITIONS:

Cob-specific terms not found in the IRC are defined. Some terms already defined in the IRC are adjusted to give

specific meaning for cob construction. Some definitions are consistent with identical terms defined in IRC Appendix R – Light Straw Clay Construction, and Appendix S – Strawbale Construction.

MATERIALS, MIXING AND INSTALLATION:

The provisions for materials, mixing, and installation are based on existing codes, standards, and guidelines from the UK, New Zealand and the U.S., including ASTM E2392-10 Standard Guide for the Design of Earthen Wall Systems, as well as the experience of designers and builders of cob and earthen buildings in the U.S. and other countries.

Though the materials for cob can vary considerably, the material specifications coupled with the mix design tests for shrinkage, compressive strength and modulus of rupture ensure adequate strength and stability of the wall materials.

FINISHES:

Where cob walls are not substantially rain-exposed they are allowed to remain without finish. Minor erosion has proven to be acceptable on cob walls, and is a matter of maintenance, not unlike the need to periodically repaint the exterior of buildings of conventional construction. However, where cob walls are susceptible to excessive erosion or water intrusion from weather, finishes are necessary to protect the wall while ensuring that any moisture that might enter the wall is able to escape without causing harm. Thus, finishes and finish assemblies must be a minimum of 5 perms, the IRC defined threshold of vapor permeable. Class I and II vapor retarders are prohibited on cob walls except where specifically permitted or required, for example at showers.

A range of plaster types are allowed and described, specifying critical components and characteristics of the plasters, the recognized standards with which they must comply, and other necessary details for their installation. The plasters allowed in the appendix have a history of successful use on cob and other earthen wall systems.

Non-plaster finishes systems are allowed with approved specifications that ensure: adequate attachment or support, the ability to safely discharge moisture, a minimum vapor permeance rating, and compliance with stated weight limits.

COB WALLS - GENERAL:

General limits are given for all cob buildings, including: one story; maximum building height of 25 feet; Seismic Design Categories A, B, and C (except with an approved engineered design); wall height and wall thickness limitations; and an approved engineered design for interior cob walls that addresses their seismic lateral loads (except in Seismic Design Category A).

A method of out-of-plane resistance is required for all walls, and wall height limits are given. Bond beams are required and described for all cob walls, as are lintels over door and window openings. Reinforcing at window and door openings is required for openings wider than 2 feet. Window openings are limited to 6 feet in width and horizontal and vertical reinforcing at window and door openings is required and described. A minimum cob wall length between openings is given and reinforcing required to ensure the wall's stability.

Moisture control requirements address potential moisture intrusion from rain or snow, or through capillary action from the ground and help ensure that moisture that might enter is not trapped. That protection includes limiting the use of membranes and barriers between the cob and plaster finishes. Limiting the use of membranes also enables a mechanical bond between the plaster and the cob.

A Class I or II vapor retarder is required between the bottom of the cob wall and the foundation to prevent ground moisture from rising into the wall, unless the particular project conditions and design eliminate this need. A minimum separation of the cob wall above finished grade is required. Protection of horizontal surfaces is required to prevent erosion and water intrusion.

Requirements for installing windows and doors are given so they are secure and prevent the passage of air or moisture through or into the wall.

In addition to inspections normally required, inspections specific to cob construction are required for the anchors connecting cob walls to the foundation and the bond beam, for required vertical or horizontal reinforcing in the walls, and for reinforcing in any concrete bond beams or lintels.

COB WALLS - STRUCTURAL:

Cob walls are a compression dominant wall system containing a micro-reinforcing system of straw throughout. Testing has shown this increases ductility compared to earthen materials with no straw. Cob can be reinforced with other standard reinforcing materials such as steel bar and welded wire mesh, making it akin to concrete construction in this respect. Cob wall systems using these reinforcing materials are included in the proposed appendix.

University and independent lab structural tests on cob have been conducted and documented since the 1990s. Testing this proposed code has used as the bases of its analysis include: In-Plane Reverse Cyclic Tests as well as small scale batch testing at Santa Clara University; Small Scale batch testing at the University of Plymouth (England); Federal Institute for Materials Research and Testing, Berlin, Germany; The University of Oregon; Wuhan University of Technology, China; the University of San Francisco; and the Washington State University. Shake table test results were also used from the University of Sydney (Australia), and the University of British Columbia (Canada).

This proposed code also drew on the following codes, standards and earthen engineering texts: ASTM E2392 Standard Guide for Design of Earthen Wall Building Systems; the engineered and prescriptive New Zealand Standard for Earth Buildings NZS4297-99; The New Mexico Earthen Building Materials Code; the prescriptive German Earthen Building Standard, DIN 4102; and earthen engineering texts such as Building with Earth: Design and Technology of a Sustainable Architecture, by Gernot Minke.

Gravity load-bearing values are based on project specific, required material tests. Lateral loads are limited to Seismic Design Categories (SDC) A, B, and C, with increased safety factors and decreased Response Modification Factors for SDC C. Gravity and earthquake effects of the cob weight itself have been generated assuming a material density of 110 pcf which is the upper limit of density for all tests assessed. A common density range of 80-105 pcf is expected in the field. Appropriate adjustment factors have been applied for other structural elements and connections contained in other parts of the IRC that may be uniquely affected by the increased dead load of cob walls, such as the roof diaphragm. A full report of the structural analysis that generated this proposed appendix is available at: https://www.cobcode.org/cobcode-documents

COB FLOORS:

Cob floors on grade, with or without straw, are permitted in cob buildings, but the specifications must be approved by the building official. There are numerous viable cob floor systems. The modern evolution and growing use of cob and other earthen floors in high-end custom homes is testament to their serviceability, aesthetic appeal, and low environmental impact.

FIRE RESISTANCE:

ASTM E119 Fire-Resistance Rating Equivalency for Monolithic Adobe (Cob) walls.

To establish the minimum 1-hour fire resistance rating for a 10" thick cob wall included in this appendix, extensive research was done into existing ratings in codes and standards, testing, and fire experience in earthen wall buildings. A technical equivalency evaluation was conducted by Reax Engineering, Inc., which is summarized below. In addition, it is worth noting that in Australia as in the western U.S., devastating wildfires, or bushfires as they are called in Australia, have been increasing in frequency and intensity. Because of a tradition of buildings with earthen walls in areas that have experienced the most intense bushfires, they have had the opportunity to observe how earthen walls perform in firestorms.

The Australian Standard AS 3959-2009, "Construction of buildings in bushfire-prone areas," was developed as a result. This standard lists "earth wall including mud brick" as one of only three external wall materials not needing additional testing even in the most extreme and vulnerable bushfire zones, BAL FZ (Bushfire Attack Level- Flame Zone). The standard stipulates that the exposed components of external walls shall be of non-combustible material at least 90mm (3.54 inches) thick. Along with earth walls, the other materials listed as acceptable without additional testing for external walls are full masonry and precast or in situ concrete. The minimum 10-inch thick 1-hour cob wall in this proposed appendix is almost three times as thick as the minimum

thickness of the earth wall accepted by that standard for the highest fire risk zones in Australia.

Additionally, the Australian Earth Building Handbook, HB195-2002, in Section 4.6 Fire Resistance Level, states, "In the absence of specific test data, the general fire resistance level (FRL) of earth walls satisfying the minimum thickness requirements outlined in Clause 4.3.4 may be taken as not greater than 120/120/120, or 90/90/90 where wall thickness is less than 200 mm." Clause 4.3.4 Structural Adequacy states: "Minimum recommended thicknesses for mud brick, stabilized pressed block and rammed earth are as follows: External walling - 200 mm, Internal walling - 125 mm. The minimum wall thickness for poured earth and cob wall construction is also recommended to be 200 mm, though in practice wall thickness will often exceed this value."

The three numbers in the FRL represent minutes before failure for structural adequacy/integrity/insulation. In other words the time for the wall to be able to maintain a load, maintain its integrity, and before heat increase on the unheated side of the wall exceeds accepted limits. Thus Australia gives a 2-hour fire resistance rating for a 200 mm (7.87") earth wall. This Standards Australia handbook is available via the supporting documents link above.

Summary of the Reax Engineering Inc. evaluation and analysis of historical tests and other relevant evidence to determine a fire-resistance rating equivalency for cob walls.

Code Requirement

IRC Section R302.1 Exterior Walls and Table R302.1(1) requires 1-hour fire-resistance rated walls to be tested in accordance with ASTM E119 or UL 263 with exposure from both sides. E119 fire-resistance ratings ≥ 1 hour must include a one-minute hose stream test following the fire-resistance test.

Proposed Equivalency

ASTM E119 and equivalent international tests AS 1530 and EN 1363 on closely-related compressed earth block and adobe block walls, were used to demonstrate a minimum of 1-hour fire resistance of Monolithic Adobe (Cob) walls greater than or equal to 10 inches thick, including a significant factor of safety.

Rational Engineering Analysis of Proposed Equivalency

Reax Engineering Inc. evaluated results from standardized testing, published standards, and empirical evidence, to establish a conservative minimum value for the fire resistance of monolithic adobe (sand, straw and unfired clay in monolithic form). Data was from allied construction systems using the same sand, clay, straw materials in brick form (brick and monolithic walls of these materials are referred to collectively as “earthen walls”).

The tests are described below and summarized in Table 1. All tests except test (c) (run to insulation failure) passed all parameters tested: loadbearing, integrity, insulation. Test (a) also included and passed a hose stream test. All wall specimen sizes were 10’ x 10’ or the close metric equivalent of 3.1 x 3.1 meters.

Test Descriptions

a. A test of a 10” thick, compressed earth block wall was conducted in 2013 in Texas to the ASTM E119 2-hour load-bearing standard. Results for the test including the hose stream component are proprietary but a video is available at the following link: Urban Earth Fire Resistance Test (video)

b. A test of a 9.84” thick compressed earth block wall was conducted in 2011 in South Africa to a 1-hour

standard using an ISO 834 time/temperature curve identical to the ASTM E119 temperature curve. This test provided the basis for a 2-hour loadbearing fire-resistance rating for 9.84" thick compressed earth block wall.

c. A test of a 5.9" thick Cinva-ram earth block wall was conducted in Australia to insulation failure at 3 hrs 41 minutes, to the AS1530.4 standard. It was reported in the Commonwealth Scientific and Industrial Research Organization's (CSIRO) Bulletin 5: Earth Wall Construction, 1976. CISRO is an independent Australian federal government agency responsible for scientific research.

d. A test was conducted in Australia in 1982 to the AS1530.4-1975 4-hour standard, which is nearly identical to the ASTM E119 4-hour standard. The test provided a 4-hour loadbearing fire-resistance rating for a 9.8" thick adobe block wall. The test was stopped after 4 hours. Researchers extrapolated a 6 to 7-hour rating had the test continued, with heat rise on the unexposed face the predicted limiting factor.

e. A test of a 5.9" thick walls was conducted at the Laboratory for Structures and Fire Resistance at the University of Aveiro, Portugal, using ISO 834 time-temp curve and the European Standards for testing fire resistance (EN1363-1 and EN 1364-1). One wall tested soil stabilized with cement, and one tested soil stabilized with Kraft fibers.

Table 1. Summary of Testing

Test	Material	Rating (hours) / Test duration (hours)	Load Bearing	Hose Stream	Thickness (in.)	Standard / Variation from E119
a	Compressed Earth Block	2.0 / 2.4	Y	Pass	10	ASTM E119 / no variation
b	Compressed Earth Block	2.0 / 2.4	Y	Not done	9.84	ISO 834 / Nearly identical to ASTM E119
c	Ram Earth Block	3.6 / 7.3	Y	Not done	5.9	AS 1530-1975 / Based on ISO 834
d	Adobe Block	4.0 / 4.9	Y	Not done	9.8	AS 1530-1975 / Based on ISO 834
e	Compressed Earth Block	2.0 / 4.1	N	Not done	5.9	EN 1363-1 w ISO 834 time temp curve to 120

						minutes

Several of these tests are on compressed earth block systems which lack the straw component of cob wall construction. Straw adds resistance to heat transfer thus decreasing the rate of surface temperature rise on the unexposed side. Straw in the wall will not combust due to lack of oxygen, and it will continue to offer its primary role in adobe of limiting crack propagation, a property expected to enhance a cob wall's resistance to thermally induced structural failure.

As a massive system, a monolithic adobe wall can absorb a significantly greater amount of heat when compared to a standard stuccoed wood-framed wall. For slow growing fires, this translates to less heat on the interior, and prolonged time to flashover with increased protection and time for escape.

Photos were reviewed of surviving earthen walls with completely incinerated wooden floor and roof structures in California and Australian firestorms. These show further evidence of the resistance of earthen wall systems to intense fire conditions.

Monolithic adobe is used to construct fireplaces, ovens, kilns, and forges, a testament to its ability to contain fire. It is favored for these applications over concrete, rock, and red brick, for its lesser tendency to crack or spall.

Comparison to Tests and Adopted Standards

The engineering judgment was checked against standards from two jurisdictions with prescribed fire-resistance ratings for earthen walls. The Pima County Approved Standard for Earthen IBC Structures, provides a 2-hour rating for a 10" thick wall. New Zealand's NZS 4297 Engineering Design of Earth Buildings provides a 2-hour rating for a 5.9" thick wall. Thus an engineering judgment of a 1-hour fire-resistance rating for a 10" thick monolithic adobe wall provides a 100% safety margin compared to these standards and as compared to four of the five described tests. A 1-hour rating provides a 300% safety margin compared with the Australian adobe block test that yielded a 4-hour rating.

Conclusion

All relevant evidence strongly supports the judgment that monolithic adobe (cob) walls constructed to a minimum thickness of 10 inches provide a conservative minimum fire-resistance rating of 1-hour.

Fire testing reports, related documents and the equivalency report are available at https://www.cobcode.org/cobcode-documents

THERMAL PERFORMANCE:

Cob walls are classified as mass walls in accordance with Section N1102.2.5 because the heat capacity of cob walls is greater than the 6 Btu/ft^2 x ^{o}F threshold defined in that section. The lowest heat capacity of a cob wall is 16 Btu/ft^2 x ^{o}F, for the required minimum wall thickness of 10" and at the lowest practical density of 70 pcf.

Cob's assigned unit R-value of 0.22 per inch with a density of 110 pcf was determined with an ASTM C1363 thermal resistance test at Intertek Laboratory in Fresno, CA in December 2018. The R-value of the wall assembly is determined by adding the thermal resistance of the air films and any finish or additional insulation.

Adding insulation to the face of cob walls can allow them to be used more readily in cold climates. This is allowed, providing the insulation assembly complies with the requirement in Section AU104.1 for attachment or

support, vapor permeance, and weight limits.

Bibliography: *The following documents relate to one or more categories in the code proposal as indicated: General (G), Structural (S), Fire (F).*

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AS 3959-2009, Australian Standard Construction of Buildings in Bushfire Prone Areas, (incorporating Amendments 1, 2 and 3), Standards Australia, 2009-2011. *S, F*

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"Cob: A Sustainable Building Material," D. Eberhard, J. Novara, B. Popovec, Santa Clara University Department of Civil Engineering, 2018. *S*

"Cob Property Analysis," G. Brunello, J. Espinoza, A. Golitz, Santa Clara University Department of Civil Engineering, 2018. *S*

Building With Earth: Design and Technology of Sustainable Architecture, Gernot Minke, 2006. *G, S*

"Transforming building regulatory systems to address climate change," David Eisenberg, Building Research and Information, 2016. *G*

Cost Impact: The code change proposal will not increase or decrease the cost of construction
As a wall system cob can be more costly or less costly than conventional wall systems found in the IRC, depending on many variables. The materials for cob walls or clay soil (often from the site), sand, and straw are relatively inexpensive whereas the cob walls can be more labor intensive. Other elements or systems in the building such as the foundation, roof, electrical, plumbing and mechanical can be very similar to those used in conventional construction and therefore the same cost. As an overview this proposal will not affect the cost of construction.