

# RB316-22

IRC: AY101 (New)

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## 2021 International Residential Code

Add new text as follows:

### **SECTION AY101** **GENERAL**

**AY101.1 Scope.** This appendix shall govern the use of hemp-lime as a nonbearing building material, and wall infill system in Seismic Design Categories A, B, and C, and in Seismic Design Categories D<sub>0</sub>, D<sub>1</sub>, and D<sub>2</sub> with an *approved* engineered design by a *registered design professional* in accordance with Section R301.1.3.

### **SECTION AY102** **DEFINITIONS**

**AY102.1 General.** The following words and terms shall, for the purposes of this appendix, have the meanings shown herein. Refer to Chapter 2 for general definitions.

**BINDER.** The material that binds the hemp hurd in a hemp-lime mix.

**BONDING COAT.** The initial thin layer of binder-rich granulated plaster used in lined applications of hemp-lime construction to ensure adhesive and/or mechanical bonding. Also known as *gobetis*.

**CAST-IN-PLACE.** Installation of hemp-lime mix by hand or by spraying into forms in its permanent location.

**CASTING.** Placing wet hemp-lime into forms.

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

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

**FIBER CLUMPS.** Long fibers that are attached to hemp hurd, or for other reasons, cause clumping of fibrous balls when agitated.

**FINISH.** Exposed surface material on the interior or exterior face of a hemp-lime infill wall.

**FORM.** The material into which hemp-lime infill, panels, or blocks are cast.

**FORMWORK.** The system of forms, their bracing and fasteners assembled for casting of hemp-lime infill.

**HAND CAST.** Hemp-lime infill cast by placing hemp-lime mix into formwork and evenly tamping by hand or with a tool.

**HEMP.** A class of the *Cannabis sativa* plant grown for industrial purposes in which the concentration of total delta-9 tetrahydrocannabinol (THC) in the flowering tops is equal to or less than the regulated maximum level established by authorities having jurisdiction.

**HEMPCRETE.** Common usage term for hemp-lime.

**HEMP-LIME.** A bio-aggregate composite consisting of hemp hurd and a lime-based binder. Also known as *hempcrete*.

**HEMP HURD.** The chopped woody core of the stalks of the hemp plant, stripped of its surrounding hemp fibers. Also known as *hemp shiv* or *shive*.

**INFILL.** Hemp-lime placed between or around the structural or nonstructural framing of a building as insulation, thermal mass, and a substrate for finish.

**LIFT.** A horizontal layer of hemp-lime infill.

**LIME.** Lime is composed of calcium hydroxide (Ca(OH)<sub>2</sub>) including Type N or S hydrated lime, hydraulic lime, natural hydraulic lime or slaked quicklime.

**LINED APPLICATION.** Installation of a vertical hemp-lime layer, lining a masonry or concrete wall.

**NATURAL CEMENT.** Hydraulic cement made from naturally occurring limestone.

**NONBEARING.** Not bearing the weight of the building other than the weight of the hemp-lime infill and its finish.

**PLASTER.** Lime, clay, clay-lime, or hemp-lime plaster as described in Section AY104.3, applied to the interior or exterior face of hemp-lime walls.

**POZZOLAN.** A siliceous or alumino-siliceous material that when finely divided and combined with hydrated lime in the presence of water forms new chemical compounds with cementitious properties.

**PRECAST.** Blocks or panels of hemp-lime formed and cured before installation.

**SCREEDING.** Removal of excess material to form a planar surface.

**REED MAT.** A mat consisting of reed, cane, bamboo, or other similar plant material.

**SPRAY-APPLIED.** A method of mechanical projection of hemp-lime applied onto or into a form using compressed air.

**TADELAKT.** A lime-plaster which is compressed, polished, and treated with oil-based soap to make it water-repellant.

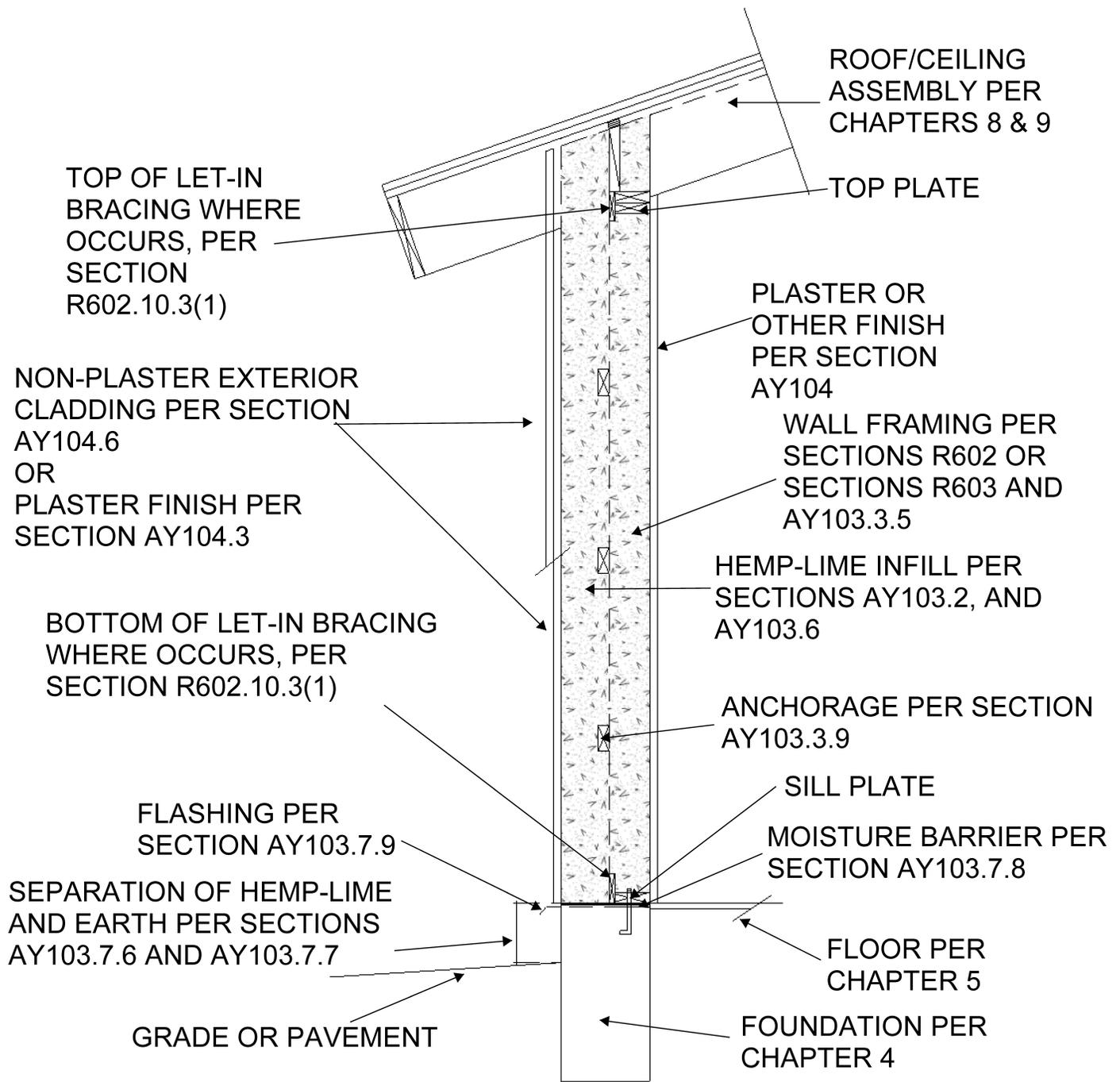
**UNIT WALL WEIGHT.** The unit wall weight is the calculated weight of a 1 foot by 1 foot (305 mm by 305 mm) section of wall surface area times the full wall thickness, including finishes. The unit wall weight is the sum of the weight of each constituent material times its volume, expressed as psf.

**VOID.** Any space in a hemp-lime wall greater than ¼ inch (6 mm) wide, 2 inches (51mm) long and 2 inches (51 mm) deep.

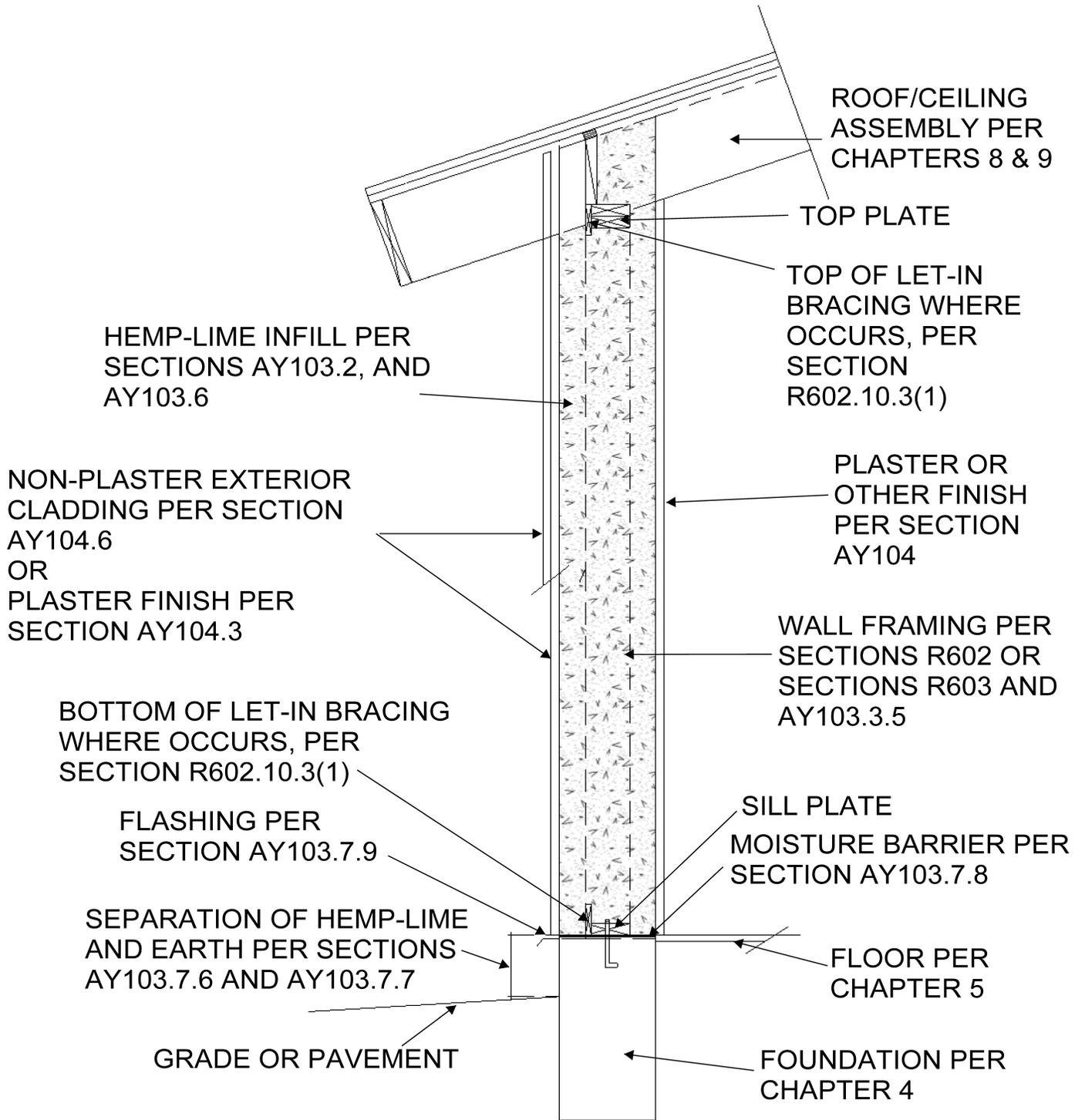
## **SECTION AY103**

### **HEMP-LIME CONSTRUCTION**

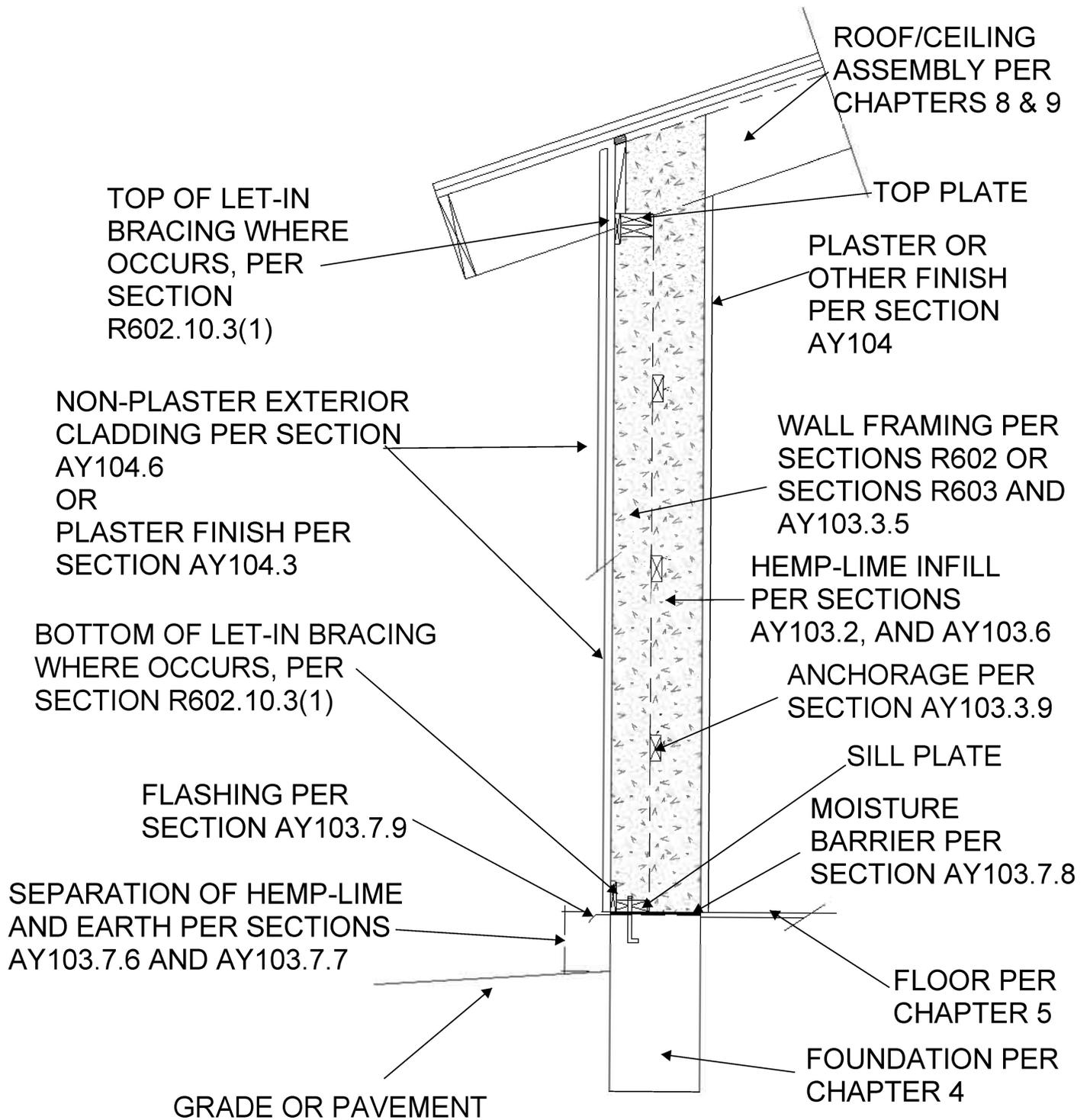
**AY103.1 General.** Hemp-lime construction shall be limited to the non-structural, solid *infill* mix of *hemp hurd* and its *binder* between or around structural and non-structural wall framing. Hemp-lime *infill* shall have a density ranging from 12.5 lb/ft<sup>3</sup> to 25 lb/ft<sup>3</sup> (200 kg/m<sup>3</sup> to 400 kg/m<sup>3</sup>). Hemp-lime walls shall be designed and constructed in accordance with Section AY103 and with Figures AY103.1(1) through AY103.1(4) or an *approved* alternative design.



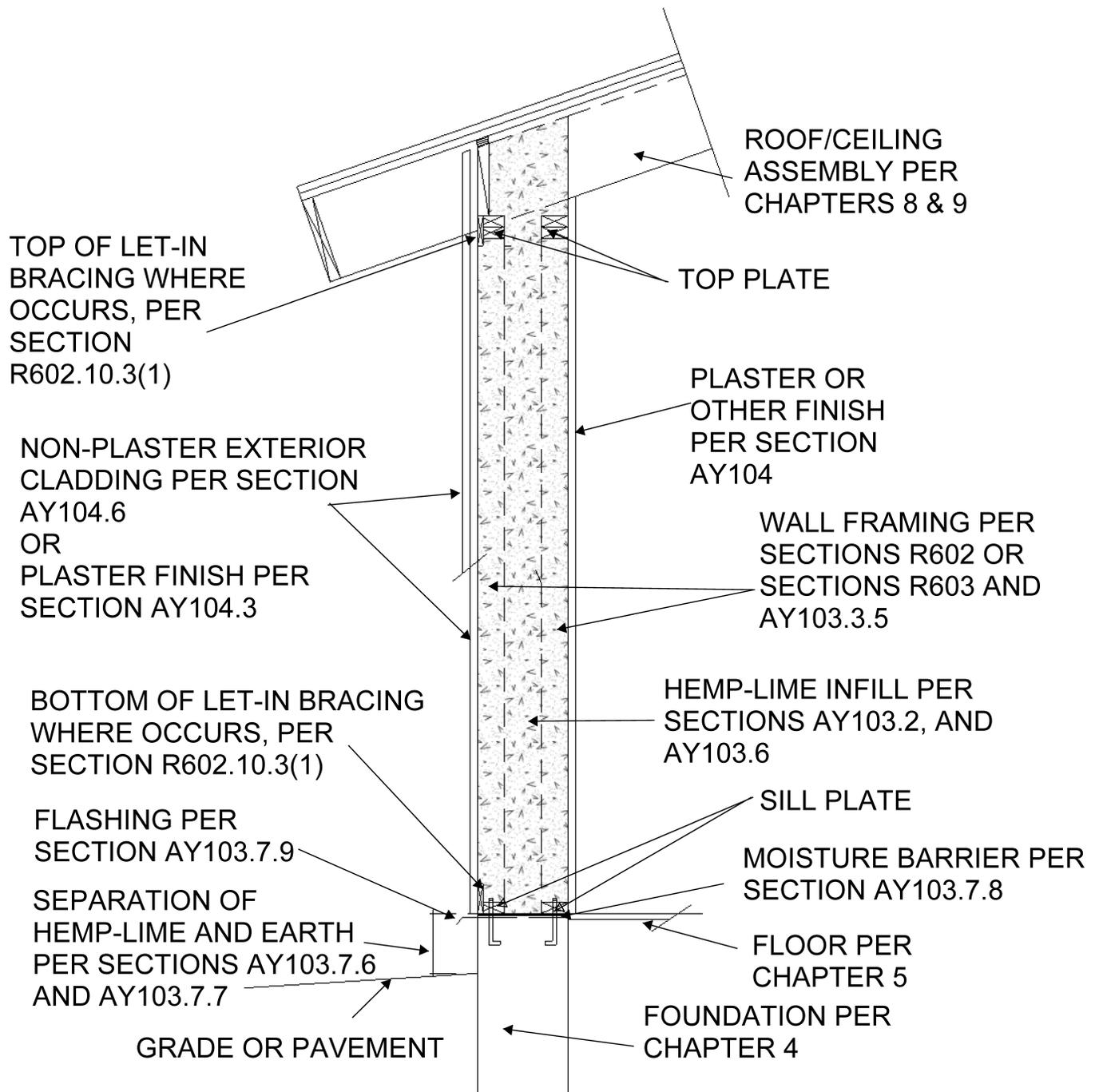
**AY103.1(1) TYPICAL HEMP-LIME WITH INTERIOR STUD FRAMING**



**AY103.1(2) TYPICAL HEMP-LIME WITH CENTER STUD FRAMING**



**AY103.1(3) TYPICAL HEMP-LIME WITH EXTERIOR STUD FRAMING**



**AY103.1(4) TYPICAL HEMP-LIME WITH DOUBLE STUD WALL FRAMING**

**AY103.2 Materials.** Materials to be used in hemp-lime construction shall be in accordance with Sections AY103.2 through AY103.2.3.

**AY103.2.1 Hemp hurd.** *Hemp hurd* shall match the specifications of the *approved* test samples in Sections AY106.3 and AY107.1. *Hemp hurd* shall be substantially free from dust and *fiber clumps* such that the installed hemp-lime maintains its integrity.

**AY103.2.2 Binders.** Acceptable *binders*, singular or in combination, include *hydraulic lime*, *hydrated lime*, *pozzolans*, *natural cements*, or other *binders* that match the specification of the *approved* test samples in Sections AY106.3 and AY107.1.

**AY103.2.3 Water and water additives.** Water and any water additives shall match the specifications of the *approved* test samples in Sections AY106.3 and AY107.1.

**AY103.3 Structure.** The structure of buildings using hemp-lime *infill* shall be in accordance with the IRC and Sections AY103.3.1 through AY103.3.9 or with an *approved* engineered design by a *registered design professional*.

**AY103.3.1 Limitations and requirements for buildings using hemp-lime infill.** Buildings using hemp-lime *infill* shall be subject to the following

limitations and requirements:

1. Number of stories: not more than one *story above grade plane*.
2. The building height shall not be more than 25 feet (7620 mm).
3. Braced wall panel lengths: in accordance with Section R602.10.3 and Section AY103.3.2.
4. Unit wall height: Hemp-lime walls shall not exceed an average *unit wall weight* of 65 pounds per square foot (217 kg/m<sup>2</sup>).

**AY103.3.2 Bracing.** Bracing for buildings with hemp-lime *infill* in Seismic Design Categories A, B, and C shall be in accordance with Section R602.10 and in accordance with the following. Walls with hemp-lime *infill* shall use Method LIB and shall not be braced with solid sheathing. Hemp-lime *infill* walls utilizing Method LIB shall not require gypsum board to be installed and the minimum braced wall lengths listed in Section R602.10. Adjustment factors in Table R602.10.3(4) shall be used as applicable. Alternatively, hemp-lime *infill* walls shall comply with Section R301.1. Walls or wall sections without hemp-lime *infill* shall be permitted to use any bracing method allowed in Section R602.10.

**AY103.3.3 Connection of light-frame walls to hemp-lime walls.** Light-frame walls perpendicular to, or at an angle to a hemp-lime wall assembly, shall be fastened to the hemp-lime wall in accordance with Section R602 or R603.

**AY103.3.4 Hemp-lime thickness.** Hemp-lime *infill* shall be not less than 3 inches (76 mm) thick between face of framing and finish. Maximum hemp-lime wall thickness is limited by the average *unit wall weight* limit of 65 pounds per square foot (317 kg/m<sup>2</sup>) in Section AY103.3.1, Item 4.

**AY103.3.5 Contact with structural metal.** Structural metal members and components in contact with hemp-lime shall be protected in accordance with Section AY103.4.

**AY103.3.6 Contact with wood members.** Hemp-lime shall be permitted to be in contact with untreated wood members.

**AY103.3.7 Openings in walls.** Door, window, and similar openings in hemp-lime walls shall be in accordance with the following:

1. Rough framing for doors and windows shall be part of, or be fastened to the wall framing in accordance with the IRC.
2. An *approved water-resistive barrier* shall be installed at openings in hemp-lime walls in accordance with Sections AY103.7.4 and AY104.5.1.
3. Header size and their maximum span above openings in bearing walls with hemp-lime *infill* shall be determined with Table R602.7(1) and Table AY103.3.7 or a design approved by a registered design professional
4. *Cast-in-place* hemp-lime over and overhanging the face of a header more than 3 inches (76 mm) shall require an *approved* design of its support by a *registered design professional*.
5. Hemp-lime blocks overhanging headers shall require an *approved* design of their support by a *registered design professional*.

**TABLE AY103.3.7 ALLOWABLE HEADER SPAN MULTIPLIER<sup>a</sup>**

WALL HEIGHT ABOVE HEADER	UNIT WALL WEIGHT (psf)			
	15	30	45	65
1'-0"	1.00	1.00	1.00	1.00
1'-6"	1.00	1.00	0.90	0.90
2'-0"	1.00	0.90	0.90	0.85
2'-6"	1.00	0.90	0.90	0.85
3'-0"	1.00	0.90	0.90	0.80

a. Multiply the maximum allowable spans from Table R602.7(1) by the applicable factor to determine the adjusted maximum allowable header span.

**AY103.3.8 Voids.** Voids shall be filled with hemp-lime or other approved material before application of finish.

**AY103.3.9 Anchorage of hemp-lime.** Hemp-lime for interior and exterior stud walls shall be anchored, or shall be in accordance with an approved design by a registered design professional. Horizontal anchorage rails shall be installed at not more than 24 inches (610 mm) on center and in accordance with Figure AY103.1(1) and AY103.1(3). Horizontal anchorage rails shall be no less than 1 inch by 2 inch (25 mm by 51 mm). Anchorage rails shall be wood, metal per Section AY103.4, or other approved material. Anchorage rails should be attached to the side of the stud facing the interior of the wall with (1) - 8d box nail to each stud and run the entire length of the wall.

**AY103.4 Contact with metal.** Metal in contact with hemp-lime shall be stainless steel or primed and painted with a coating in accordance with Section AY103.4.1.

**AY103.4.1 Protective coatings.** Metal shall be painted with an epoxy, oil, bituminous paint or other approved coating. Water based paints shall not be used.

**Exception:** Heads of pneumatically driven hot-dip galvanized nails.

**AY103.5 Mechanical, electrical and plumbing in hemp-lime infill.** Electrical and telecommunication wiring, panels, and boxes, mechanical ducts, plumbing pipes, and other mechanical, electrical and plumbing components in or in contact with hemp-lime infill shall be isolated in sleeves, pipes, conduits, or tubing made of plastic, or of metal in accordance with Section AY103.4, or separated from hemp-lime with an approved alkaline-resistant material.

**AY103.6 Hemp-lime installation methods.** Hemp-lime shall be installed in accordance with Sections AY103.6.1 and AY103.6.2, and one of Sections AY103.6.3 through AY103.6.7.

**AY103.6.1 Mix and mixing.** The materials and ratio of hemp hurd to binder to water shall match the specifications of the approved test samples in Sections AY106.3 and AY107.1. The water to binder ratio shall be not less than 1:1 and not greater than 2:1 by weight or by binder manufacturer's recommendations. The hemp hurd, binder, and water shall be thoroughly and uniformly mixed by manual or mechanical means.

**AY103.6.2 Formwork for hand cast and spray-applied methods.** Forms shall be removable or permanent and shall not deform under the lateral pressure of the installed wet hemp-lime.

**AY103.6.2.1 Permanent forms.** Permanent forms shall be permitted to be installed on only one side. Permanent forms shall be reed mats, or other approved materials with an open weave. Sheet materials shall not be used as permanent forms. Permanent forms remain after curing as a finish or substrate for another finish.

**Exception:** Permanent forms of any material shall be permitted at the jambs, heads, and sills of openings.

**AY103.6.2.2 Removable forms.** Removable forms shall be removed within 24 hours after hemp-lime placement or per the binder manufacturer's specifications.

**Exception:** Removable forms temporarily supporting hemp-lime infill above wall openings shall not be removed for a minimum of 3 days or per binder manufacturer's specifications.

**AY103.6.3 Hand cast.** Hand cast hemp-lime infill shall be installed in uniform lifts not greater than 4 inches (102 mm) in height. Each lift shall be tamped to achieve stable walls free of voids.

**AY103.6.4 Spray-applied.** Spray-applied hemp-lime infill shall be installed in accordance with Sections AY103.6.4.1 through AY103.6.4.4.

**AY103.6.4.1 Forms.** Forms shall be installed on one side in accordance with Section AY103.6.2 or AY103.6.7.2 for lined applications.

**AY103.6.4.2 Mixing.** Mixing shall be in accordance with Sections AY103.6.1 or the spray equipment manufacturer's instructions.

**AY103.6.4.3 Installation.** Hemp-lime shall be sprayed from the base up and per the spray equipment manufacturer's and/or binder manufacturer's instructions.

**AY103.6.4.4 Screeding.** Excess hemp-lime shall be removed by *screeding* per the spray equipment manufacturer's and/or *binder* manufacturer's instructions.

**AY103.6.5 Precast blocks.** Precast hemp-lime blocks shall be cast and installed in accordance with Sections AY103.6.5.1 through AY103.6.5.5 or per manufacturer's specifications:

**AY103.6.5.1 Block dimensions.** Hemp-lime blocks shall be a minimum thickness of 3 inches (76 mm) in all dimensions and shall not exceed the maximum thickness in accordance with Section AY103.3.4.

**AY103.6.5.2 Casting.** Hemp-lime blocks shall be cast in accordance with Sections AY103.6.1 through AY103.6.6 as applicable, or by other means that produce *approved* blocks.

**AY103.6.5.3 Mortar.** Mortar shall consist of *lime* and sand or other aggregate with a ratio of not less than 1:1 and not greater than 1:3, or other *approved* mortar. The *lime* shall be hydrated Type N or S, or hydraulic *lime*.

**AY103.6.5.4 Installation.** Hemp-lime blocks shall be installed in a running bond between and around wall framing members. Mortar shall fill all voids between blocks and shall not be not less than 1/8 inch (3 mm) thick. Spaces between blocks and framing shall be not more than 3/4 inch (19 mm) and shall be filled with mortar.

**AY103.6.5.5 Hemp-lime block veneer.** Hemp-lime block veneer shall not exceed 50 pounds per square foot (244 kg/m<sup>2</sup>) of veneer only *unit wall weight*, shall be limited to 5-inch (127 mm) thickness, and shall be anchored to the supporting wall studs in accordance with Section R703.8.4 or secured with *approved* ties and fasteners to an *approved* backing. Metal ties and fasteners shall be protected in accordance with Section AY103.4.

**AY103.6.6 Hemp-lime panels.** Hemp-lime panels shall require an *approved* design by a *registered design professional*.

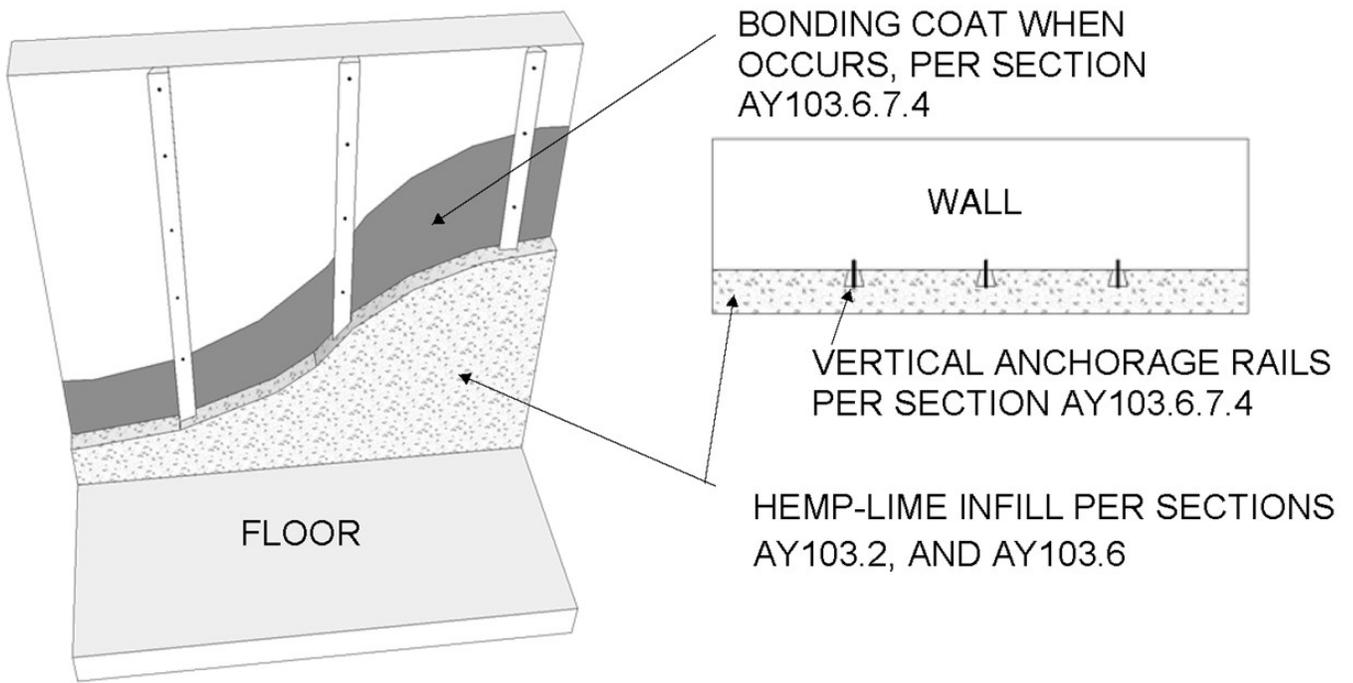
**AY103.6.7 Lined application.** Interior and exterior hemp-lime *lined applications* shall be installed in accordance with Section AY103.6.7.1 through AY103.6.7.6 and Sections AY103.6.3 through AY103.6.6 as applicable.

**AY103.6.7.1 General.** Prior to installation, the concrete or masonry walls receiving the installation shall be clean, and free of loose mortar. Lined installations on basement walls shall require an *approved* design by a *registered design professional*. Exterior applications shall be in accordance with Section AY103.7.6. Attachment of *precast* blocks to the receiving wall shall be in accordance with Section AY103.6.5.5. Attachment of hemp-lime panels to the receiving wall shall be in accordance with Section AY103.6.6.

**AY103.6.7.2 Formwork.** *Forms* shall be in accordance with Section AY103.6.2. Permanent *formwork* shall not be allowed on the non-receiving wall side.

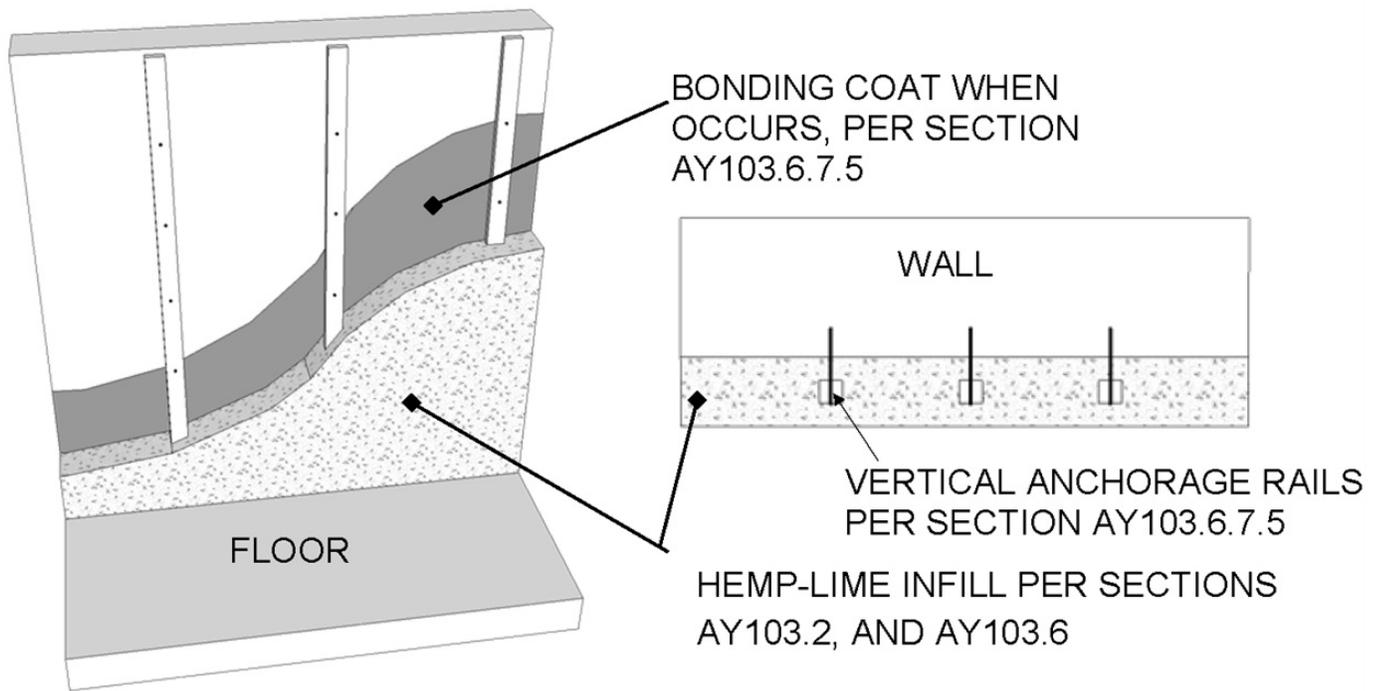
**AY103.6.7.3 Thin lining.** Thin linings are from 3 to 4 3/4 inches (76 to 121 mm) thick. Hand troweled hemp-lime shall be installed over a *bonding coat*.

**AY103.6.7.4 Medium lining.** Medium linings exceed 4 3/4 inches (121 mm) and are not greater than 6 1/2 inches (165 mm) thick. For *hand cast* or *spray-applied*, 1 1/2 inch (38 mm) X 1 1/2 inch (38 mm) dovetail shaped vertical anchorage rails shall be attached with the narrowest face to the receiving wall, spaced not less than 20 inches (508 mm) and not greater than 32 inches (813 mm), with fasteners not less than 2 feet (610 mm) and not greater than 3 feet (914 mm) apart. *Hand cast* medium linings shall be installed over a *bonding coat* on the receiving wall. See Figure AY103.6.7.4.



**FIGURE AY103.6.7.4 TYPICAL HEMP-LIME MEDIUM LINING**

**AY103.6.7.5 Thick lining.** Thick linings exceed 6½ inches (165 mm) and shall not be greater than 8 inches (203 mm) thick or per the binder manufacturer's specifications. For *hand cast* or *spray-applied*, 1½ inch (38 mm) x 2½ inch (64 mm) vertical anchorage rails shall be attached with the 2½ inch (64 mm) face parallel to the receiving wall and spaced not less than 20 inches (508 mm) and not greater than 32 inches (813 mm). The anchorage rails shall be fastened to and separated from the receiving wall with 2 inch (51 mm) spacers not less than 3 feet (914 mm) and not greater than 4 feet (1,219 mm) apart. *Hand cast* thick linings shall be installed over a *bonding coat* on the receiving wall. See Figure AY103.6.7.5.



**FIGURE AY103.6.7.5 TYPICAL HEMP-LIME THICK LINING**

**AY103.6.7.6 Minimum thickness at anchorage rails.** The minimum thickness of hemp-lime between the exterior face of vertical anchorage rails and finished face of hemp-lime shall be 3 inches (76 mm) or in accordance with the *binder* manufacturer's specifications.

**AY103.7 Moisture Control.** Hemp-lime assemblies shall be protected from water intrusion and damage in accordance with Section AY103.7.1 through AY103.7.9.

**AY103.7.1 Water-resistive barriers.** *Water-resistive barriers* are prohibited on hemp-lime walls, except as permitted or required elsewhere in this appendix.

**AY103.7.2 Vapor retarders.** Vapor retarders are prohibited on hemp-lime walls, except as permitted or required elsewhere in this appendix.

**AY103.7.3 Penetrations in hemp-lime walls.** Penetrations in exterior hemp-lime walls shall be sealed with an *approved* sealant or gasket on the exterior side of the wall in all climate zones, and on the interior side of the wall in Climate Zones 5, 6, 7, 8 and Marine 4, as defined in Chapter 11.

**AY103.7.4 Horizontal surfaces.** Hemp-lime walls and other hemp-lime assemblies shall be provided with a *water-resistive barrier* at weather-exposed horizontal surfaces. The *water-resistive barrier* shall be of a material and installation that will prevent water from entering the wall system. Horizontal surfaces shall include exterior window sills, and sills at exterior niches. Horizontal surfaces shall be sloped not less than 1 unit vertical in 12 units horizontal (8-percent slope) and shall drain away from hemp-lime walls and other assemblies. Where the *water-resistive barrier* is below the finish material, it shall be sloped not less than 1 unit vertical in 12 units horizontal (8-percent slope) and shall drain to the exterior surface of the hemp-lime wall's vertical finish.

**AY103.7.5 Air barrier.** Exterior hemp-lime walls shall have a *vapor permeable air barrier* on all exterior and interior surfaces, except as permitted or required elsewhere in this appendix. Plaster in accordance with Section AY104.3 shall be acceptable as an *air barrier*.

**AY103.7.6 Separation of hemp-lime and earth or paved areas.** Hemp-lime shall be not less than 8 inches (203 mm) above exposed earth or paved areas.

**AY103.7.7 Separation of exterior plaster and earth or paved areas.** Exterior *plaster* applied to hemp-lime shall be not less than 8 inches (203 mm) above exposed earth or paved areas.

**AY103.7.8 Separation of hemp-lime and exterior plaster from foundation.** Hemp-lime and exterior *plaster* shall be separated from the foundation with an *approved* moisture barrier.

**AY103.7.9 Base of wall flashing.** Outer face of exterior walls shall be flashed to prevent water intrusion at the base of the wall.

## **SECTION AY104**

### **FINISHES**

**AY104.1 General.** The interior and exterior surfaces of hemp-lime walls shall be protected with a finish in accordance with Section AY104. Finishes shall have a vapor permeance rating of 5 perms or greater tested in accordance with Procedure B of ASTM E96.

**AY104.2 Moisture content prior to application of finish.** Hemp-lime *infill* shall have an average moisture content of no more than 20 percent at a depth of 1½ inches (38 mm), as measured from the face of the wall to which the finish will be applied for each wall. Moisture content shall be measured with a probe style wood moisture equivalent (WME) meter.

**AY104.3 Plaster Finish.** Exterior plaster shall be *lime plaster*, *clay plaster* in accordance with Section AY104.3.6.3, or other *approved plaster*. Interior plasters shall be any *plaster* permitted in Sections AY104.3.1 through AY104.3.9. Plasters shall be permitted to be applied directly to the surface of the hemp-lime *infill* without reinforcement, except that the juncture of dissimilar substrates shall be in accordance with Section AY104.5. Plasters shall have a thickness of not less than ½ inch (13 mm) on the interior and ¾ inch (19 mm) on the exterior, and shall be installed in not less than two coats, or per binder manufacturer's instructions. Not less than ⅜ inch (10 mm) exterior plaster is permitted behind exterior cladding in accordance with Section AY104.6.

**AY104.3.1 Membranes.** Membranes are prohibited between plaster and hemp-lime except where a membrane is allowed or required elsewhere in this appendix.

**AY104.3.2 Lath and mesh for plaster.** The surface of the hemp-lime functions as lath, and other lath or mesh shall not be required, except as required in Section AY104.5.

**AY104.3.3 Plaster additives.** Additives shall be permitted to increase plaster workability, durability, strength or water resistance. Additives shall not reduce the plaster vapor permeance rating to less than 5 perms. Additives containing polymers are prohibited.

**AY104.3.4 Plaster reinforcing fibers.** Reinforcing fibers shall be permitted in plaster. Acceptable reinforcing fibers include hemp fiber, chopped straw, sisal, animal hair and fiberglass.

**AY104.3.5 Lime plaster.** Lime plaster is any plaster with a binder primarily composed of calcium hydroxide (Ca(OH)<sub>2</sub>) 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 CEN EN 459. Quicklime shall comply with ASTM C5. Lime plaster shall contain sufficient lime to fully bind the sand or other aggregate, and shall be permitted to contain pozzolans.

**AY104.3.6 Clay plaster.** 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.

**AY104.3.6.1 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.

**AY104.3.6.2 Thickness and coats.** Clay plaster shall be not less than ¾ inch (19 mm) thick, and shall be applied in not less than two coats.

**AY104.3.6.3 Rain-exposed.** Clay plaster, where exposed to rain, shall be finished with an approved erosion-resistant finish.

**AY104.3.6.4 Prohibited finish coat.** Plaster containing Portland cement shall not be permitted as a finish coat over clay plasters.

**AY104.3.7 Clay-lime plaster.** Clay-lime plaster shall be composed of refined clay or clay subsoil, sand, and lime.

**AY104.3.8 Hemp-lime plaster.** Hemp-lime plaster shall be composed of hemp hurd and lime, and shall be permitted to contain sand or other aggregate, and pozzolans.

**AY104.3.9 Hemp-clay plaster.** Hemp-clay plaster shall be composed of hemp hurd and clay or clay subsoil, and shall be permitted to contain sand or other aggregate.

**AY104.4 Separation of wood and plaster.** Wood framing at the exterior surface of hemp-lime walls shall be separated from exterior plaster with Grade D paper or other approved material, except where the wood is naturally durable.

**Exception:** Exterior clay plaster shall not be required to be separated from wood.

**AY104.5 Bridging across dissimilar substrates.** Bridging shall be installed onto and across dissimilar substrates prior to the application of plaster on the interior or exterior. Acceptable bridging materials include expanded metal lath, woven wire mesh, welded wire mesh, fiberglass mesh, reed mat, burlap, or other approved material. Bridging shall extend not less than 3 inches (76 mm), on both sides of the juncture.

**AY104.5.1 Returns on recessed openings.** Plaster or other exterior finish returns at recessed windows and doors shall require an approved design that prevents the intrusion of moisture.

**AY104.6 Non-plaster exterior cladding.** Non-plaster exterior cladding shall be spaced not less than 1 inch (25 mm) from the face of the water-resistive barrier or air barrier to the back of the cladding to allow for ventilation. The ventilation space shall be open at the top and bottom and be provided with insect screening.

**AY104.6.1 Water-resistive and air barriers.** Water-resistive barriers and air barriers, when vapor permeable, are permitted to be applied directly to the hemp-lime when exterior cladding is installed in accordance with Section AY104.6.

**AY104.7 High moisture interior environments.** Exterior hemp-lime walls enclosing showers or steam rooms shall be lined on the interior side with ceramic tiles on an approved tile backer board, ceramic tiles on a lime plaster, or a tadelakt finish.

## **SECTION AY105** **FIRE RESISTANCE**

**AY105.1 Fire-resistance rating.** Hemp-lime walls do not have a fire-resistance rating. Fire-resistance ratings for hemp-lime wall assemblies shall be determined in accordance with the required testing in Section R302.9.3.

**AY105.2 Clearance to fireplaces and chimneys.** Hemp-lime surfaces adjacent to fireplaces or chimneys shall be finished with not less than 3/8 inch (10 mm) thick plaster of any type permitted by this appendix. Clearance from the face of such plaster to fireplaces and chimneys shall be maintained as required from fireplaces and chimneys to combustibles in Chapter 10, or as required by manufacturer's instructions, whichever is more restrictive.

## **SECTION AY106** **THERMAL PERFORMANCE**

**AY106.1 Mass Walls.** Walls with hemp-lime infill shall be classified as mass walls in accordance with Section N1102.2.5 (R402.2.5) and shall meet the R-value requirements for mass walls in Table N1102.1.3 (R402.1.2), when their heat capacity (C) is greater than or equal to 6 Btu/ft<sup>2</sup> × °F (123 kJ/m<sup>2</sup> × K) in Equation AY-1.

$$C = \rho \times t \times 0.299 \text{ Btu/lb} \times \text{°F}$$

**(Equation AY-1)**

where:

C = Heat capacity (Btu/ft<sup>2</sup> × °F).

ρ = Density of hemp-lime infill (pounds per cubic foot).

t = Thickness of hemp-lime infill (in feet).

**AY106.2 Thermal resistance.** Hemp-lime has the unit thermal resistance values in accordance with Table AY106.2. Alternatively, the unit R-value of hemp-lime shall be determined with one of the following tests by an approved laboratory: ASTM C518, ASTM C1363, ASTM C177, or ASTM C1114. Test results from a specific hemp-lime mix shall be permitted to be used for multiple projects.

**Table AY106.2 Thermal Resistance of Hemp-Lime<sup>a</sup>**

<b>Density (pounds per cu.ft.)</b>	<b>R-value (ft<sup>2</sup>·°F·h/BTU per inch of thickness)</b>
<u>12.5</u>	<u>R-2.10</u>
<u>15</u>	<u>R-1.86</u>
<u>20</u>	<u>R-1.54</u>
<u>25</u>	<u>R-1.20</u>

a. Linear interpolation is permitted. Extrapolation is not permitted.

**AY106.3 Density measurement.** Hemp-lime density shall be measured based on *approved* test samples as follows:

1. Three samples of the proposed hemp-lime 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, a 6 inch (152mm) diameter x 12 inch (305 mm) length form or other *approved* form, following the application method and procedure that will be used during construction.
2. Samples shall be removed from the forms within 24 hours after hemp-lime placement or per the *binder* manufacturer's specifications.
3. Samples shall be cured/dried for a minimum of 14 days in indoor ambient conditions before density determination.
4. Density shall be determined by Equation AY-2.

$$\rho = w / V$$

**(Equation AY-2)**

where:

$\rho$  = Density of hemp-lime infill (pounds per cubic foot).

w = Weight of hemp-lime infill sample (pounds).

V = Volume of hemp-lime sample (in cubic feet).

**AY106.4 Compliance with Section R302.10.1.** Hemp-lime *infill* meet the requirements for insulation materials in Section R302.10.1 for flame spread index and smoke-developed index as tested in accordance with ASTM E84.

## **SECTION AY107** **MECHANICAL PERFORMANCE**

**AY107.1 Hemp-lime infill integrity.** The integrity of hemp-lime *infill* and its ability to hold a plaster finish shall be demonstrated with a minimum compressive strength of 29 psi (0.2 MPa). Test results from a specific hemp-lime mix shall be permitted to be used for multiple projects.

**AY107.1.1 Demonstration of compressive strength.** The compressive strength of the hemp-lime mix shall be demonstrated to the building official before the placement of hemp-lime infill, with compressive strength tests and an associated report by an *approved* laboratory tested as follows:

1. Three samples of the proposed hemp-lime 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, a 6 inch (152mm) diameter x 12 inch (305 mm) length form, or other *approved* form, following the application method and procedure that will be used during construction.
2. Samples shall be removed from the forms within 24 hours after hemp-lime placement or per the *binder* manufacturer's specifications.
3. Samples shall be cured/dried for a minimum of 14 days in indoor ambient conditions before testing.
4. The opposite faces shall be capped with plaster of paris to achieve smooth and parallel faces, after which the sample shall reach ambient moisture conditions before testing.
5. 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.
6. The average value of the samples shall be used to determine the mix's compressive strength.

## **SECTION AY108** **REFERENCED STANDARDS**

**AY108.1 General.** See Table AY108.1 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 this standard.

**TABLE AY108.1 REFERENCED STANDARDS**

<b>STANDARD ACRONYM</b>	<b>STANDARD NAME</b>	<b>SECTIONS HEREIN REFERENCED</b>
ASTM E96-00	<i>Standard Test Methods for Water Vapor Transmission of Materials</i>	AY104.1
ASTM C5-10	<i>Standard Specification for Quicklime for Structural Purposes</i>	AY104.3.5
ASTM C141/C141M-14	<i>Standard Specification for Hydrated Hydraulic Lime for Structural Purposes</i>	AY104.3.5
ASTM C206-14	<i>Standard Specification for Finishing Hydrated Lime</i>	AY104.3.5
ASTM C1707-11	<i>Standard Specification for Pozzolanic Hydraulic Lime for Structural Purposes</i>	AY104.3.5
ASTM E2392/ ASTM E2392M-10	<i>Standard Guide for Design of Earth Wall Building Systems</i>	AY104.3.6.1
CEN EN 459-2015	<i>Part 1: Building Lime. Definitions, Specifications and Conformity Criteria; Part 2: Test Methods</i>	AY104.3.5
ASTM C518-21	<i>Transmission Properties by Means of the Heat Flow Meter Apparatus</i>	AY106.2
ASTM C1363-19	<i>Standard Test Method for Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box Apparatus</i>	AY106.2
ASTM C177-19	<i>Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus</i>	AY106.2
ASTM C1114-06(2019)	<i>Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Thin-Heater Apparatus</i>	AY106.2
ASTM E84-21a	<i>Standard Test Method for Surface Burning Characteristics of Building Materials</i>	AY106.4

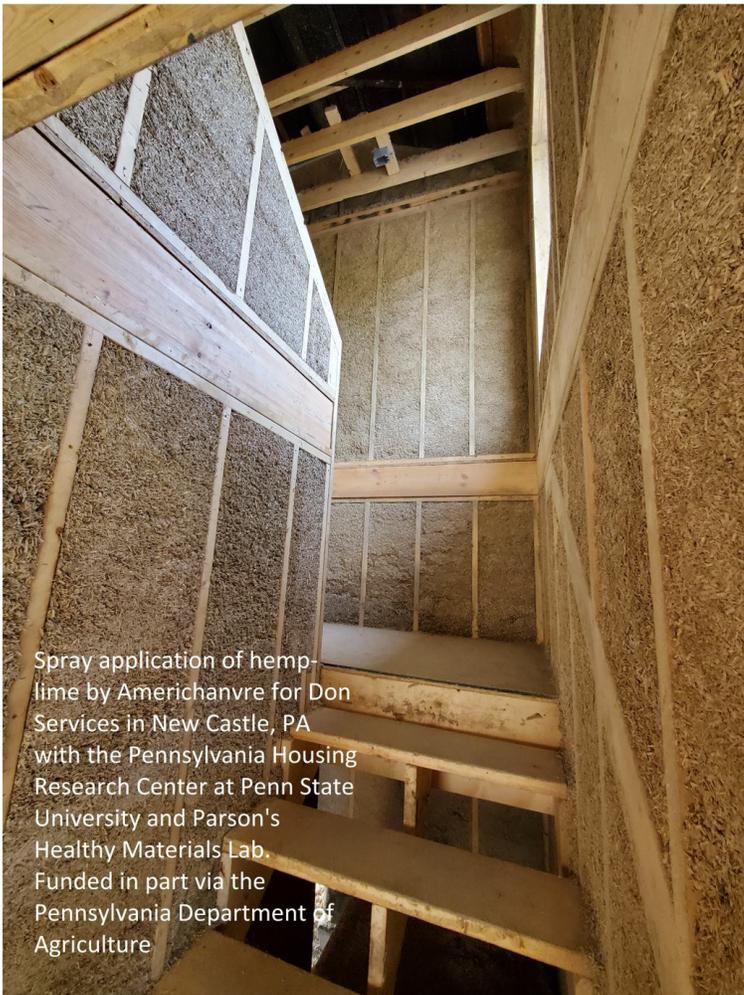
**Reason:** Hemp-lime, commonly referred to as hempcrete, is a non-structural, bio-composite insulation infill material composed of hemp hurd and a lime-based binder. Hemp-lime originated in the mid-1980s in France as a method for renovating historic buildings that required the addition of insulation with sufficient vapor permeability to preserve the structure's integrity. Since then, hemp-lime has been utilized and studied around the world, with its viability demonstrated in thousands of single-family homes, multi-family housing and commercial buildings. The benefits of hemp-lime include high thermal performance, low embodied carbon emissions in production, high carbon sequestration in service, healthy living environments, and high fire-resistance. These benefits, along with the 2018 U.S. legalization of hemp as a commercial crop, are driving rapid growth in interest and projects across the U.S. Hemp-lime provisions in the building code are greatly needed to remove obstacles to its safe and proper use.



Coastal Compound photo courtesy of Tim Callhan



**Triangle Housing Project source image**



New Castle stairs photo courtesy of Cameron McIntosh

Examples of hemp-lime homes have existed in the U.S. for over a decade, but not until industrial hemp became legal to grow via the Agricultural

Improvement Act of 2018 was there the potential for a U.S. hemp-lime industry. This emerging industry requires the development and availability of regulations in order to expand in a safe and controlled manner. The proposed Hemp-lime (Hempcrete) Construction appendix for the IRC is an important step in this process. This document has been reviewed and has received input from over 25 hemp-lime design and building professionals in the US and around the world, as well as experts in ICC code development.

Hemp-lime modulates interior temperature and humidity, creating a comfortable living environment with its low thermal conductivity, thermal mass, and dynamic hygrothermal effects. Hemp-lime's excellent thermal performance reduces energy use, lowering utility bills while broadly benefiting the environment.

Current construction methods often rely on vapor-closed building envelopes that can promote mold and mildew growth, which reduces interior air quality. Hemp-lime offers a non-toxic insulation option that resists or prevents mold growth. Hemp-lime buildings allow the free passage of water vapor through the exterior walls without creating a point where it becomes trapped to condense. As the binder for hemp-lime is composed primarily of lime, the entire wall system resists mold and mildew growth due to the alkalinity of the lime. This is a major benefit to occupants sensitive to such toxins, as well as others who want to minimize their exposure to mold.

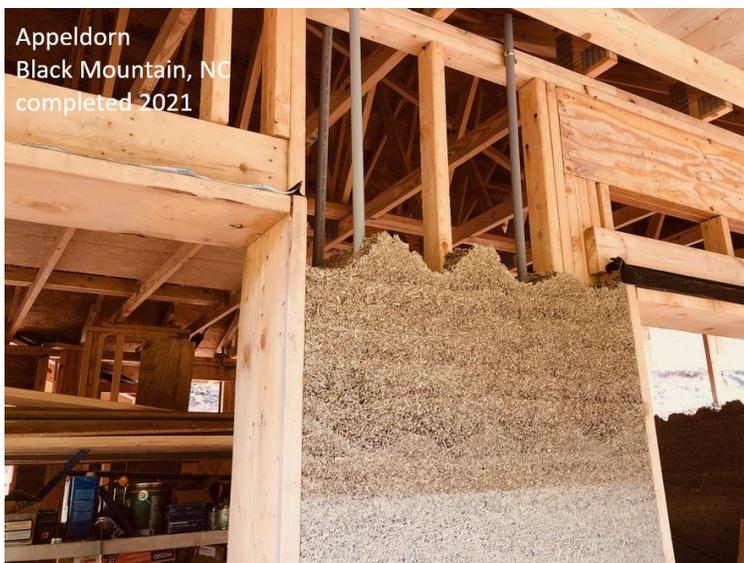
Hemp-lime walls provide a high level of fire resistance because the lime encapsulates the hemp in the matrix. Hemp-lime does not emit smoke or ignite when exposed to direct flame, as demonstrated by European fire tests and an ASTM E84 test where hemp-lime recorded the lowest possible index for flame spread and smoke development.

Though this proposal does not seek a fire-resistance rating, the U.S. hemp industry is planning to conduct an ASTM E119 test to establish a rating for hemp-lime wall assemblies.

The U.S. government has made lowering its carbon footprint a priority as it tries to meet its global environmental commitments. The building industry accounts for up to 40% of the world's carbon footprint, including both the embodied carbon of materials and the operational impact of buildings. Hemp-lime construction can have an enormous impact with its negative embodied carbon and its high thermal performance that reduces energy use. Industrial-scale hemp crops absorb significant quantities of carbon from the atmosphere, and when used in hemp-lime, its carbon is sequestered for the life of the building. Hydrated lime in the binder also absorbs carbon dioxide as it cures. This presents a major reversal in impact compared with some carbon intensive materials currently used in the building industry.

Supporting documents for the proposed Hemp-lime (Hempcrete) Construction appendix are available at:

<https://ushba.org/icc-supporting-documents/>



Appeldorn photo courtesy of Tim Callahan



Spray application of hemp-lime

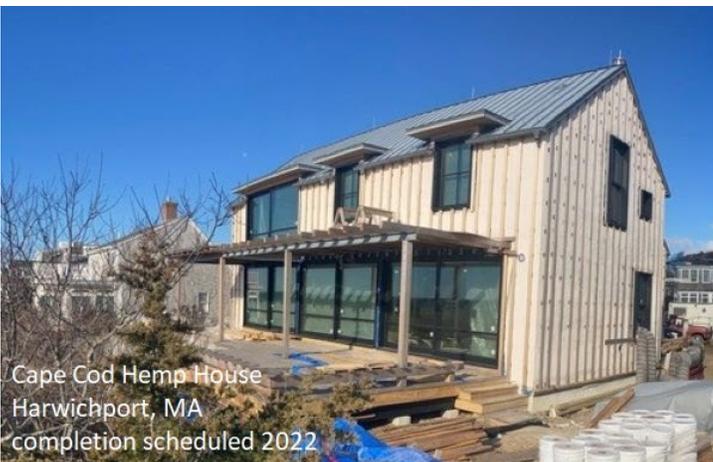
Installation of precast  
hemp-lime blocks

Cape Cod Hemp House photo courtesy of Mpacful Ventures, PBLLC=



Hand casting  
hemp-lime  
onto  
prefabricated  
hemp-lime  
blocks, 2021

Hand Casting photo courtesy of Graham Durrant



Cape Cod Hemp House  
Harwichport, MA  
completion scheduled 2022

CCHH photo courtesy of Mpacful Ventures

## Rationale for Specific Sections of Proposed Appendix Y – Hemp-Lime (Hempcrete) Construction

### SECTION AY101 - GENERAL:

Hemp-lime is limited to use as a nonbearing, wall infill material. It primarily functions as insulation and a substrate for finish. Until further seismic testing is done, hemp-lime construction is restricted to use in Seismic Design Categories (SDCs) A, B, and C, except with an approved engineered design. Engineering analysis based on structural and materials tests and accepted engineering practice have determined hemp-lime's safe prescriptive use in SDCs A, B, and C, within the limits of the IRC's structural provisions and this appendix. Testing reports, structural analysis, and other supporting documents are available at: <https://ushba.org/icc-supporting-documents/>

### SECTION AY102 - DEFINITIONS:

Hemp-lime specific terms not found in the IRC are defined. Some definitions are consistent with identical or related terms defined in IRC appendices AR – Light Straw-Clay Construction, AS - Strawbale Construction, and AU - Cob Construction.

### SECTION AY103 - HEMP-LIME CONSTRUCTION:

Hemp-lime as a non-structural infill must comply with the Figures in Section AY103 or an approved alternative. The four Figures show different locations of the structural stud wall framing; interior, center, exterior, or double (interior and exterior). These Figures indicate the IRC sections that the foundation, wall framing, floor, and roof/ceiling assembly must comply with, unless otherwise stated in the appendix. They also identify code sections for other elements of a hemp-lime wall. Hemp-lime infill is limited to densities within a range of 12.5 to 25 pcf. This range encompasses the practical and commonly used hemp-lime densities.

The description and requirements of hemp-lime materials in this appendix are based on ASTM standards currently under development, and on input from hemp-lime building professionals and researchers. The binder is restricted to lime based binders because of their well established performance. Most importantly, all materials used in hemp-lime projects must match the materials used in the approved density and integrity test samples required in Sections AY106.3 and AY107.1.

Section AY103.3 contains provisions related to structure. General limits and requirements are given for all hemp-lime buildings, including: 1) maximum one story; 2) maximum building height of 25 feet; 3) braced wall panel lengths, and 4) maximum unit wall weight. Bracing is restricted to the IRC's Method LIB due to the low vapor permeability of braced wall panel sheathing options in the IRC. Structural metal, and all metal in contact with hemp-lime, must be stainless steel or coated to prevent corrosion. Door and window openings are addressed, including the support of hemp-lime by headers with required adjustments. Anchorage rails must be fastened to studs for interior or exterior wall designs, to anchor the hemp-lime to resist out-of-plane forces. Anchorage rails are not required for center and double wall designs, because those stud locations provide sufficient out-of-plane resistance by containment (double wall) or anchoring the hemp-lime in both directions (center wall).

The required minimum spacing between studs is to allow sufficient space to insert the hemp-lime. The required minimum thickness of hemp-lime is to ensure a cohesive infill. Window and door openings must be designed and constructed to prevent water intrusion.

Hemp-lime infill can be installed by hand casting or spray applying on site, or by precasting blocks or panels. Mixing of the material must allow the binder to coat the hemp hurd and to hydrate. Formwork must be vapor permeable or removed within 24 hours to allow the hemp-lime to dry. Hand cast hemp-lime infill must be installed in lifts of no more than 4" to allow a uniform density consistent with approved samples. Spray applied hemp-lime must be installed per the manufacturer's directions for the spray equipment.

Precast blocks and panels are a developing market with great potential. They can be cast by hand, spray equipment, or mechanical means, and can provide highly consistent materials that can be installed ready to be finished. Lined applications provide an easy way to use hemp-lime infill to increase the performance of existing homes. Lined applications must not be used in areas with high moisture content. The appropriateness of hemp-lime lined applications must be evaluated and designed by a registered design professional before use below grade.

Though lime is excellent at inhibiting mold growth and preserving the hemp and wood framing, hemp-lime requires vapor permeable finishes and protection from water intrusion. Water-resistive barriers and vapor retarders are generally prohibited because they interfere with the required vapor permeability and the mechanical bond of plaster. They are allowed only where necessary to prevent water intrusion, for example at horizontal surfaces such as window sills. Interior and exterior air barriers, typically plaster, are essential for optimal thermal performance of hemp-lime walls and to satisfy IRC Section N11024.1.1. Adequate distance between hemp-lime infill and its plaster and the exterior grade is required to protect against water intrusion.

### SECTION AY104 - FINISHES:

Hemp-lime infill requires vapor permeable finishes on the interior and exterior of the wall. The finish is necessary to create an air barrier and the high vapor permeability is required to allow vapor to move through the wall. As with many other building materials, hemp-lime infill must be sufficiently dry

before finishes are applied.

Hemp-lime is most commonly finished with plaster. Plaster is best applied directly to the hemp-lime infill.

Membranes must not be applied between the hemp-lime infill and plaster to ensure adequate vapor permeability and a mechanical bond for plaster. Other lath or mesh is not required. Plaster additives are allowed if they do not reduce vapor permeability below the required minimum of 5 perms (the IRC definition of vapor permeable). Reinforcing fibers are allowed to strengthen the plaster. Lime plaster is the most common plaster used on hemp-lime, because of its high vapor permeability and compatibility with the hemp-lime substrate. Clay plaster, with its even higher vapor permeability, is also acceptable for hemp-lime. Exterior clay plaster must be protected with a more durable material. Clay-lime and hemp-lime plasters have also been successfully used on hemp-lime.

When wood members are on the surface of the wall where plaster is to be applied, it is necessary to cover the wood with a water-resistive barrier unless the wood is otherwise protected from water. Exterior clay plaster can be in direct contact with wood, because clay's hygroscopic properties protect wood from moisture damage.

Where plaster is to be applied to hemp-lime adjacent to another material, a bridging material is required to reinforce the plaster. The bridging material strengthens the plaster, improves bonding, and prevents cracking. Recessed window and door openings in hemp-lime infill must be designed to prevent water intrusion.

Non-plaster exterior cladding can be used over hemp-lime infill. The hemp-lime must be covered with a vapor permeable air barrier such as lime plaster, and an air gap must be provided between the hemp-lime wall and the exterior cladding that is vented to allow air movement. The exterior cladding can have a water-resistive barrier behind it.

In high moisture conditions, such as showers or steam rooms, a water-resistant finish must be applied on the interior side of exterior hemp-lime walls.

#### SECTION AY105 - FIRE RESISTANCE:

Hemp-lime is known for its fire-resistive properties through tests in Europe. When structural members are surrounded by hemp-lime infill, it can protect them from fire. However because ASTM E119 or UL263 tests have not yet been performed, a fire-resistance rating is not included in this proposal.

#### SECTION AY106 - THERMAL PERFORMANCE:

Hemp-lime walls provide well-balanced thermal performance, with a combination of low thermal conductivity, thermal mass, and hygrothermal effects. Hemp-lime walls in this appendix are classified as mass walls per Section N1102.2.5, if their heat capacity is greater than 6 Btu/ft<sup>2</sup> x °F. An Equation is given to calculate a mix's heat capacity. Hemp-lime infill's density is a determining factor of its R-value. The lower the density, the higher the R-value per inch. The relationship of density to unit R-value in Table AY106.2 was determined from a thorough review of research and testing.

In order to determine the density of the hemp-lime infill, samples are made from the materials to be used to construct the hemp-lime infill and tested following a specified procedure representative of the planned installation method. A hemp-lime ASTM E84 test conducted in 2020 yielded the lowest possible values, thus easily meeting the IRC requirements in R302.10.1 for flame spread index and smoke-developed index for insulating materials in wall assemblies.

#### SECTION AY107 - MECHANICAL PERFORMANCE:

Though hemp-lime infill is not structural, it must be capable of bearing its own weight and maintaining its integrity for the lifetime of the wall. To determine the integrity of the hemp-lime infill, a compression test must be performed on a representative sample made with the materials to be used to construct the hemp-lime infill, created using a procedure representative of the planned installation method.

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Tradical (2018) Tradical Hempcretes [Brochure] <https://www.bcb-tradical.com/wp-content/uploads/2018/02/Tradical-Hempcrete-brochure.pdf>

**Cost Impact:** The code change proposal will not increase or decrease the cost of construction

As a wall system, hemp-lime construction can be more costly or less costly than conventional wall systems in the IRC, depending on many variables. Hemp is inexpensive, some lime binders are of modest expense while some proprietary lime binders are expensive. Installing hemp-lime is labor intensive, but in one installation it provides insulation, thermal mass, and a substrate for finish.

Clay plasters use the inexpensive materials of clay subsoil (often from the site) and sand. The lime binder in lime plasters is more costly than clay subsoil, as well as the Portland cement binder used in conventional cement plaster. Clay, lime, and cement plasters all require a similar amount of labor. However unlike cement plaster over wood-frame walls, clay and lime plasters applied to hemp-lime infill do not require wire lath or a water-resistive barrier.

Other elements or systems in a hemp-lime building such as the foundation, roof/ceiling, electrical, plumbing and mechanical are typically similar to those used in conventional construction and therefore of similar cost.

On average, this proposal will not affect the cost of construction.

**Staff Analysis:** The following standards are already referenced in the IBC:

- CEN/EN 459-2015 Part 1: Building Lime. Definitions, Specifications and Conformity Criteria; Part 2: Test Methods
- ASTM C141/C141M-14 Standard Specification for Hydrated Hydraulic Lime for Structural Purposes
- ASTM C206-14 Standard Specification for Finishing Hydrated Lime
- ASTM E2392/E2392M-10 Standard Guide for Design of Earthen Wall Building Systems.

Also, the following are also referenced in the current codes but under newer versions. These are simply new occurrences of the references in the I-Codes.

- ASTM E96-00 Standard Test Methods for Water Vapor Transmission of Materials
- ASTM C5-10 Standard Specification for Quicklime for Structural Purposes
- ASTM C1707-11 Standard Specification for Pozzolanic Hydraulic Lime for Structural Purposes

A review of the following standards proposed for inclusion in the code, and , with regard to some of the key ICC criteria for referenced standards (Section 3.6 of CP#28) will be posted on the ICC website on or before March 16, 2022.

- ASTM C518-21 Transmission Properties by Means of the Heat Flow Meter Apparatus
- ASTM 1363-19 Standard Test Method for Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box Apparatus
- ASTM C177-19 Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus
- ASTM C1114-06(2019) Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Thin-Heater Apparatus,

The proposal is referencing an updated version of an existing referenced standard . Therefore the updated version is considered an new standard. A review of the standard proposed for inclusion in the code, with regard to some of the key ICC criteria for referenced standards (Section 3.6 of CP#28) will be posted on the ICC website on or before March 16, 2022.

- ASTM E84-21a Standard Test Method for Surface Burning Characteristics of Building Materials,