Appendix AU:
Cob Construction (Monolithic Adobe)

The provisions contained in this appendix are not mandatory unless specifically referenced in the adopting ordinance.

**General Comments**

Cob is an earthen material made of clay subsoil, straw and added sand when needed. These are mixed together with water and placed onto a foundation in horizontal layers to produce a monolithic wall. Because cob’s constituent materials and density are very similar to those of adobe bricks, this building technique is sometimes known as “monolithic adobe.” Under many names, 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 fifteenth century.

Historically, the materials were mixed in shallow pits by either draft animals or human labor. The stiff, plastic mixture was extracted manually from the pit and applied to the wall in lumps. The term “cob” derives from an Old English word for “lump” and has evolved to be the name of the material. Today, cob is mixed either manually by human feet or mechanically using tractors, excavators or rotary mixers. Wall construction is still typically manual and without formwork. However, mechanical placement and the use of formwork are recent trends that speed construction, and cob has potential for robotic 3D printing.

The provisions in this appendix are based on a combination of heritage methods of cob building successfully used for centuries, recent decades of innovation and practice, relevant existing US and international codes and standards, recent materials and system testing, and modern building science.

Cob buildings feature raised foundations and extended roof eaves to protect the walls from moisture and weather. Cob walls are often plastered with clay or lime plasters, which protect and beautify the cob without leading to the moisture problems associated with less vapor-permeable finishes such as conventional cement stucco on historic adobe structures.

Since the 1990’s, there has been a resurgence of interest in cob construction in the United States and much of the world. Compared to manufactured building materials, the use of cob and other earthen materials can greatly reduce the embodied energy and life-cycle CO₂ emissions of buildings. With good design, construction and maintenance, and their natural resistance to rot and fire, cob buildings have proven to last many centuries. The oldest continuously inhabited building in the United States, the Taos Pueblo, is over 700 years old and made of a combination of adobe brick and cob.

The constituent materials are inexpensive and typically require little transportation compared with lumber, steel, concrete and other remotely produced building materials. Cob is highly fire resistant, easily recyclable and nontoxic in all stages of construction and use. Cob’s thermal mass and moisture management properties modulate interior temperature and humidity, helping to create thermally comfortable and healthy buildings.

Many credible sources such as books, websites and associations provide information, training, building methods and best practices for cob construction for those who need them. Such guidance is beyond the scope of this appendix and its commentary, which address the minimum requirements for safe and durable cob structures.

**Purpose**

While adobe masonry is included in the masonry chapter of the *International Building Code®* (IBC®), and cob building codes or guidelines exist in England and New Zealand, prior to the approval of this appendix there has been no building code for cob construction in North America. As a result, the permitting of cob buildings has been left to building officials on a case-by-case basis. Designers, builders and building officials may be unaware of the design and construction practices that make cob buildings safe and durable. The desire to utilize cob construction is growing and promises to accelerate in response to economic and environmental pressures. There is also a particular need for fire-resistant construction systems that can withstand the increased frequency and intensity of wildfires in the western United States. The lack of a cob building code has been an impediment to the safe and widespread adoption of this building system.

The purpose of this appendix is to enable permitting of cob buildings while aligning the use of cob with safe practices derived from both historical evidence and recent testing. The goal is to provide builders with the flexibility to make use of time-tested regional variations as well as viable new methods as cob construction continues to evolve.
APPENDIX AU—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.

This appendix covers the use of natural cob as an earthen building material and system. It does not cover cob with added stabilizers such as cement or asphalt emulsion that are often used in other earthen building systems. (See the commentary to definitions of “Natural cob,” “Stabilized” and “Unstabilized.”) It is not intended to preclude the use of stabilized cob; however, such use should be evaluated as an alternative material.

All components and aspects of cob buildings other than their cob walls—including foundations; non-cob walls; roof structure; energy efficiency; and mechanical, plumbing and electrical systems—must comply with the code unless otherwise stated in this appendix. Integrating cob construction with provisions designed for use with wood-frame and masonry construction will likely require flexibility in meeting the intent of some aspects of the code.

Historically, many variations of cob construction have been practiced, influenced by climate, high-wind and seismic risk, available materials, local building practices and regional architecture. This appendix, through prescriptive and performance-based requirements, is intended to be inclusive of as many safe and durable methods of cob construction as possible. See Commentary Figure AU101.1 for typical cob building components, Figure AU101.4 for a typical cob wall, and their corresponding commentary. See also Sections AU101.4 and AU105.1 and their commentary.

Electrical wiring systems in cob buildings must meet the same criteria for other wall systems in the code such as protection of wiring from damage in service, secure attachment of wiring, conduit systems and electrical boxes, and air sealing of penetrations in exterior walls.

Decades of electrical installations in cob buildings have yielded common practices. Wiring in conduit or armored cable has been surface mounted to cob walls with code-compliant attachments or embedded in the cob wall. Protective chase spaces are sometimes created on the surface of the wall or in the floor to run nonmetallic sheathed cable. Where wiring is directly embedded in a cob wall, UF cable rated for direct burial in earth has been commonly used and approved.

Electrical boxes in cob walls are typically fastened to the wooden frames surrounding doors or windows (see Section AU105.4.5) or to a nail-studded wood block embedded in the cob. Surface-mounted electrical boxes are also common.

Wiring and electrical boxes must not be embedded in cob structural walls except in their "surface voids" as allowed in Section AU106.5, Item 3, or in a location and dimension that does not reduce the wall's required thickness. See Section AU106.2, Item 2. Wiring and electrical boxes can be embedded anywhere in nonstructural cob walls, including below windows. See the commentary to the definition of “Nonstructural wall.”

Plumbing supply, waste and vent pipes have historically been kept out of cob walls where possible, and instead are run in wood-framed walls or secured to the surface of cob walls. Where unavoidable, pipes in cob walls can be run in shallow chases and wrapped or sleeved as needed. The same restrictions that apply to electrical wiring and boxes in structural walls apply to plumbing pipes and fixtures.

Commentary Figure AU101.1 shows typical components of a cob building. Like other building systems, many design configurations and variations are possi-
ble within the limits of the code. Not all components shown are required or present in all cob buildings, for example the wall reinforcing shown is not required for all wall types or situations. See also Figure AU101.4.

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 to permit combinations of historical and modern techniques.

- The purpose of this appendix is to establish the minimum requirements for cob construction (described broadly in Section R101.3) and to provide needed flexibility in the application of certain provisions of the code. Because many cob construction materials and methods are not covered in the code, or may not align with conventional materials and systems, there is greater reliance on the intent of certain code provisions. This includes the use of site-sourced subsoil and other local materials, as well as innovative combinations of proven historical and modern techniques that reduce life-cycle impacts and/or increase affordability where shown to be equivalent in performance to materials and systems in the code. The flexibility is intended for both the approval and inspection processes.

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.

- Where cob construction varies substantially from this appendix, or other components of the building vary substantially from the requirements of the code, the building official has the authority to approve the design as an alternative material, design or method of construction as described in Section R104.11. When the building official determines a test is necessary to approve the design, Section R104.11.1 specifies the way the tests shall be conducted. However, for cob construction and its associated construction, the building official also has the authority to consider a history of successful use, as presented by the applicant, in lieu of such testing. This is similar to Section 2109 on adobe construction in the IBC, which uses empirical evidence as the basis for its provisions.

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

- "Cob wall systems" is a general term encompassing the systems of cob construction shown in Figure AU101.4 as well as approved variations. Each element in the figure references a section in this appendix or the code. Historically, many variations of cob construction have been practiced, and the illustrated systems are not meant to preclude viable variations. However, systems that vary substantially from what is shown in Figure AU101.4 must be approved by the building official.
Figure AU101.4 illustrates the elements of a typical cob wall. Each element references a section in this appendix or the code. Where “where occur(s)” appears in the reference note, the element is not necessarily part of the cob wall system but is sometimes required, depending on the structural demands of the building’s location and design.

**AU101.5 Definitions.** The words and terms in Section AU102 shall, for the purposes of this appendix, have the meanings shown herein. Refer to Chapter 2 for general definitions.

- Section AU102 clarifies the terminology used in this appendix. The terms take on unique and specific meanings, with many of the terms used solely in the context of cob construction.

### SECTION AU102 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.

- The term “Braced wall panel” in this appendix refers to cob walls constructed in accordance with Section AU106.11 for prescriptive use as braced wall panels and is synonymous with “shear wall.” Cob walls with various means of reinforcement and connections at the top and bottom of the wall have been tested in laboratory settings to determine their ultimate strength and allowable capacity to safely resist in-plane lateral loads. This testing is the basis for the prescribed use of cob wall types included in Table AU106.11(1) as braced wall panels.

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

- A buttress provides support perpendicular to the plane of the wall. See the commentary to Section AU106.14.

**CLAY.** Inorganic soil with particle sizes less than 0.00008 inch (0.002 mm) and 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 has been used for thousands of years as a building material. This includes unfired clay in adobe bricks; rammed earth; cob; light straw-clay; earthen plasters and earthen floors; and fired clay in bricks, roofing tiles, and floor and wall tiles. In all of these materials, clay is the binder, sometimes along with another binder such as lime or cement, that holds together other materials such as sand or straw. For this appendix, clay is the binding material in cob and is typically found in the clay subsoil used in the mix. Clay can also be obtained as a commercially quarried and bagged material. See also the commentary to the definitions of “Clay subsoil” and Section AU103.4.

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

- The word “soil” is commonly associated with topsoil, which contains organic matter. Clay subsoil (below the layer of topsoil) used to make cob is an inorganic mineral soil containing clay, sand and silt in varying proportions. It is often obtained from the building site. Experience shows that trace amounts of organic matter have no discernible effect on performance and are therefore acceptable. The term “trace amounts” is subjective and should be judged based on reason and the experience of the cob practitioner and building official as to what amount will not affect performance; for example, fine roots. See the commentary to Section AU103.1 regarding clay subsoil suitability.

**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 is a composite earthen building material that has been used for centuries in many parts of the world. It consists of clay subsoil or refined clay, straw and sand (added and/or in the subsoil) that are wet-mixed and used to create walls and other architectural elements such as benches and fireplaces. Cob is also known as “monolithic adobe” because its materials are similar or identical to those in adobe blocks, but instead are used to create monolithic walls. See also the General Comments at the beginning of this appendix, the commentary to Sections AU103.1 through AU103.6 and the commentary to the definition of “Monolithic adobe.”

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

- Cob construction is a building system using cob, placed in layers, to create monolithic earthen walls. During construction, the wet cob mix is self-supporting and does not require mechanical compaction, so cob walls are typically built without formwork. The lack of formwork is conducive to creating curved walls and other free-form building elements. Formwork is allowed and is advantageous for some applications and designs. See also the General Comments at the beginning of this appendix and the commentary to Section AU101.4.

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

- Dry joints between layers of cob should be minimized or avoided, when possible, to allow proper integration of layers for a monolithic wall. See the commentary to Section AU103.7.

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

- See Section AU104 for acceptable finishes on cob walls.
LIFT. A layer of installed cob.

- The term “lift” is commonly used for a layer of cob material in a cob wall. It is similar to a course in masonry construction, but without mortar. Layers of cob are instead integrated with the layer below when both layers are wet and pliable. See the commentary to Section AU103.6.

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.

- The definition of this term is consistent with the definition of “Wall, load-bearing” for stud walls in the IBC. Vertical loads include superimposed dead and live loads from the roof and/or ceiling.

MONOLITHIC ADOBE. See “Cob.”

- In recent decades, modern cob is increasingly referred to as “monolithic adobe” because its materials are similar or identical to those in adobe blocks, but instead are used to create monolithic walls. Adobe construction is a modular masonry system that uses dry adobe blocks stacked in courses with earthen mortar. Cob construction uses a wet cob mix installed in layers (lifts) where each layer bonds and is integrated with adjacent layers, effectively becoming monolithic (see commentary, Section AU103.6). The term helps people understand and accept the material and building system by relating them to the more familiar material and system of adobe, which is included in the IBC.

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

- This appendix covers only natural cob. Though synonymous with unstabilized cob, the term “natural cob” is preferred because “unstabilized” incorrectly implies the material is not stable. Though stabilizers are sometimes added to earthen materials for greater durability and increased compressive strength, natural cob is sufficiently stable, strong and durable for applications meeting the requirements of this appendix. Cob’s comparative high straw content increases tensile strength and durability, its monolithic nature increases wall integrity, and like all thick-walled systems, it is inherently stable.

- In many parts of the world, unstabilized or natural cob buildings remain in service after more than 600 years. Though appropriate in some circumstances, stabilizers can add cost and have negative environmental and human health effects. See also the definition and commentary to “Unstabilized.”

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

- This definition is consistent with the definition in ASCE 7, a standard used as the basis for defining structural loads imposed on buildings in the IRC and IBC. Nonstructural cob walls do not carry superimposed loads (from the roof and/or ceiling) and are not designed or constructed as shear walls to resist in-plane lateral loads (from wind and/or earthquakes). The cob material in nonstructural walls serves only as enclosure and as a substrate for any finishes. Nonstructural cob walls must be capable of withstanding out-of-plane lateral loads (see Section AU105.3). Nonstructural cob walls include portions of walls below window openings, which are neither load-bearing nor shear walls, and can include portions of walls above window and door openings if they are not load bearing. See the definitions of “Load-bearing wall” and “Shear wall.”

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

- In the code, the word “plaster” is used only for cement and gypsum plasters. The word “plaster” in this appendix is used with all plaster types 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.”

- The term “shear wall” is used interchangeably with the term “braced wall panel” in this appendix. See the definition of “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.

- The use of stabilizers in earthen construction such as adobe, rammed earth and compressed earth block has become common in recent decades and has potential for cob construction. However, stabilizers are outside the scope of this appendix (see commentary, Section AU101.1). Stabilizers can be appropriate to achieve the intended qualities stated in the definition; however, they are unnecessary for many applications in all types of earthen construction. In cob construction, some stabilizers may interfere with bonding between layers. Stabilizers also add cost and can have negative environmental and human health effects. The term “stabilized” in this appendix refers to stabilization achieved by chemical rather than mechanical means. See the definition of “Unstabilized.”

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

- Straw is an agricultural byproduct of grain plants after the nutrient grains have been harvested. Straw is not hay. See Section AU103.3 regarding the types of straw used in cob buildings.

STRUCTURAL WALL. A wall that meets the definition for a “Load-bearing wall” or “Shear wall.”

- This definition is consistent with the definition in ASCE 7, a standard used as the basis for structural loads on buildings in the IRC and IBC. See the definitions of “Load-bearing wall,” “Shear wall” and “Nonstructural wall.”

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

- This appendix covers only unstabilized, or natural, cob. (See also the definitions and commentary to “Natural cob” and “Stabilized.”) The term “unstabilized” is
commonly used for earthen materials such as adobe where stabilizers are not used, but it has an undeserved negative connotation because it incorrectly implies the material is not stable.

UNSTABILIZED COB. See “Natural cob.”

❖ See the commentary to the definitions for “Unstabilized” and “Natural cob.”

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.

❖ Clay subsoil that is appropriate for cob construction typically contains sand and silt in addition to clay. However, only the clay binds the straw and sand or other aggregate. Cob practitioners use various methods to determine the suitability of a clay subsoil for cob, including whether the subsoil contains sufficient clay to bind the mix. The “Ribbon Test” and “Ball Test” (of the subsoil alone) described in ASTM E2392, Standard Guide for Earthen Wall Building Systems, and/or test bricks of different cob mixes are often used for this purpose. However, ultimately the cob mix with all of its constituent materials, including the clay subsoil, must meet the requirements of Section AU103.4. See also Section AU103.4 and the definition of “Clay subsoil.”

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.

❖ Most cob mixes require added sand or other aggregate so that the material will not exceed the shrinkage limits in Section AU103.4.1. This reduces or eliminates cracking in the dried material and helps ensure the wall performs adequately. Some clay subsoils contain sufficient aggregate to meet the requirements of Section AU103.4.1 with only the addition of water and straw. Where additional sand is needed, it is ideally sharp (not rounded river sand) and should not contain salt (not ocean beach sand) and is best well-graded (of varying sizes) with minimal fines. Unlike sand used in concrete, it can contain silt or clay, materials already present in clay subsoil. See Section AU103.4.1.

Other aggregates can be used in cob mixes in addition to or in lieu of sand, including but not limited to gravel, pumice and lava rock. They can be of varying size and quantity but still need to meet the requirements of Section AU103.4.1 along with the other constituent materials in the cob mix. Pumice and lava rock are less dense than sand and gravel and are used to create lighter, more insulating cob.

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.

❖ Straw for cob is dry, intact stems of wheat, rice, rye, barley or oat plants that is free of visible decay or discoloration and should be free of contaminants such as insects, topsoil and green plant material because mold and mildew can grow in the presence of these microbial food sources. Straw is best harvested dry and kept dry until mixed with the other constituent materials of cob.

Straw is not hay, which includes grasses and other plants cultivated as livestock feed. Hay is baled green, contains nutrients and supports active decomposition. Hay is unacceptable for building. See the commentary to the definition of “Straw.” Alternative reinforcing fibers can be used if similar performance is demonstrated.

AU103.4 Mix proportions. Cob mixes shall be of any proportions of refined clay or clay subsoil, added sand (if any) and straw that produce 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.

❖ Historically, cob was made by simply mixing site soil with water and adding plant fiber—usually straw and/or animal manure. The best cob soils had a low proportion of clay (about 5 percent in English cob) and a high proportion of sand and gravel; however, a wide range of soil types and mixtures have been used successfully. Cob builders today commonly add sand to the subsoil to increase compressive strength and reduce shrinkage, though some soils are well suited to making cob with only added straw. Modern cob typically contains a much higher ratio of straw than was common historically, which improves tensile and shear strength, decreases weight and increases thermal resistance. If the subsoil has insufficient clay to hold the mix together, clay can be added.

Because the makeup of clay subsoil and the properties of its clay vary widely, acceptable cob mix proportions also vary widely. Experimentation is typically necessary to find a mix that yields desired qualities and meets requirements. Practitioners commonly create samples with clay subsoil to sand ratios ranging from 1:0 to 1:3, both with and without added straw. Practitioners have a variety of ways to assess these samples for suitability. Added sand or refined clay might not be needed for an acceptable mix, but clay subsoil and straw are required.

Ultimately, the mix can be any proportion of the materials stated in this section, and as described in Sections AU103.1, AU103.2 and AU103.3, as long as the mix passes the shrinkage test required in Section AU103.4.1. Furthermore, mixes for all cob walls must be tested for and comply with the compressive strength requirements of Section AU106.6, and mixes for cob braced wall panels must be tested for and comply with the modulus of rupture requirements of Section AU106.7. The materials in the tests should be representative of those that will be used in construction of the walls, within reasonable limits of the inherent variability of the materials. See also Sections AU103.1, AU103.2 and AU103.3 and their commentary regarding each constituent material.

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\(\frac{1}{2}\)-inch by 3\(\frac{1}{2}\)-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 greater than \(\frac{1}{16}\) 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.

- The test method described in this section must be used to determine the acceptability of a proposed cob mix and to demonstrate its acceptability to the building official. If mixes of significantly different materials and/or proportions will be used in construction, they should each be tested and approved. A slip sheet is necessary to allow movement of the material as it dries. Oil instead of a sheet material has also been used and is acceptable.

The sample must dry to ambient moisture conditions to ensure the mix has finished shrinking before shrinkage is measured. The specimen may dry in any location and during any season because relative humidity has negligible effect on the amount of shrinkage. It does, however, affect drying time. Oven drying and sun drying are acceptable, but typically lead to greater shrinkage than air drying and are therefore conservative.

The 1-inch measurement limit refers to the total shrinkage at both ends of the sample. Cracks in the length of the material not greater than \(\frac{1}{16}\) inch are not counted in the shrinkage length.

**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.

- The goal of mixing cob is to achieve a stiff, homogeneous, plastic mixture that is easy to form and will bond to itself to the previous layer while holding its shape when placed on the wall. The clay subsoil and sand (where part of the mix) are first blended with water. If the subsoil is dry and powdery, it can be premixed with any sand before water is added. If the subsoil is clumpy, it is helpful to first soak it with water until soft. After the subsoil, water and any sand are uniformly blended, the straw is mixed in. Both manual mixing (typically by human feet) and mechanical mixing (using equipment such as an excavator, tractor, front loader or rotary mortar mixer) are acceptable.

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

- Cob must be installed in lifts (layers) of a height limited by the mix’s ability to support itself. The term “minimal slumping” is subjective, based on experience and the practical need for each lift to add maximally to the height of the wall while maintaining a consistent wall thickness. Some slumping is common and acceptable, and the excess material can be trimmed after partial drying. Formwork can be used to eliminate slumping, increase lift heights and speed construction, or to achieve highly controlled wall shapes or surfaces.

**APPENDIX AU**—**COB CONSTRUCTION (MONOLITHIC ADOBE)**

A stiff plastic mixture is typically installed in lumps of varying size, depending on the manual or mechanical application limits, on top of the previous moist and plastic lift. A stiff mix reduces slumping, allows lifts of greater height and reduces drying time between lifts. Too dry a mix can adversely affect cohesion between layers and leave voids that are detrimental to the cob wall’s strength.

In Britain, cob is placed on the wall manually or with an excavator, where it is trodden by foot in the traditional manner. With a stiff cob mix and a wide wall (3 to 5 feet thick), lifts up to 18 inches high are possible. In the United States, cob walls are typically narrower (1 to 2 feet thick) and manually installed. Narrower walls, and seismic risk in some regions, have led to more careful installation methods, with lesser lift heights calibrated to the conditions so that slumping is not excessive.

Bonding and integration of successive lifts is important for the strength and integrity of the wall. The clay in the wet cob enables successive layers to bond as the cob dries. Straw from one layer pushed into the previous layer integrates them mechanically. One technique for integrating lifts is by pushing one’s thumbs or a rounded dowel called a “cobbler’s thumb” down through the new layer into the top of the previous layer, which must be plastic for both bonding and integration. Indentations in the top of a layer can also allow keying of the next layer.

Where vertical reinforcement is part of the wall assembly, the cob must be worked tightly around the reinforcement. Any horizontal reinforcement must be integrated between lifts, and where required, must be installed in the proper locations and with the proper spacing. See Table AU106.11(1).

Commentary Figure AU103.6(1) shows a cob wall being installed with only integral straw reinforcing. Commentary Figure AU103.6(2) shows a cob wall being installed with added vertical reinforcing. See the commentary to Section AU103.6. Added horizontal reinforcing is sometimes used or required but is not shown in either figure.

**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.
3. Wetting.

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

- While each installed layer must dry to a sufficient rigidity to support the installation and weight of the next layer, the top 1 to 2 inches of cob should remain in a moist and plastic state to allow bonding and integration with the next layer. In cool or damp weather conditions, extra measures may not be needed to ensure this. In hot and dry weather, or if construction is interrupted for hours or days, employing one or more of the
methods specified in Section AU103.7 may be needed. If the top of the most recent lift has hardened, it must be wetted (ideally, repeatedly over several hours) and worked to soften the top few inches before adding the next layer. Because this is less effective than preventing the top surface from drying, dry joints should be avoided when possible.

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 10 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 percent of the allowable bearing capacity as determined in accordance with Section AU106.8. Drying holes shall be filled with cob before final inspection.

* Drying holes are used where drying must be accelerated due to damp climate conditions or construction schedule. After their purpose is fulfilled, the holes must be filled with a moist and similar mix of cob.

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.

* Wet cob is pliable and can compress under load. Dry cob is stiff and can carry significant loads without compressing. As the cob material dries, its load-carrying capacity increases. A cob building’s roof and ceiling must not be installed until its supporting cob walls are dry enough to support their dead and live loads without compressing. It can be difficult to determine at what point a cob wall is dry enough to carry a particular load and is largely based on experience.

It is the builder’s responsibility to provide the drying time and assessment needed to ensure walls are sufficiently dry prior to the application of roof and ceiling loads. If compression occurs from the application of roof and ceiling loads to an inadequately dried wall, the load should be removed and the compressed portion of wall repaired/restored to its previous condition.

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 comply with this section and Chapters 3 and 7 unless stated otherwise in this section.

* Where cob walls are not substantially rain exposed (see Section AU104.2), they do not require a finish.
Minor erosion has proven acceptable on cob walls and is a matter of maintenance, similar to the need to periodically repaint the exterior of buildings of conventional construction. However, where cob walls are susceptible to excessive erosion from rain, finishes are necessary to protect the wall while ensuring that any moisture that might enter the wall can escape without causing harm.

A range of plaster types are allowed as described in Section AU104.4. Nonplaster exterior wall coverings must comply with the applicable sections in Section AU104 and Chapter 7. Other exterior finish systems are allowed with the specifications in Section AU104.1.2. Interior finishes must comply with Chapter 3 as described in Section AU104.1.1.

**AU104.1.1 Interior wall finishes.** Where installed, interior wall finishes and interior fire protection shall comply with the applicable provisions of Section R302, and shall be plasters in accordance with Section AU104.4 or nonplaster wall coverings in accordance with Section R702.

- Although no interior finish is required, it is common practice to install an interior plaster on cob walls for functional or aesthetic reasons. Plasters must comply with Section AU104.4. Nonplaster interior finishes can also be used and must comply with Section R702. All interior finishes are subject to the applicable interior fire protection provisions of Section R302. Cob has been used for centuries to build ovens, fireplaces and kilns, demonstrating that cob walls do not burn or support combustion. Similarly, the plasters in this section are not flammable and therefore pose no fire hazard (see Section AU108). See Section AU104.3 regarding restrictions on vapor retarders on cob walls.

**AU104.1.2 Exterior wall finishes.** Where installed, exterior wall finishes shall be plasters in accordance with Section AU104.4, nonplaster 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 greater than 10 pounds per square foot (48.9 kg/m) and less than or equal to 20 pounds per square foot (97.8 kg/m) of wall area 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 greater than 20 pounds per square foot (97.8 kg/m) of wall area shall require an engineered design.

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The purpose of these requirements is to ensure sufficient mechanical support for the finish system and drainage of any water that may penetrate it, ensure adequate permeability for drying and account for the weight of the finish system in the building’s structural design. Section AU104 addresses the issues in Items 1–4 for plasters. Nonplaster wall coverings in Section R703 should be evaluated for compliance with Items 1–4. In particular, conventional attachment methods may not be appropriate for cob walls. Some finishes may need an alternative means of attachment or may not have a perm rating of 5 or greater. See also Section AU104.3.

The perm rating of a finish system of more than one material is determined by adding the reciprocal of each material’s perm rating (for the given thickness) and then taking the reciprocal of that sum. The perm rating of a finish assembly will always be less than the perm rating of the least permeable element.

For example, if three materials in a finish system have perm ratings of 5, 10 and 3, the perm rating of the entire system is calculated as follows:

\[
\frac{1}{P_1} + \frac{1}{P_2} + \frac{1}{P_3} = \frac{1}{P_{TOTAL}}
\]

\[
\frac{1}{5} + \frac{1}{10} + \frac{1}{3} = 0.63
\]

\[
1/0.63 = 1.59 \text{ perms (not vapor permeable per the code threshold of 5 perms)}
\]

**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.

- Only cob walls substantially exposed to rain are required to be protected by an exterior finish or cladding. Climate, microclimate, building design and wall orientation should all be considered when determining if a wall is exposed to rain. Dry climates, deep roof overhangs, veranda or porch roofs, and walls oriented away from prevailing storm winds can all factor into determining that a wall is not exposed to rain. Where a wall is partially protected by a roof overhang, it can also be determined that the bottom portion of a wall is exposed to rain, whereas the upper portion is not. Where required, the finish can be plaster or a nonplaster cladding, or a rain screen that protects the wall from rain and allows drying.

Other local conditions such as a history of insect damage may be present that necessitate particular finishes to protect the wall.

**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.

- High vapor permeability of both interior and exterior finishes is desirable for cob walls to allow for dispersal of any moisture that enters the walls. Cob’s component materials of clay and straw are highly vapor permeable, as are the plasters allowed for cob walls. Other finishes allowed should also be vapor permeable. For these reasons, Class I and Class II vapor retarders are not allowed on cob walls except in extreme situations, such as on walls surrounding
shower, where the importance of keeping water vapor from entering the wall exceeds the importance of enabling moisture to exit the wall.

This section does not prohibit the use of Class III vapor retarders (> 1.0 to ≤ 10 perms), but it is recommended that all finishes or finish systems, including any vapor retarder, have a vapor permeance of at least 5 perms, which is the definition of vapor permeable in the code. Section AU104.1.2, Item 1 explicitly requires this for nonplaster exterior wall finish systems not covered in Chapter 7, but it is important for all finishes and finish systems. All plasters as allowed in this appendix achieve a minimum vapor permeance of 5 perms by virtue of their requirements. Care should be taken with nonplaster wall coverings allowed in Section R703 to achieve this as well. See Section AU104.1.2.

**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 approved engineered design is provided.

The plasters as allowed in this section have a history of successful use on cob and other earthen wall systems. Plaster thickness on each face of the wall is limited to 3 inches (76 mm) because the additional weight of thicker plaster has potential structural consequences, especially in areas of moderate to high seismic risk. Thicker plaster may also unacceptably reduce vapor permeability, depending on the plaster. However, there are potential benefits of thicker plaster, including improved thermal performance in some climates due to the increased mass. The building official may allow thicker plaster with an approved engineered design.

**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.

Cob construction has historically been practiced with plaster applied directly to the cob without any membrane, air barrier or water-resistive barrier between the plaster and the cob. This allows the plaster to mechanically bond with the cob. Also, under certain conditions, the presence of a membrane may impede the dispersion of moisture through the plaster to the interior or exterior. While the code requires a water-resistive barrier for exterior cement plaster over wood-frame construction in accordance with Section R703.7.3, a water-resistive barrier is not required for cement plaster or any exterior plaster allowed over cob walls by this appendix. The moisture management characteristics of cob walls compared with wood-frame construction account for the differing requirements. The clay and straw in cob walls give them considerably more capacity than a wood-frame wall to safely store and disperse moisture. Where a membrane is allowed or required by this appendix, such as for walls enclosing showers or steam rooms, adequately attached mesh or lath is necessary to ensure adequate support of the finish.

**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, increase the plaster bond to the wall, or to bridge dissimilar materials.

The cob wall surface, with its typically irregular texture, can serve as lath for plaster, and thus no other lath is required. However, lath of the listed types is allowed where needed or desired to reduce plaster cracking, increase adhesion to the wall or create a bridge where plaster crosses different materials. See the commentary to Sections AU104.4.8 and AU104.4.9 regarding lath for cement-lime and cement plaster.

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

Clay plasters are the most commonly and historically used plasters for cob walls because they can be easily repaired and maintained, are comparatively inexpensive and bond well to the cob since they both contain clay.

**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, sisa, hemp, animal hair or other similar approved fibers.

The relative amounts of clay subsoil and added sand in the plaster mix depend on the amount of clay, sand and silt in the subsoil. Experimentation or experience is necessary to determine mixes that are workable and yield a plaster with minimal or no cracking. In all clay plasters, clay is the binder, sand and other aggregates reduce cracking, and fibers reduce cracking and resist erosion and abrasion.

See Section AU104.4.3.2 regarding the suitability of clay subsoil for clay plasters. Sand and other fine aggregate should be sharp, well graded (of differing sizes) and free of salt.

**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.

This section requires the use of both tests referenced in ASTM E2392 to determine the suitability of clay subsoil for clay plaster. The first tests for plasticity and cohesion of the damp soil, and the second tests for strength and durability of the dried soil. These tests are commonly used by clay plaster and other earthen building practitioners. However, this section is not intended to prohibit the use of other tests that demonstrate clay subsoil suitability, such as a laboratory soils analysis.

**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.

The relative amounts of clay subsoil and added sand in the plaster mix depend on the amount of clay, sand and silt in the subsoil. Site subsoil can sometimes be used, thus requiring less or no imported sand. Experi-
mentation or experience is necessary to determine workable mixes that yield a durable plaster with minimal or no cracking.

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

- Gypsum plaster on cob walls must comply with Section R702.2.1. However, it is not subject to lathing requirements because all plasters in this appendix can be applied directly to cob walls in accordance with Section AU104.4.2. It is limited to interior use because it is not weather resistant.

**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.

- Lime plaster provides a durable, vapor permeable finish that can be readily repaired and maintained. There are many types of lime that can be used and this section lists the appropriate standards for each. Though successful applications are common and have a long historical precedent, delamination has occurred in some cases, depending on many variables. Plaster tests on the wall with a 28-day cure time are recommended to evaluate the bond. Applying a lime wash to the cob before plaster can increase the bond.

**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.

- Clay-lime plaster on cob walls provides a durable, vapor permeable finish that can be readily repaired and maintained. Site subsoil can sometimes be used, thus requiring less or no imported sand. Clay-lime plaster often bonds better to cob than lime plaster because both contain clay. Experimentation or experience is necessary to determine workable mixes that yield a durable plaster with minimal or no cracking.

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

- Cement-lime plasters use Portland cement and lime together as the binder in roughly equal proportions. The mix types listed in this section are shown in Tables 3 and 4 of ASTM C926 and are the only types allowed on cob walls because only they contain sufficient lime to achieve an acceptable vapor permeability. The Portland cement-lime proportions for CL, F and FL plaster range from 1:0.75 to 1:2. While not required, cement-lime plaster can benefit from properly attached lath because it has shown greater tendency to crack or delaminate than other plasters where applied to earthen walls. See Section AU104.4.2.

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

- The only subsections of Section R703.7 that pertain to cement plaster used on cob walls are Sections R703.7.4 and R703.7.5. Cement plaster is required to contain lime in the proportion stated in order to achieve a vapor permeability. While not required, cement plaster can benefit from properly attached lath because it has shown greater tendency to crack or delaminate than other plasters where applied to earthen walls. See Section AU104.4.2.

**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 cob walls in this section, cob structural walls shall comply with Section AU106.

- The provisions of this section apply to all cob walls, both nonstructural and structural (see the definitions of “Nonstructural wall” and “Structural wall”), except where a subsection states that the provision(s) apply only to nonstructural walls. In addition, structural cob walls must be designed and constructed in accordance with Section AU106.

Figure AU101.4 illustrates an acceptable and typical cob wall system. Each element in the figure references a section in this appendix or the code. Historically, many variations of cob construction have been practiced, and the illustrated system is not meant to preclude viable variations. However, systems that vary substantially from those shown in Figure AU101.4 must be approved by the building official.

**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 20 feet (6096 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 AU105.3, and with Table AU106.11(1) for braced wall panels.
5. Wall thickness, excluding finish, shall be not less than 10 inches (254 mm), not greater than 24 inches (610 mm) at the top two-thirds, not limited at the bottom third and, for structural walls, shall comply with Section AU106.2, Item 2. Wall taper is permitted in accordance with Section AU106.5, Item 1.
APPENDIX AU—COB CONSTRUCTION (MONOLITHIC ADOBE)

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 less than or equal to 6.

Items 1 and 2: The number of stories and the building height for buildings using cob construction are limited in this appendix to help ensure safe use of the building system. This is not meant to exclude multistory or taller cob buildings designed by a registered design professional who adequately demonstrates their safety to the building official.

Item 2: See the definition of “Height, building” in Chapter 2, which is the vertical distance from grade plane to the average height of the highest roof surface.

Item 3: Cob walls are limited to use in Seismic Design Categories A, B and C to help ensure safe use of the building system. However, cob walls are allowed in Seismic Design Categories D and E with an approved engineered design because this provides additional assurance of safe use in these higher seismic risk categories.

Item 4: The height of all cob walls is limited by Table AU105.3, and the height of cob braced wall panels is also limited by Table AU106.11(1), whichever is more restrictive. Wall height means the cob portion of the wall only. See Figure AU101.4.

Item 5: All cob walls must be at least 10 inches thick [except where surface voids reduce wall thickness as allowed in Section AU106.5(3)], and not greater than 24 inches thick in the top two-thirds of the wall height (cob portion only). The wall thickness is not limited for the bottom third of the cob wall because additional thickness in this portion only provides structural benefit (greater load-bearing capacity, greater out-of-plane stability) without increasing seismic load on roof or ceiling diaphragms or shear walls in the building. Tapered walls are allowed per Section AU106.5(1).

Item 6: Where a building includes interior cob walls, an approved engineered design is required that accounts for the seismic load of those walls. These walls can present seismic hazards if not properly designed and detailed, especially their connection at the top of the wall to other building elements. Improper connection can result in out-of-plane instability or over-stressed connections to ceiling or roof elements or to exterior cob shear walls.

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.

All cob walls must employ a method of out-of-plane load resistance in accordance with Table AU105.3 because all walls are subject to out-of-plane wind and/or seismic loads. See Table AU105.3.

The maximum unrestrained height of a cob wall, whether nonstructural or structural, is a function of its method of out-of-plane resistance and other parameters listed in Table AU105.3. See Notes c and h for allowable increases in wall height.

One method of improving out-of-plane resistance is to employ curved walls, whose geometry improves their out-of-plane stability. A design benefit resulting from this improved stability is a less restrictive wall height limit compared with straight walls. See Table AU105.3, Note h.

**TABLE AU105.3**. See page Appendix AU-13.

Table AU105.3 includes Wall Types 1 and 2 and Wall Types A through E, each with their out-of-plane load resistance method. All wall types in Table AU105.3 can be used as nonload-bearing or load-bearing walls, but only Wall Types A through E can be used as braced wall panels.

The out-of-plane resistance methods (anchors and vertical reinforcing) in Table AU105.3 for Wall Types A through E are also part of their in-plane load-resisting system as braced wall panels. However, where used as braced wall panels, all requirements in Table AU106.11(1) must be met, including the more restrictive maximum height and the aspect ratio, and inclusion of horizontal steel reinforcing for Wall Types B, C and D.

The reinforcing materials in this appendix are limited to straw and steel. Other plant fibers, other metals and plastics have also been successfully used to reinforce cob walls but are outside the scope of this appendix.

Note c allows the height of a cob wall to exceed the unrestrained height limits of Table AU105.3 where an approved engineered horizontal restraint is employed at an intermediate height between the wall’s foundation and bond beam. This intermediate restraint effectively creates two cob wall heights in one wall. Each of those separate wall heights must not exceed the limits in Table AU105.3.

Note h allows the \( H/T \) factor and the absolute wall height limit in Table AU105.3 to be increased for curved walls that meet or exceed an arc length:radius ratio of 1.5:1. The arc length and radius are intended to be \( ARC \) and \( R \), as described in Section AU106.11.3 and Figure AU106.11.3. The \( H/T \) factor is the number in the “Limit based on wall thickness” column in Table AU105.3.

Note i requires the modulus of rupture bending strength test for wall types not containing full-height vertical reinforcing. These wall types with only straw reinforcing rely primarily on the cob material’s bending strength to resist out-of-plane loads, whereas wall types with vertical steel reinforcing rely primarily on the steel. Thus, the test is required for Wall Types 1, A and B.

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 where wind design is required in accordance with Figure R301.2.1.1.

Out-of-plane loading for cob walls for the use of Table AU105.3 is determined, as for other building systems in the code, by finding the ultimate design wind speed and the seismic design category for the building’s location per Sections R301.2.1 and R301.2.2. This infor-
mation is also used for designing the building’s in-plane lateral load-resisting system and its braced wall panels per Section AU106.11.

Cob buildings require an approved engineered design where located in either a Special Wind Region or Wind Design Required location. Approximate locations for both can be found in Figure R301.2.1.1. Local jurisdiction ultimate design wind speeds or other related local requirements take precedence.

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.

A bond beam is required for all cob walls, including nonstructural walls, because it is necessary for their resistance to out-of-plane loads and collection of in-plane loads and the transfer of both. Other than cob walls in post-and-beam systems, which are not covered by this appendix (see Section AU106.12), it is rare for a cob building to contain a nonstructural exterior wall (see definition of “Nonstructural”). In such cases a bond beam is still required in accordance with Section AU106, and only Section AU106.9.4 does not apply.

Although Section AU105.3.2 states that bond beams for nonstructural walls do not need to meet requirements relating to roof and/or ceiling loads, it is not meant to exempt them from Section AU106.9.3 because this connection is needed to transfer out-of-plane wall loads to the roof diaphragm.

The most common type of nonstructural cob wall in a cob building is an interior cob wall. These walls will likely require a bond beam as part of the approved engineered design required in Section AU105.2. Item 6. See Section AU105.2.

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.

The weight of the cob above openings is still present in nonstructural cob walls and must be supported by a properly sized lintel. Lintel designs in Table AU106.10, as required by this section, are conservative for nonstructural walls because the table includes roof and/or ceiling loads. Using this section’s exemption from requirements related to these loads and to braced wall panels would need an approved engineered design.

### TABLE AU105.3

<table>
<thead>
<tr>
<th>WALL TYPE</th>
<th>FOR ULTIMATE DESIGN WIND SPEEDS (mph)</th>
<th>FOR SEISMIC DESIGN CATEGORIES</th>
<th>UNRESTRAINED COB WALL HEIGHT $H_{\text{c,c,b}}$</th>
<th>TOP ANCHOR SPACING (inches)</th>
<th>TENSION TIE SPACING (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall 1: top anchors, no steel wall reinforcing</td>
<td>≤ 110</td>
<td>A</td>
<td>$H \leq 8$</td>
<td>$H \leq 6T$</td>
<td>None</td>
</tr>
<tr>
<td>Wall 2: top anchors, continuous vertical 6&quot; x 6&quot; x 6&quot; gage steel mesh in center of wall embedded in foundation 12 inches</td>
<td>≤ 140</td>
<td>A, B, C</td>
<td>$H \leq 8$</td>
<td>$H \leq 8T$</td>
<td>12</td>
</tr>
<tr>
<td>Wall A: top anchors, no vertical steel reinforcing</td>
<td>≤ 120</td>
<td>A, B</td>
<td>$H \leq 8$</td>
<td>$H \leq 6T$</td>
<td>12</td>
</tr>
<tr>
<td>Wall B: top and bottom anchors, no vertical steel reinforcing</td>
<td>≤ 130</td>
<td>A, B</td>
<td>$H \leq 8$</td>
<td>$H \leq 6T$</td>
<td>12</td>
</tr>
<tr>
<td>Wall C: top and bottom anchors, continuous vertical threaded rod at 4 feet on center embedded in foundation and connected to bond beam</td>
<td>≤ 140</td>
<td>A, B, C</td>
<td>$H \leq 8$</td>
<td>$H \leq 8T$</td>
<td>12</td>
</tr>
<tr>
<td>Wall D: continuous vertical threaded rod at 1 foot on center embedded in foundation and connected to bond beam</td>
<td>≤ 140</td>
<td>A, B, C</td>
<td>$H \leq 8$</td>
<td>$H \leq 8T$</td>
<td>N/A</td>
</tr>
<tr>
<td>Wall E: top anchors, continuous vertical 6&quot; x 6&quot; x 6&quot; gage steel mesh 2 inches from each face of wall embedded in foundation</td>
<td>≤ 140</td>
<td>A, B, C</td>
<td>$H \leq 8$</td>
<td>$H \leq 8T$</td>
<td>12</td>
</tr>
</tbody>
</table>

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 anchor specifications for wall Types A, B, C, D and E.

b. $H$\textsuperscript{a} = height of the cob portion of the wall only. See Figure AU101.4. The maximum $H$\textsuperscript{a} 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. $T$\textsuperscript{a} = 3\textsubscript{4} inch threaded rod anchors at prescribed spacing with 12-inch 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 AU106.9.5. Where rafters are attached to tension ties, 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 to 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.

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Arches over wall openings are an alternative to lintels but need an approved engineered design. See Section AU106.10.

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 Sections AU105.3.4.1 through AU105.3.4.3. Surface voids deeper than 25 percent of the wall thickness shall be considered an opening.

- Reinforcing is required above and/or below and on each side of wall openings, such as windows and doors, to address increased out-of-plane loading on wall segments next to openings from the portions of wall above and/or below the opening.

- Cob walls often contain recessed shelving, niches or built-in seating. If these or other surface voids decrease the wall thickness to less than 75 percent of its full thickness, then the reinforcing requirements of this section apply.

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.

- Openings can create significant additional out-of-plane stresses on surrounding wall segments (see commentary, Section AU105.3.4). The height of a cob wall below an opening is restricted to 6 feet to limit the out-of-plane forces transferred to the adjacent full-height wall segments. Openings that exceed the limits of this section require an approved engineered design.

AU105.3.4.2 Horizontal reinforcing. Two-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 feet 6 inches (1372 mm) in height shall be provided with additional horizontal reinforcing at midheight.

- The required horizontal steel mesh above and below wall openings transfers the out-of-plane loads from those portions of wall to the adjacent full-height wall segments and their vertical reinforcing. Where a wall portion below a window is greater than 4 feet 6 inches in height, reinforcing is required at its midheight in addition to the reinforcing required 4 inches below the opening. Nonferrous horizontal reinforcement can be used as an alternative to the prescribed mesh above and below openings, but there needs to be an approved engineered design or other documentation of equivalent performance.

AU105.3.4.3 Vertical reinforcing. Full-height 7/16-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.

- The required vertical steel rod on each side of an opening transfers out-of-plane loads from wall portions above and below the adjacent opening to the foundation and to the bond beam with connections to each, as described in this section. This reinforcing is intended to be within the central two-thirds of the cob wall thickness.

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

- Wall segments less than 2 feet 6 inches in length are considered cob columns and are outside the scope of this appendix. The vertical reinforcement required in this section is to ensure adequate out-of-plane load resistance for walls within that length range.

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.

- Preventing intrusion of moisture into cob walls and ensuring that any such moisture can get out is as important for cob walls as it is for other materials and wall systems. A colloquial metaphor commonly used by practitioners of cob and other related construction types summarizes the basic principles for keeping a wall dry: “Good boots, a good hat, and a coat that breathes.” This translates into keeping the bottom of the wall protected from ground and weather-related moisture, providing ample roof overhangs (especially in wet climates) to shield the walls and their openings from rain, and providing a protective wall finish that is vapor permeable. This dictum is also considered wise for buildings constructed of wood frame and other materials.

- Sections AU105.4.1 through AU105.4.5 contain requirements to minimize the possibility of moisture intrusion from rain or snow and condensation (from uncontrolled flow of relatively warm, moist air into the wall), and from moisture rising into the wall from the ground.

- In addition to the importance of preventing moisture from entering a cob wall, moisture must also be allowed to readily exit the wall. Thus, the finish on each side should be as vapor permeable as possible. Exterior wall finish systems are required to have an overall vapor permeance rating of 5 perms or greater in Section AU104.1.2, Item 2. However, this is important for all finishes and finish systems on cob walls. See Sections AU104.1.2 and AU104.3.

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 Item 2 of Section AU104.1.2 for the combined vapor permeance rating.

- Plaster is optional for cob walls, but where it is used, it must be applied directly to the cob wall without a membrane barrier between the plaster and the cob, except where a membrane is required in this appendix. This is to provide a good mechanical bond for the plaster and to facilitate the transpiration of moisture out of the wall. Where a water-resistant barrier is placed behind a nonplaster exterior finish system, it must be sufficiently vapor permeable so that the combined system meets the minimum 5-perm requirement in Section AU104.1.2, Item 2.

**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 inch vertical in 12 units horizontal to drain away from exterior surfaces, including exterior window sills, sills at exterior niches and exterior buttresses, shall be sloped not less than 1 inch vertical in 12 units horizontal to drain away from cob walls or other cob elements.

- As with wood-frame walls, horizontal (or nearly horizontal) surfaces in or on cob walls can be vulnerable to weather-related moisture intrusion. Window sills are especially vulnerable and should be carefully detailed and constructed to meet the prescriptive and performance criteria of this section.

  Horizontal surfaces that are not weather exposed do not require a water-resistive barrier. Exception 2 in the definition of “Weather-exposed surfaces” in the IBC provides guidance for determining whether a horizontal surface is considered weather exposed, subject to the evaluation of the local building official, with additional consideration of local climate. Ample roof overhangs and wrap-around porch roofs have been employed, especially in wet climates and heavy snowfall areas, to protect walls and their openings from weather-related moisture intrusion.

**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.

- A Class II vapor retarder is required to separate the base of the cob wall from supporting concrete or masonry to prevent “rising damp” from entering the wall from below. In certain situations where a combination of conditions, including the climate, site and foundation design, preclude or greatly reduce the ability of ground moisture to enter the base of the wall, the vapor retarder is not required. One example is the use of a moisture barrier or capillary break between the foundation and the earth.

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**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 Section N1101.7.2, and shall be 2 inches (51 mm) on walls that are not weather exposed.

- The required 8-inch vertical separation between finished grade and the bottom of the cob wall is intended to minimize exterior wetting at the base of the wall from rain splash back, vegetation, landscape sprinklers and other sources. This requirement is for all cob walls whether plastered or not. The reduced required separations in the exception are due to reduced risk of wetting in those conditions.

**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 2-inch by 4-inch (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 1½ 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 R301.2.1(1). 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.

- The common term for the wooden frame used to create rough openings for windows and doors is a “buck,” which is typically made of nominal 2x4, 2x6, or 2x8 lumber. The hydrophilic quality of clay helps preserve wood, and typically cob is dry enough in service not to cause decay in embedded wood. Therefore, it is generally not necessary to separate the wood buck from cob, or use wood that is treated or naturally resistant to decay, unless local experience and conditions necessitate it.

  Vertical settling, shrinkage and lateral movement are normal in cob walls as they dry. The settling and movement can exert significant pressure on the buck until the cob has dried. Therefore, window and door bucks must be sufficiently strong and braced, both in the wall plane and perpendicular to it, to keep them square and plumb. It is common to leave space above a buck to allow for settling, which is later filled with cob or plaster (see Commentary Figure AU105.4.5).

  Commentary Figure AU105.4.5 shows a typical method of buck construction and installation. The 2x4 “stiffeners” shown at the sides of the buck are not required by this appendix but are a common and stronger anchoring alternative. Both “stiffer” and “nonstiffer” anchoring options are shown.

  The cob on both sides of the window or door buck should be dry enough to have fully settled before installing the lintel and cob above. Otherwise, diagonal structural cracks can occur at the upper corners of the window or door buck or lintel. The top surface of the cob on each side of the opening must be kept moist per Section AU103.7 during this time of settling and
drying. For similar reasons, a 1-inch gap should be left between the top of the buck and the lintel.

In order to minimize the area of exposed sill that needs a water-resistant barrier per Section AU105.4.2, windows can be installed at or near the exterior plane of the wall. To achieve this while maintaining the required minimum 3-inch embedment of the buck in the cob wall, a 2x buck extension can be added to the inside of the buck.

Because there is no weather-resistant barrier to integrate with, sealant is recommended between the window or door frame and/or its nail-on fin and the buck to mitigate the passage of air and moisture through the wall system, as required in this section. For the same purpose, all gaps between the buck and (1) the window or door jamb, (2) the lintel and (3) the surrounding cob due to shrinkage should be filled with a flexible sealant capable of bonding with the cob. A plaster finish or wood trim is often used to protect and visually conceal the sealed interface between the window or door and the buck and surrounding cob, flashed as needed to prevent the intrusion of water.

As an alternative to installing a wood buck, the frames of manufactured windows or unframed glass can be embedded directly in the cob wall. Such installations must be capable of resisting the wind loads in Table R301.2.1(1). As with a buck installation, a 1-inch gap between the top of such windows and the bottom of the lintel is necessary.

**AU105.5 Inspections.** In addition to ensuring compliance with Section R109.1, the building official shall inspect the following aspects of cob construction:

1. Anchors and vertical and horizontal reinforcing in cob walls, where required in accordance with Tables AU105.3 and AU106.11(1) and Sections AU105.3.4 through AU105.3.5.
2. Reinforcing in any concrete bond beams or lintels, in accordance with Section AU106.9.2 and Table AU106.10.

The building official shall inspect anchors and reinforcing required by the stated tables and sections to verify proper installation. Where anchors or reinforcing are installed voluntarily, no inspection is required. The “required tests” refer to the shrinkage test in Section AU103.4.1, the compressive strength test in Section AU106.6.1 and the modulus of rupture test in Section AU106.7.1. These inspections and tests are in addition to the normal inspections required in Section R109.1.

**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.

The provisions of Section AU106 apply to structural cob walls (load-bearing and/or shear walls). Structural designs or portions that do not comply with this section 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 Table AU106.11(1) for cob braced wall panels, as applicable and most restrictive.
2. Wall thickness: shall be in accordance with Sections AU105.2, Item 5 and Section AU106.8.1 for load-bearing cob walls or Table 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 Table AU106.11(2) for wind loads and Table AU106.11(3), AU106.11(4) or AU106.11(5) for seismic loads shall be used.

- All cob buildings and all cob walls are subject to the limitations and requirements of Section AU105.2. Structural cob walls (load-bearing and/or shear walls) must also meet the requirements for wall height, thickness and length in the applicable sections as identified in Items 1, 2 and 3. The wall design must always meet the most restrictive applicable requirement(s). Structural cob walls also require a higher minimum compressive strength than nonstructural cob walls per Section AU106.6 and a minimum modulus of rupture in accordance with Sections AU105.2, Item 5 and Section AU106.8.1 for load-bearing capacity. Where used as structural and nonstructural walls, the weight of the cob itself creates significant compressive forces at the base of the wall, hence the minimum required value in this section. Compressive strength is also important for all walls in their inherent out-of-plane stability, may also take advantage of Table AU105.3.4. Surface voids are prohibited in braced wall panels.

- To transmit loads safely to the foundation, irregularities in cob walls, such as taper, curvature and voids must be designed within the limits of this section. Wall taper is acceptable if it conforms with Section AU105.2(5). Both straight and curved cob walls may be used. However, curved walls used as braced wall panels must meet the requirements of Sections AU106.11.12 and AU106.11.13. Curved walls, with their inherent out-of-plane stability, may also take advantage of Table AU105.3. Note h. Finally, niches and other surface voids are restricted by the limits in Item 3 because voids exceeding these limits can create unsafe stress concentrations on adjacent wall segments.

- Foundations that satisfy the requirements of Chapter 4 are acceptable for buildings with cob walls. Three tables in the code are used to determine footing width and thickness, depending on the type of wall construction. Cob walls, with any finish allowed in this appendix, are closest to the weight of cast-in-place concrete or fully grouted masonry walls in Table R403.1(3); therefore, that table should be used. See Section AU106.3.

- Figure AU101.4 shows a typical foundation and stem wall supporting a cob wall across its entire width as required in this section. The figure also shows a cob structural wall with its required anchors (except for Wall Type A) to the stem wall. Normal 7-inch (178 mm) embedment for these anchor bolts is required by Section R403.1.6, except that cob braced wall panels B,

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C, D and E require 8-inch (203 mm) embedment per Table AU106.11(1).

The use of materials or designs for foundations other than those in Chapter 4 are not covered by this appendix and code and require an approved engineered design.

**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, Item 5 and the wall height in accordance with Section AU105.2, Item 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).

Compressive strength is a critical material property where using cob either structurally or nonstructurally. In nonstructural walls, the weight of the cob itself creates significant compressive forces at the base of the wall, hence the minimum required value in this section. Compressive strength is also important for all walls in their resistance to out-of-plane forces. Where used as a braced wall panel, the higher required value ensures that the wall remains safe under potential combined stresses from static and dynamic loading. See Section AU106.8 regarding compressive strength and a wall’s load-bearing capacity.

*Though the minimum required compressive strength for cob in this appendix is 60 psi or 85 psi, depending on the use, the compressive strength of natural cob (unstabilized cob) can exceed 250 psi when fully dried.*
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.
2. Samples shall not be oven dried.
3. 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.
4. 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.
5. The fourth-lowest value shall be used to determine the mix's compressive strength.

The required compressive strength test is best done in conjunction with the required shrinkage test in Section AU103.4.1 because both tests must be satisfied for a mix to be approved and used in a cob wall. The minimum required compressive strength depends on the application as described in Section AU106.6.

The testing described in Item 1 must be conducted by a laboratory approved by the building official or with a means of on-site testing approved by the building official. A report of the test results must accompany the laboratory or on-site testing.

Because of variation in cob’s constituent materials, especially the clay subsoil, cob test data often exhibits variability, thereby requiring multiple tests. Using the fourth lowest test value to assign the mix's compressive strength is conservative, ensuring the mix will provide the minimum required strength and performance.

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 pounds per square inch (345 kPa).

Modulus of rupture—a measure of bending strength—is an important material property for cob in braced wall panels; therefore, the minimum stated value is required in that application. Clay and sand alone have a low modulus of rupture. The straw in the mix increases bending strength through its ability to resist tension forces.

Modulus of rupture is also important to resist out-of-plane loads, especially for cob walls without steel reinforcing. This section applies to three wall types even where they are not braced wall panels. See Table AU105.3, Note i.

AU106.7.1 Demonstration of modulus of rupture. The modulus of rupture of cob used in structural walls 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.
2. Samples shall not be oven dried.
3. Each sample shall be tested with the 12-inch (305 mm) dimension horizontal.
4. The fourth-lowest value shall be used to determine if the mix meets the minimum required modulus of rupture.

Where a cob mix is to be used in a braced wall panel or for wall types described in Table AU105.3, Note i, the required modulus of rupture test is best done in conjunction with the required tests for shrinkage in Section AU103.4.1 and for compressive strength in Section AU106.6.1. All three tests must be satisfied for a mix to be approved and used in these applications.

See the commentary to Section AU106.6.1 regarding the subjects of approved testing and use of the fourth lowest value of the results. These requirements and their explanations are identical for both sections.

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 by Equation AU-2.

\[
BC = \frac{144 \times (C \times T_{\text{min}})}{3} - (H \times T_{\text{avg}} \times D) \quad (\text{Equation AU-2})
\]

\[
BC = \text{Allowable bearing capacity of wall (in pounds per lineal foot of wall)}.
\]

\[
C = \text{Compressive strength (in psi) as determined in accordance with Section AU106.6}.
\]

\[
T_{\text{min}} = \text{Thickness of wall (in feet) at its minimum}.
\]

\[
H = \text{Height of cob portion of wall (in feet)}.
\]

\[
T_{\text{avg}} = \text{Average thickness of wall (in feet)}.
\]

\[
D = \text{Density of cob = 110 (in pounds per cubic foot), unless a lesser value at equilibrium moisture content is demonstrated}.
\]

A wall’s allowable bearing capacity is determined primarily by the compressive strength of the approved cob mix and the wall’s minimum thickness. Allowable bearing capacity is typically expressed in pounds per lineal foot; thus, Equation AU-2 uses the mix’s compressive strength in psi times the minimum wall thickness in feet and divides it by the commonly used safety factor of 3. The number 144 at the front of the equation represents 144 in²/ft² to yield units of pounds per lineal foot from the first half of the equation.

The second half of the equation subtracts the weight of the wall because a cob wall must support its own substantial weight. The remaining value is the allowable bearing capacity of the wall to support roof and/or ceiling loads determined in accordance with Section R301 (see Section AU106.8.1). The average wall thickness is used to determine the wall’s weight, along with the wall’s height and density.
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 Equation AU-3.

\[ BL \leq BC \]  \hspace{1cm} (Equation AU-3)

\[ BL = \text{Design load on the wall (in pounds per lineal foot) determined in accordance with Sections R301.4 and R301.6.} \]

\[ BC = \text{Allowable bearing capacity of wall (in pounds per lineal foot of wall) determined in accordance with Section AU106.8.} \]

- The design roof and/or ceiling loads on cob walls determined per Sections R301.4 and R301.6 must not exceed the wall’s allowable bearing capacity as calculated with Equation AU-2.

AU106.8.2 Support of concentrated loads. Concentrated roof and 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.

- The bearing capacity of cob walls (see Section AU106.8) is typically large enough to support uniform roof and ceiling loads with significant remaining capacity (see Section AU106.8.1) to also support moderate concentrated loads. However, in a similar way that Equation AU-3 checks that uniform roof and ceiling loads do not exceed the wall’s bearing capacity, concentrated loads from the roof or ceiling (for example, from a ridge beam post or a hip rafter) must be checked to be sure they do not exceed the wall’s available bearing capacity.

Concentrated loads are first delivered to the wall’s bond beam. Conservatively, the bond beams required on cob bearing walls (see Section AU106.9) are capable of distributing a moderate concentrated load along a 3-foot length of bearing wall. The bond beam suffices as the key horizontal element of the “structural elements” required in this section. Other elements, such as a ridge beam post and its connections, must also be adequate.

Any uniform roof and ceiling load (in pounds per foot) must first be subtracted from the wall’s allowable bearing capacity (Equation AU-2) to find its remaining capacity (in pounds per foot) to support a concentrated load. Multiplying the remaining capacity by 3 (for 3 linear feet of supporting wall, assuming 1.5 feet of uninterrupted wall on each side of the load) yields the maximum concentrated load that that portion of wall can support.

If a concentrated load exceeds a wall’s available bearing capacity, structural posts can be employed to carry the load directly to the foundation. This condition is outside the scope of this appendix, as are concentrated loads over lintels or bond beams spanning openings.

AU106.9 Bond beams. Cob structural walls shall require a bond beam at the top of the wall in accordance with Section 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.

- Bond beams are very important for the structural integrity of cob buildings and are required for all cob walls. Bond beams for structural walls must comply with this section, and nonstructural walls must comply with Section AU105.3.2. The bond beam on load-bearing walls distributes vertical roof and ceiling loads into the cob wall and sometimes across openings. The bond beam on cob braced wall panels (shear walls) distributes lateral wind and seismic loads from the roof (or other walls in the same line) into the cob braced wall panel. Bond beams on nonstructural walls, as well as bond beams on structural walls, distribute out-of-plane wind and seismic loads to the roof diaphragm in order to deliver them to perpendicular braced wall panels elsewhere in the building.

Bond beams can be of wood or concrete with their respective requirements in Section AU106.9.1 and Section AU109.2. Bond beams of other materials are possible but require an approved engineered design per Section AU106.9.3.

- Bond beams above openings perform like lintels and must meet the requirements in Section 106.9.4. The connections of roof framing to bond beams are covered in Section AU106.9.5, and the significantly different condition of bond beams at gable and shed roof end walls is covered in Section AU106.9.6.

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.

- Wood bond beams are acceptable for structural walls. They must be of at least the stated size in this section and must comply with Sections AU106.9.1.1 through AU106.9.1.3 regarding species and grade, discontinuity, corners and curved walls.

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 No. 2 grade or better. Composite lumber bond beams shall have an \( F_{b} \) of not less than 850 psi (5.9 MPa), and an \( E \) of not less than 1,300,000 psi (8964 MPa).

- The National Design Specification (NDS) Supplement: Design Values for Wood Construction lists the extreme fiber in bending \( F_{b} \) and the modulus of elasticity \( E \) for wood and composite lumber, depending on the species, grade, and size of the lumber. Wood bond beams must be at least No. 2 grade. The wood or composite lumber used for bond beams must have at least the \( F_{b} \) and \( E \) values stated in this section.

“Extreme fiber in bending” is the tensile or compressive stress experienced by the outermost material of a beam in bending and is the common measure of the bending strength of lumber. Modulus of elasticity measures the stiffness of lumber. Both values directly affect the ability of a wood bond beam to distribute vertical and lateral loads into and from the wall.

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, 2,500 pounds (11 kN); B, 4,500 pounds (20 kN); C, 6,000 pounds (26.7 kN).
2. For braced wall line lengths, when wind governs: 10 feet, 2,500 pounds (11 kN); 20 feet, 3,400 pounds (15.1 kN); 30 feet, 5,000 pounds (22.2 kN).

- In certain loading conditions bond beams distribute tension forces along the length of its wall line. If a bond beam is discontinuous, the tension forces must be transmitted to the next section of bond beam with a metal strap with the capacity to transmit the larger of the tension forces of the applicable seismic and wind loading conditions in Items 1 and 2.

**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 accordance with Section AU106.9.1.2.

- Straps across wood bond beam discontinuities transmit lateral tension loads and assist with out-of-plane stability. The required straps on the exterior face of bond beams atop curved walls and at corners will remain tight against the bond beam while transmitting tension forces. In contrast, if applied to the interior face of the bond beam, the strap could separate from the bond beam when loaded and its fasteners would be subject to withdrawal.

**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 No. 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 2,500 pounds per square inch (17.2 MPa) at 28 days.

- Concrete bond beams are acceptable for structural walls and must be at least the size stated in this section to accept and distribute both uniform and concentrated loads. The concrete must be reinforced to ensure the safe transmission of tension forces, hence the reinforcing requirements in this section, Table R608.5.4(1) and Section R608.6.4 for corners. A minimum concrete compressive strength of 2500 psi (17.2 MPa) is required.

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

- Many materials and designs may serve safely as a bond beam for cob walls. However, the use of alternative materials and designs requires 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.

- Bond beams may also serve as lintels over openings if the opening occurs at the top of a wall. The design of the bond beam over an opening is the same as that for a lintel over a same-sized opening. For safe load transmission, the bond beam must be continuous over the opening, must extend at least 1 foot beyond each side, and must adhere to the other requirements for lintels in Table AU106.10.

**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 and 6, and Figure AU106.9.5. Roof sheathing shall be attached to roof framing in accordance with Figure AU106.9.5. A minimum nominal 2-inch by 6-inch (51 mm by 152 mm) wood plate shall be installed on concrete bond beams with 1/4-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 straps.

- The required connections between bond beams and roof and ceiling framing are as detailed in Table R602.3(1), Items 2 and 6, and in Figure AU106.9.5. Figure AU106.9.5 also shows the required attachment—particular to cob buildings—of roof sheathing to tension tie rafters and additional nailing where applicable [see Tables AU106.11(4) and (5)], in addition to the normal attachment requirements in Table R602.3(1). If a concrete bond beam is used, the connection to roof and ceiling framing is achieved through a wood plate attached to the bond beam as described in this section.

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

1. End walls shall not exceed 20 feet (6096 mm) in length.
2. Bond beams shall be continuous and straight for the entire wall line.
3. Wood bond beams shall comply with the following:
   3.1. Not less than nominal 4 inches by 8 inches (102 mm by 203 mm) where wind design governs in accordance with Table AU106.11(2) and where seismic design governs in accordance with Table AU106.11(3), AU106.11(4) or AU106.11(5) for wall lengths less than or equal to 20 feet (6096 mm) in Seismic Design Category A or wall lengths less than or equal to 10 feet (3048 mm) in Seismic Design Categories B and C.
   3.2. Not less than nominal 4 inches by 10 inches (102 mm by 254 mm) for wall lengths less than or equal to 20 feet (6096 mm) in Seismic Design Category B.
   3.3. Not less than nominal 6 inches by 12 inches (152 mm by 305 mm) or 4 inches by 16 inches (102 mm by 406 mm) for wall lengths less than or equal to 20 feet (6096 mm) in Seismic Design Category C.
3.4. Corners shall be connected in accordance with Section AU106.9.3.

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 less than or equal to 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. The ratio of its greatest height to its length shall not exceed 1:2. The wall shall not contain openings.

- Where roof framing is parallel to a wall line, such as at the end walls of buildings with a gable or shed roof, it is not possible to directly connect the roof framing to those walls to resist and transfer out-of-plane wall loads (as shown in Figure AU106.9.5). Though there are many ways to resist and transfer these loads in this condition, this appendix requires the bond beam to transfer the out-of-plane loads to the end walls and their integral braced wall panels.

Section AU106.9.6 and Figure AU106.9.6 give the detailed requirements and connections between and including the bond beam and roof for this condition.

An important note in Figure AU106.9.6 states that its requirements pertain to short wood-framed walls that support a shed roof between a cob wall’s bond beam and the shed roof rafters. This condition results in a similar inability for the roof framing to directly connect
to the bond beam; therefore, the connection requirements in Figure AU106.9.6 apply. This condition occurs where a cob wall is not tall enough to directly support the shed roof due to the height limit of the cob wall or because of design preference.

**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.

- Openings in load-bearing cob walls must be provided with a lintel that supports the weight of the cob above it in addition to the roof and ceiling loads. These loads are transferred to each side of the opening as concentrated loads. In Table AU106.10, the required lintel length of 1 foot beyond each side of the opening provides sufficient bearing capacity in the wall to support the live and dead loads for the conditions in the table, except where indicated as NP (not permitted). Table AU106.10 also provides required specifications and sizes of lintels in either wood or concrete for various building sizes, wall thicknesses and spans. This section is also used for bond beams spanning openings.

### Table AU106.10

<table>
<thead>
<tr>
<th>Building Width (feet)</th>
<th>Cob above Lintel (feet)</th>
<th>Total Cob Wall and Plaster Thickness (inches)</th>
<th>Size of Wood Lintel or Bond Beam—H × W (nominal inches)</th>
<th>Width of Concrete Lintel or Bond Beam (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>For Span ≤ 4 ft</td>
<td>For Span ≥ 6 ft</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
<td>≤ 27</td>
<td>4 × 8</td>
<td>4 × 8</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>15</td>
<td>4 × 12</td>
<td>4 × 12</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>19</td>
<td>4 × 16</td>
<td>4 × 16</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>27</td>
<td>4 × 24</td>
<td>4 × 24</td>
</tr>
<tr>
<td>10</td>
<td>2</td>
<td>15</td>
<td>4 × 24</td>
<td>4 × 24</td>
</tr>
<tr>
<td>10</td>
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<td>19</td>
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<td>4 × 24</td>
</tr>
<tr>
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<td>≤ 27</td>
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<td>6 × 8</td>
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<tr>
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<td>6 × 12</td>
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<td>4 × 16</td>
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<td>6 × 24</td>
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<tr>
<td>30</td>
<td>0</td>
<td>≤ 27</td>
<td>4 × 8</td>
<td>6 × 8</td>
</tr>
<tr>
<td>30</td>
<td>1</td>
<td>15</td>
<td>4 × 12</td>
<td>6 × 12</td>
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<tr>
<td>30</td>
<td>1</td>
<td>19</td>
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<td>6 × 16</td>
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<td>27</td>
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<td>6 × 24</td>
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<tr>
<td>30</td>
<td>2</td>
<td>15</td>
<td>4 × 12</td>
<td>6 × 12</td>
</tr>
<tr>
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<td>2</td>
<td>19</td>
<td>4 × 16</td>
<td>6 × 16</td>
</tr>
<tr>
<td>30</td>
<td>2</td>
<td>27</td>
<td>4 × 24</td>
<td>6 × 24</td>
</tr>
</tbody>
</table>

**Wood:**
- $F_c ≥ 850$ psi
- $E ≥ 1,300,000$ psi
- No. 2 Grade or better
- Oriented flat
- 1 piece or 2 equal-width pieces
- Extend 1 foot beyond opening sides

**Concrete:**
- 2500 psi compressive strength
- Height = 6 inches
- Extend 1 foot beyond opening sides
- Reinforcement two No. 4 bars
- 2 inches clear from bottom
- 2 inches clear from sides

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa.

NP = Not Permitted.

A. Concrete bond beams spanning openings, and lintels greater than 16 inches in width, shall have an additional No. 4 bar in the center of their width.
speed and seismic design category as determined by Sections R301.2.1 and R301.2.2, respectively.

The code contains prescriptive provisions for all elements of the lateral force-resisting system and their connections. Buildings with cob walls cannot use the conventional braced wall panels in the code (unless an approved engineered design is provided) because cob walls are heavier and impart seismic loads much greater than the code braced wall panels with the lengths in the IRC tables are designed to resist. The building’s cob walls can be used for its braced wall panels where it is constructed in accordance with Table AU106.11(1) and meets the minimum total lengths in Table AU106.11(2) for wind loads and Table AU106.13(3), (4) or (5) for seismic loads. These wind and seismic tables fit the same format as those for conventional braced wall panels in the code. The cob walls must connect to the roof structure in accordance with Sections AU106.9.5 and AU106.9.6 instead of the connections prescribed in the code.

To use the prescriptive braced wall panel tables in this appendix, it is necessary to select two orthogonal directions. Each orthogonal direction requires at least two braced wall lines. These tables assume a building with two sets of parallel wall lines orthogonal (perpendicular) to each other. (See Section AU106.12 for non-orthogonal braced wall panels.)

Cob braced wall panels (shear walls) are reinforced, compression-based, monolithic walls similar in concept to some forms of reinforced concrete. Like fiber-reinforced concrete, cob walls have ductility by virtue of their straw as a microfiber reinforcement throughout. Like steel bar and mesh-reinforced concrete, cob wall ductility is increased by steel bar and mesh reinforcing. Though reinforced cob has significantly lower strength than reinforced concrete, it has considerable strength sufficient for many applications.

The reinforcing materials in this appendix are limited to straw and steel. Other plant fibers, other metals and plastics have also been successfully used to reinforce cob walls but are outside the scope of this appendix.

Testing of straw- and steel-reinforced cob walls has demonstrated their capacity to safely absorb and dissipate energy under in-plane loading. The resulting test data were used to determine the braced wall panel provisions of this appendix. The braced wall panel tables in this section are limited to Seismic Design Categories A, B and C because the entire appendix is likewise limited, except with an approved engineered design in Seismic Design Categories D and E. See Section AU105.2, Item 3.

The braced wall panel tables based on seismic design category contain two columns indicating the minimum percentage of wall openings in the braced wall lines: 0 percent, 25 percent or 50 percent. The percentage of openings affects the seismic load on the building and the total required braced wall panel length because the weight of cob walls is a significant portion of the building’s seismic load. Windows, doors and other openings reduce that load. A column for percent-age of wall openings does not appear in Table AU106.11(2) for wind design because wind loads are independent of a building’s weight.

The minimum length of a braced wall panel is determined by the maximum aspect ratio (H:L) in Table AU106.11(1) for the wall type used. For example, if the maximum aspect ratio (H:L) is 2:1, and the height of the cob portion of the wall is 7 feet, then the minimum braced wall panel length is 3.5 feet. For a 1:1 maximum aspect ratio, the minimum braced wall panel length would be 7 feet. If a wall meets the minimum required length for that wall type and height, its length counts toward the minimum total braced wall panel length in the applicable table(s) in Section AU106.11.

The total length of braced wall panels along each braced wall line must comply with Table AU106.11(2) for wind loads and Table AU106.11(3), (4) or (5) for seismic loads. The greater value of the minimum total length in each table must be used in the building’s design.

Meeting the braced wall panel requirements in this appendix provides a prescriptive lateral load-resisting system for cob buildings. This appendix does not provide the necessary data for an engineered lateral load-resisting design using cob shear walls, such as an R-factor and allowable shear for cob braced wall panels (shear walls). Design professionals must rely on testing from credible sources or credible published literature or test reports (for example, those in the commentary bibliography) and use accepted engineering principles and judgment for such a design.

Cob buildings require an approved engineered design where located in either a special wind region or wind design required location. Approximate locations for both can be found in Figure R301.2.1.1. Local jurisdiction ultimate design wind speeds or other related local requirements take precedence.

### Table AU106.11(1)

See page Appendix AU-24.

- See the commentary to Sections AU106.11 and AU106.11.3.

### Table AU106.11(2)

See page Appendix AU-25.

- See the commentary to Sections AU106.11, AU106.11.1 and AU106.11.2.

### Table AU106.11(3)

See page Appendix AU-25.

- See the commentary to Sections AU106.11, AU106.11.1 and AU106.11.2.

### Table AU106.11(4)

See page Appendix AU-26.

- See the commentary to Sections AU106.11 and AU106.11.1.

### Table AU106.11(5)

See page Appendix AU-27.

- Though Wall Type A has sufficient in-plane load-resistance capacity as shown in this table, Wall Type A is not allowed in Seismic Design Category C because it is not allowed in Table AU105.2 due to its out-of-plane load-resistance limitations. For other aspects of Table AU106.11(5), see the commentary to Sections AU106.11 and AU106.11.1.
### TABLE AU106.11(1)
**COB BRACED WALL PANEL TYPES**

<table>
<thead>
<tr>
<th>WALL TYPE** DESIGNATION</th>
<th>ANCHORS TO FOUNDATION**</th>
<th>ANCHORS TO BOND BEAM**</th>
<th>VERTICAL STEEL REINFORCING**</th>
<th>HORIZONTAL STEEL REINFORCING</th>
<th>MAXIMUM HEIGHT ( H^{d} ) (in feet)</th>
<th>MAXIMUM ASPECT RATIO (( H: L ))</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>none</td>
<td>( \frac{1}{8} )” threaded rod @ 12”, 4” from wall ends; 16” embedment in cob</td>
<td>none</td>
<td>none</td>
<td>7&quot;</td>
<td>1:1</td>
</tr>
<tr>
<td>B</td>
<td>#5 bar @ 12”, 16” embedment in cob</td>
<td>( \frac{7}{8} )” threaded rod @ 12”; 4” from wall ends; 16” embedment in cob; 2” × 2” × ( \frac{1}{4} )” washer and nut at cob end</td>
<td>none</td>
<td>2” × 2” × 14 gage welded wire mesh @ 18”; 6” from foundation and bond beam</td>
<td>7&quot;</td>
<td>1:1</td>
</tr>
<tr>
<td>C</td>
<td>#5 bar @ 12”; 16” embedment in cob</td>
<td>( \frac{5}{8} )” threaded rod @ 12”; 16” embedment in cob</td>
<td>( \frac{5}{8} )” threaded rod; 4” from each end of braced wall panel; continuous from foundation to bond beam</td>
<td>2” × 2” × 14 gage welded wire mesh @ 18”; 6” from foundation and bond beam</td>
<td>7&quot;</td>
<td>2:1</td>
</tr>
<tr>
<td>D</td>
<td>(see vertical steel reinforcing)</td>
<td>(see vertical steel reinforcing)</td>
<td>( \frac{5}{8} )” threaded rod; 4” from each end of braced wall panel and @ 12”; continuous from foundation to bond beam</td>
<td>2” × 2” × 14 gage welded wire mesh @ 18”; 6” from foundation and bond beam</td>
<td>7&quot;</td>
<td>2:1</td>
</tr>
<tr>
<td>E</td>
<td>6” × 6” × 6 gage welded wire mesh; 12” embedment in foundation</td>
<td>( \frac{5}{8} )” threaded rod @ 12”; 4” from wall ends; 12” embedment in cob</td>
<td>6” × 6” × 6 gage welded wire mesh; 2” from each wall face</td>
<td>none</td>
<td>7.5</td>
<td>1:1</td>
</tr>
</tbody>
</table>

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

a. Braced wall panel Types A, B, C and D shall be not less than 16 inches thick. Braced 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-inch embedment into foundation, unless otherwise stated.

c. Not less than 4-inch 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 inches.

f. Galvanized mesh.
### TABLE AU106.11(2)

**BRACING REQUIREMENTS FOR COB BRACED WALL PANELS BASED ON WIND SPEED**

<table>
<thead>
<tr>
<th>Ultimate Design Wind Speed (mph)</th>
<th>Story Location</th>
<th>Braced Wall Line Spacing (feet)</th>
<th>Cob Braced Wall Panel A; (aspect ratio (H:L) ≤ 1:1)</th>
<th>Cob Braced Wall Panel B; (aspect ratio (H:L) ≤ 1:1)</th>
<th>Cob Braced Wall Panel C, D; (aspect ratio (H:L) ≤ 2:1)</th>
<th>Cob Braced Wall Panel E; (aspect ratio (H:L) ≤ 1:1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\leq 110)</td>
<td>One-story building</td>
<td>10</td>
<td>6.0</td>
<td>6.0</td>
<td>3.7</td>
<td>6.0</td>
</tr>
<tr>
<td>(\leq 110)</td>
<td>One-story building</td>
<td>20</td>
<td>7.9</td>
<td>7.4</td>
<td>4.1</td>
<td>6.0</td>
</tr>
<tr>
<td>(\leq 110)</td>
<td>One-story building</td>
<td>30</td>
<td>11.8</td>
<td>11.0</td>
<td>11.0</td>
<td>6.9</td>
</tr>
<tr>
<td>(\leq 115)</td>
<td>One-story building</td>
<td>10</td>
<td>6.0</td>
<td>6.0</td>
<td>4.1</td>
<td>6.0</td>
</tr>
<tr>
<td>(\leq 115)</td>
<td>One-story building</td>
<td>20</td>
<td>8.7</td>
<td>8.1</td>
<td>8.1</td>
<td>6.0</td>
</tr>
<tr>
<td>(\leq 115)</td>
<td>One-story building</td>
<td>30</td>
<td>13.0</td>
<td>12.1</td>
<td>12.1</td>
<td>7.6</td>
</tr>
<tr>
<td>(\leq 120)</td>
<td>One-story building</td>
<td>10</td>
<td>6.0</td>
<td>6.0</td>
<td>4.4</td>
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<td>One-story building</td>
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<td>13.1</td>
<td>13.1</td>
<td>8.3</td>
</tr>
<tr>
<td>(\leq 130)</td>
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<td>6.0</td>
<td>6.0</td>
<td>5.1</td>
<td>6.0</td>
</tr>
<tr>
<td>(\leq 130)</td>
<td>One-story building</td>
<td>20</td>
<td>11.0</td>
<td>10.3</td>
<td>10.3</td>
<td>6.5</td>
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<td>30</td>
<td>16.5</td>
<td>15.4</td>
<td>15.4</td>
<td>9.7</td>
</tr>
<tr>
<td>(\leq 140)</td>
<td>One-story building</td>
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<td>6.0</td>
<td>5.9</td>
<td>6.0</td>
</tr>
<tr>
<td>(\leq 140)</td>
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<td>12.7</td>
<td>11.9</td>
<td>11.9</td>
<td>7.5</td>
</tr>
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<td>One-story building</td>
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<td>19.1</td>
<td>17.8</td>
<td>17.8</td>
<td>11.2</td>
</tr>
</tbody>
</table>

For SI: 1 foot = 304.8 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 wall panel types indicated shall comply with Section AU106.11 and Table AU106.11(1).

### TABLE AU106.11(3)

**BRACING REQUIREMENTS FOR COB BRACED WALL PANELS BASED ON SEISMIC DESIGN CATEGORY A**

<table>
<thead>
<tr>
<th>Braced Wall Line Spacing (feet)</th>
<th>Braced Wall Line Length (feet)</th>
<th>Min. Braced Wall Line % Openings</th>
<th>Min. Perpendicular Braced Wall Line % Openings</th>
<th>Cob Braced Wall Panel A, B</th>
<th>Cob Braced Wall Panel C, D</th>
<th>Cob Braced Wall Panel E</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>30</td>
<td>0</td>
<td>0</td>
<td>---</td>
<td>---</td>
<td>---</td>
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<td>20</td>
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<tr>
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<td>30</td>
<td>0</td>
<td>0</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 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 wall panel types indicated shall comply with Section AU106.11 and Table AU106.11(1).
- f. Wall bracing lengths are based on a soil site class D. Interpolation of bracing lengths between \(S_{\text{SDS}}\) values associated with the seismic design categories is allowable where a site-specific \(S_{\text{SDS}}\) value is determined in accordance with Section 1613 of the *International Building Code*.
- g. For total plaster thickness between 3 inches and 6 inches, the minimum total length of braced wall panels shall be multiplied by 1.2.
TABLE AU106.11(4)

BRACING REQUIREMENTS FOR COB BRACED WALL PANELS BASED ON SEISMIC DESIGN CATEGORY B

- Soil Class D
- Total wall height = 10 feet (including stem wall and bond beam)
- Cob wall height per Table AU106.11(1)
- 15 PSF roof-ceiling dead load
- Story location: one-story building
- Seismic design category B
- 1.5” plaster thickness each side

<table>
<thead>
<tr>
<th>Braced Wall Line Spacing (feet)</th>
<th>Braced Wall Line Length (feet)</th>
<th>Min. Braced Wall Line % Openings</th>
<th>Min. Perpendicular Braced Wall Lines % Openings</th>
<th>Cob Braced Wall Panel Type A, B</th>
<th>Cob Braced Wall Panel Type C, D</th>
<th>Cob Braced Wall Panel Type E</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>6.0</td>
<td>3.2</td>
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<td>NP</td>
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For SI: 1 inch = 25.4 mm, 1 foot = 304.8 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 \( (H:L) \leq 1:1 \). Braced wall panel Types C and D shall have an aspect ratio \( (H:L) \leq 2:1 \).
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 Section AU106.11 and Table AU106.11(1).
f. Wall bracing lengths are based on a soil site class D. Interpolation of bracing lengths between \( S_{sd} \) values associated with the seismic design categories is allowable where a site-specific \( S_{sd} \) value is determined in accordance with Section 1613 of the International Building Code.
g. For total plaster thicknesses 3 inches to 6 inches, the minimum total length of braced wall panels shall be multiplied by 1.2.
h. 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).
### TABLE AU106.11(5)

**BRACING REQUIREMENTS FOR COB BRACED WALL PANELS BASED ON SEISMIC DESIGN CATEGORY C**

- **SOIL CLASS D**
- **TOTAL WALL HEIGHT = 10 FEET (INCLUDING STEM WALL AND BOND BEAM)**
- **COB WALL HEIGHT PER TABLE AU106.11(1)**
- **15 PSF ROOF-CEILING DEAD LOAD**
- **STORY LOCATION: ONE-STORY BUILDING**
- **SEISMIC DESIGN CATEGORY C**
- **1.5" PLASTER THICKNESS EACH SIDE**

<table>
<thead>
<tr>
<th>Braced Wall Line</th>
<th>Braced Wall Line Length (feet)</th>
<th>Min. Braced Wall Line % Openings</th>
<th>Min. Perpendicular Braced Wall Lines % Openings</th>
<th>Cob Braced Wall Panel A, B</th>
<th>Cob Braced Wall Panel C, D</th>
<th>Cob Braced Wall Panel E</th>
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For SI: 1 inch = 25.4 mm, 1 foot = 304.8 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 Section AU106.11 and Table AU106.11(1).
f. Wall bracing lengths are based on a soil site class D. Interpolation of bracing lengths between \(S_{SDS}\) values associated with the seismic design categories is allowable where a site-specific \(S_{SDS}\) value is determined in accordance with Section 1613 of the International Building Code.
g. For total plaster thicknesses 3" to 6", multiply the minimum total length of braced wall panels by 1.2.
h. Total plaster thickness shall not be greater than 3 inches. Substitute 15/32" roof sheathing and 10d at 6" edge nailing for requirements in Table R602.3(1).
AU106.11.1 Nonorthogonal 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), AU106.11(3), AU106.11(4) and AU106.11(5), 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 65 percent of its length to that line.

2. A braced wall panel not more than 30 degrees to an orthogonal braced wall line shall contribute 35 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.

The braced wall panel Tables AU106.11(2), (3), (4) and (5) assume buildings with two sets of parallel braced wall lines orthogonal (perpendicular) to each other. See Section AU106.11. However, it is common for walls in cob buildings to be non-orthogonal.

The designer can count the full length of braced wall panels that are in line with an orthogonal direction toward the required length of braced wall panels along each braced wall line in the applicable table. Non-orthogonal braced wall panels are counted in both orthogonal directions, but their countable lengths are reduced because of their reduced ability to resist lateral loads relative to the chosen orthogonal lines. The percentage reduction depends on the wall’s angle relative to each orthogonal line as required and described in Items 1–3.

Item 4 describes the method for determining the angle of a curved braced wall panel relative to a braced wall line by drawing a straight line connecting the ends of the center of the curved wall (the chord). See the dashed centerline in Figure AU106.11.3, where the shaded portion represents the extent of the curved wall utilized as a braced wall panel. The chord line is not shown.

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 Tables AU106.11(3), AU106.11(4) and AU106.11(5) shall be the maximum widths of the building in the two orthogonal directions.

It is common practice for North American cob buildings to contain curved walls.

Each building design must select two orthogonal directions with a set of braced wall lines to design the building’s lateral load-resisting system (see Section AU106.11.1). This includes buildings with some or all curved walls and is intended to also include non-orthogonal walls (see Section AU106.11.1). This section provides a means of establishing the equivalent braced wall line spacing for buildings with curved and non-orthogonal walls. The spacing is the maximum exterior width of the building in each of two orthogonal directions chosen.

Curved braced wall panel lengths are determined per Section AU106.11.3 and are adjusted by their angle relative to the chosen orthogonal directions per Section AU106.11.1.

AU106.11.3 Radius, thickness and length of curved braced wall panels. Cob curved braced wall panels shall have an inside radius of at least 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 length of the curved wall 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 by Equation AU-4.

\[ ARC = 0.0175 \times RC \times A \]  

(Equation AU-4)

Where:

- \( ARC \) = Length of arc at center of wall (in feet).
- \( RC \) = Radius at center of wall = \( R_i + 0.5T \) (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).

To be counted as a braced wall panel, curved cob walls must have an inside radius of at least 5 feet. Walls with a smaller radius are less effective in resisting in-plane loads so are not considered in this appendix. The length of a curved braced wall panel is the length of its centerline arc and is determined by Equation AU-4. Section AU106.11.1, Item 4 describes how to find the equivalent straight line for curved walls to use in the chosen orthogonal braced wall panel scheme for the building.

FIGURE AU106.11.3. See page Appendix AU-29.

See the commentary to Section AU106.11.3. The chord line mentioned in Section AU106.11.3 is not shown in this figure, but it would be a line connecting the ends of the dashed center line \( ARC \).

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.

Cob walls subject to wind uplift forces according to Section R802.11 must have their bond beams anchored to the wall as specified in Table AU106.12.

The required anchor embedment is shown in the table for the applicable combination of wall thickness and wind speed.

TABLE AU106.12. See page Appendix AU-29.

See the commentary to Section AU106.12.

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.

Cob wall systems in which superimposed gravity loads are supported by posts and beams and not the cob wall are not covered in this appendix and thus require an approved engineered design.
TABLE AU106.12
ANCHORAGE OF BOND BEAMS FOR WIND UPLIFT

<table>
<thead>
<tr>
<th>WIND UPLIFT FORCE FROM TABLE R802.11 (PLF)</th>
<th>ANCHORAGE DEPTH IN INCHES, PER WALL WIDTH AND WIND UPLIFT FORCE</th>
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<tr>
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<td>≤ 12” Wall Width(^c)</td>
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<tr>
<td>&lt; 150</td>
<td>48 o.c. continuous from foundation to bond beam(^d)</td>
</tr>
<tr>
<td>&lt; 200</td>
<td>48 o.c. continuous from foundation to bond beam(^d)</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.
a. For wood bond beams a maximum of 6 inches from bond beam ends.
b. For minimum 6-inch by 8-inch concrete bond beams, at 18” o.c. for wind uplift forces less than 75 pounds per linear foot, and at 16” o.c. for wind uplift forces less than 100 pounds per linear foot.
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-inch by 2-inch by \(\frac{1}{4}\)-inch washer and nut.
APPENDIX AU—COB CONSTRUCTION (MONOLITHIC ADOBE)

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.

- Cob buttresses designed to aid out-of-plane or in-plane lateral wall strength and stability can be part of a cob building’s lateral load-resisting system. However, cob buttresses require 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.

- Cob floors on grade, with or without straw, are permitted with specifications that have been approved by the building official.
  
  The modern evolution and growing use of cob and other earthen floors in custom homes is a testament to their serviceability and aesthetic appeal. They also can reduce costs and environmental impact, especially where the floor is made from clay subsoil obtained from the site.

  Cob floors are made of some or all of the materials described in Sections AU103.1, AU103.2, and AU103.3. They are generally composed of the following layers over undisturbed grade or well-compacted fill: a capillary break, a moisture barrier, an earthen base layer, a wear layer and a penetrating finish treatment.

  Though cob floors have a history of successful raised floor applications, this section does not specifically include such installations. The primary differences include the lack of need for a capillary break and moisture barrier, the added weight to the raised floor structure and potential floor structure deflection under dynamic live loads that could induce cracking. The last two issues can be addressed with adequate structural design.

SECTION AU108 FIRE RESISTANCE

AU108.1 Fire-resistance rating. Cob walls are not fire-resistance rated.

- Although cob walls are not given a fire-resistance rating in this appendix, the materials described in the appendix for use in cob walls are the same as those used for centuries around the world to build wood-fired ovens, fireplaces and kilns. The absence of a fire rating for cob walls is due to the lack of specific fire tests required by the code for establishing a fire-resistance rating at the time this appendix was written.

  Similarly, cob has not been classified as noncombustible because the specific testing in ASTM E136 required by the code had not been performed when this appendix was written. However, the long history of cob’s use for high-heat, open-flame ovens and kilns clearly indicates its high fire resistance.

  Guidance is available to fire engineers in proposing engineered fire-resistance equivalency ratings for cob construction. The most relevant comes from the Australian national regulatory agency following recent wildfire (bushfire) catastrophes there. The Australian Standard AS 3959—2009, Construction of Buildings in Bushfire-Prone Areas, was developed in response. Historic use of earthen wall systems, including cob and mud brick (adobe), where these fires occurred gave Australians direct experience with these buildings in intense firestorms. AS 3959 lists “earthwall, including mud brick” as one of only three wall materials not needing additional testing even in the most extreme and vulnerable bushfire zone, Bushfire Attack Level—Flame Zone. The standard stipulates that exposed components of external walls shall be of noncombustible material at least 90 mm (3.54 inches) thick. The only other materials listed as acceptable without additional testing for external walls are full masonry and concrete. The minimum 10-inch thickness for cob walls required in this appendix is almost three times the minimum thickness of the earth wall accepted by the Australian standard for its highest fire risk zones.

  Additionally, The Australian Earth Building Handbook, HB 195—2002, 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 sets of numbers in the FRL represent minutes before failure for structural adequacy, integrity and insulation. Thus, Australia gives a 2-hour fire-resistance rating for a 200 mm (7.87 inches) earth wall, including cob.

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 noncombustibles is required by the manufacturer’s instructions.

- Because cob does not burn or support combustion, this section treats cob walls as the code treats masonry and other noncombustible materials. Centuries of using cob to build ovens and kilns has influenced modern cob practitioners to commonly construct cob fireplaces in cob walls. Where specific clearances to noncombustible materials are specified in the manufacturer’s instructions, those clearances are required.

SECTION AU109 THERMAL PERFORMANCE

AU109.1 Thermal characteristics. Cob walls shall be classified as mass walls in accordance with Section N1102.2.5 and shall meet the R-value requirements for mass walls in Table N1102.1.3.

- 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/ft² × °F threshold in that section. The lowest heat capacity of a cob wall is 16 Btu/ft² × °F for the required minimum wall thickness of 10 inches and at the lowest practical density of 70 pcf. Thus, cob walls must meet the R-value requirements in the Mass Wall column of Table N1102.1.3. The first number in that column applies where there is no additional insulation or where additional insulation is applied to the exterior of the wall. The second number applies where additional insulation is applied to the interior of the wall and its R-value exceeds half of the insulating value of the cob wall itself.

In certain climates, buildings with cob or other mass walls that do not meet the R-value requirements in Table N1102.1.3 may exhibit a history of thermal performance equivalent to buildings with walls that meet the requirements. As allowed by Sections AU101.2 and AU101.3, such local conditions and history can be considered in evaluating equivalent compliance.

**AU109.2 Thermal resistance.** The unit R-value for cob walls with a density of 110 pounds per cubic foot (1762 kg/m³) 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.

- 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 an independent laboratory in 2018. A density of 110 pcf is at the upper limit of the 70–110 pcf practical density range for cob. Therefore, the assigned R-value is conservative for all cob walls, even if the density is not known. Lower densities of cob, with more straw and/or less dense aggregate, will likely have a higher unit R-value. The unit R-value yielded by independent laboratory ASTM tests of lower density cob can be used in lieu of R-0.22 if reports are presented and a similar cob mix and density is utilized in a particular project.

The R-value of a cob wall assembly is determined by multiplying the unit R-value by the thickness of the cob wall in inches and adding the thermal resistance of air films and any finish or additional insulation. Use the average thickness of the wall when computing the R-value for cob walls that vary in thickness.

**AU109.3 Additional insulation.** Where 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 AU104.1.2, Items 1–4.

- Adding insulation to the face of cob walls can allow them to more readily meet energy efficiency requirements in cold climates. This is allowed provided that the insulation assembly complies with the requirements in Section AU104.1.2, Items 1–4, for attachment or support, vapor permeance and weight limits.

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**APPENDIX AU—COB CONSTRUCTION (MONOLITHIC ADOBE)**

**SECTION AU110 REFERENCED STANDARDS**

**AU110.1 General.** See Table AU110.1 for standards that are referenced in various sections of this appendix. Standards are listed by the standard identification with the effective date, the standard title and the section or sections of this appendix that reference the standard.

**TABLE AU110.1 REFERENCED STANDARDS**

<table>
<thead>
<tr>
<th>STANDARD ACRONYM</th>
<th>STANDARD NAME</th>
<th>SECTIONS HEREIN REFERENCED</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM C5—10</td>
<td>Standard Specification for Quicklime for Structural Purposes</td>
<td>AU104.4.6</td>
</tr>
<tr>
<td>ASTM C141/ C141M—14</td>
<td>Standard Specification for Hydrated Hydraulic Lime for Structural Purposes</td>
<td>AU104.4.6</td>
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<td>ASTM C206—14</td>
<td>Standard Specification for Finishing Hydrated Lime</td>
<td>AU104.4.6</td>
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<td>ASTM C926</td>
<td>Specification for Appliance of Portland Cement-based Plaster</td>
<td>AU104.4.8</td>
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<td>ASTM C1707—11</td>
<td>Standard Specification for Pozzolanic Hydraulic Lime for Structural Purposes</td>
<td>AU104.4.6</td>
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<td>ASTM E2392/ E2392M—10</td>
<td>Standard Guide for Design of Earthen Wall Building Systems</td>
<td>AU104.4.3.2</td>
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<tr>
<td>ASTM BS1, ASTM BS EN 459—2015</td>
<td>Part 1: Building Lime. Definitions, Specifications and Conformity Criteria; Part 2: Test Methods</td>
<td>AU104.4.6</td>
</tr>
</tbody>
</table>

**Bibliography**

The following resource materials were used in the preparation of the commentary for this appendix:

- Brunello, Gabi, Jose Espinoza, Alex Golitz. *Cob Property Analysis*, Santa Clara University, Department of Civil Engineering, 2018.
APPENDIX AU—COB CONSTRUCTION (MONOLITHIC ADOBE)


