Strawbale Provisions in the IRC

Crestone Energy Fair, September 12, 2025

Presented by: Jeremy Wells, PE | jeremy@wellsengineering.net

1

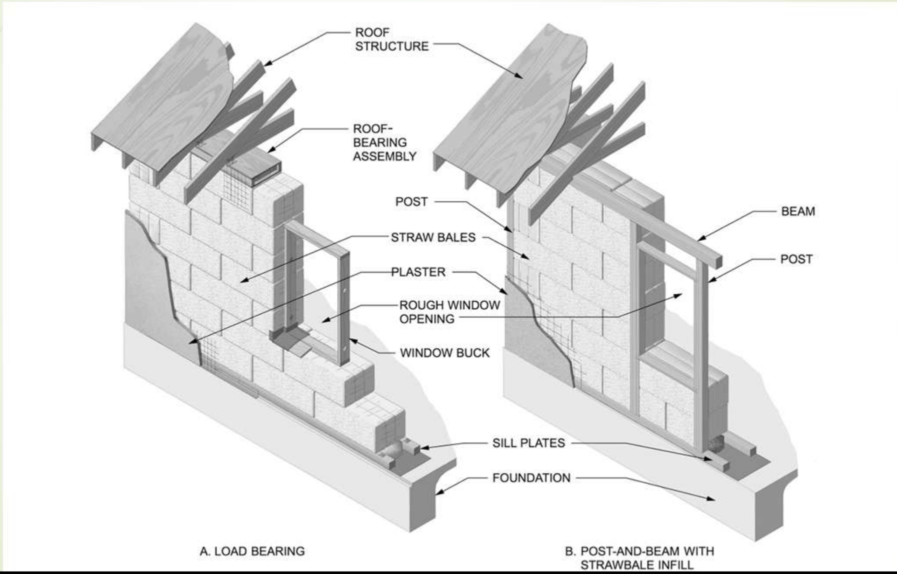
What's the IRC and when was Straw Bale Construction added?

"International Residential Code"

- **"Cookbook" for building safe houses,** *new version every 3 years.*
- *Before* **Straw bale provisions** *were added to the IRC, building officials often required testing to show the structure would meet code requirements.*
- **1995-96**: *First straw bale construction codes adopted in* **Arizona** *(written by Matts Myhrman and David Eisenberg),* **New Mexico, and California**.
- **Late 1990s–2000s**: *More jurisdictions in Oregon, Colorado, Texas, Nevada, Nebraska, and North Carolina began adopting straw bale-specific provisions.*
- **2015**: **Appendix S: Strawbale Construction** *included in the* **IRC,** *written by Architect Martin Hammer and others.*
- **2021:** *Changed to IRC Appendix AS.*
- **2024:** *Changed to IRC Appendix BJ.*

2

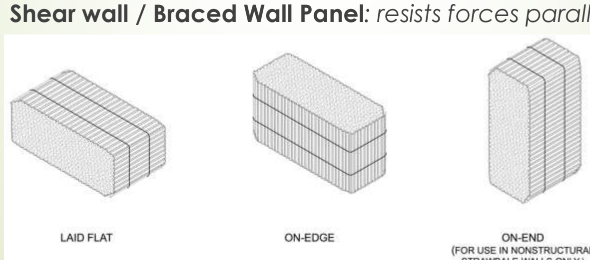
AS101: Wall System Types



3

AS102: Definitions

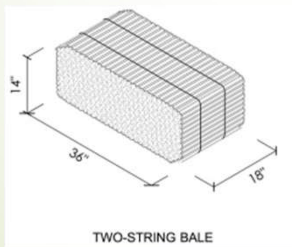
- **Bale**: *Compressed block of straw bound by* **ties**
- **Clay**: *Soil with extremely small particle size, high strength when dry*
- **Load-bearing wall**: *Supports >100 lbs/linear foot*
- **Mesh**: *Metal, plastic, or fiber fabric used for reinforcement of plaster*
- **Pin**: *Vertical metal or wooden rod in center or each face of bales*
- **Precompression**: *Vertical compression of bales prior to plastering*
- **Running Bond**: *joints in successive courses offset (like in a brick wall)*
- **Shear wall / Braced Wall Panel**: *resists forces parallel to the plane of the wall*



4

AS103: Bales

- **Typical Size**: *14"x18"x36" for two-string bale (minimum 12" per code).*
- **Moisture content**: *≤20% at time of plastering.*
- **Dry density**: *≥6.5 lbs/ft³.*
- **Straw types**: *dry stems of cereal grains such as wheat, rye, barley, or oat after the seed heads have been removed.*



5

AS104: Plaster

- **Purpose**: *Structural strength, fire resistance, weather protection, air restriction, transpiration of moisture from bales.*
- **Plaster types**: *Clay, soil-cement, lime, cement-lime, gypsum (interior only).*
  - *Suitability of clay subsoil determined by ribbon test or ball test (ASTM E2392)*
  - *Rain-exposed clay plaster must be finished with lime wash or linseed oil*
  - *Clay plaster cannot have a cement finish coat*
  - *Soil-cement must contain clay and between 10% and 20% cement*
  - *Straight cement not allowed, must be at least 1 part lime to 4 parts cement*
- **Thickness**: *typically 1" to 1-1/2" (2" max), applied in 3 coats.*

6

AS105: Walls
Wall height limitations

TABLE AS105.4OUT-OF-PLANE RESISTANCE METHODS AND UNRESTRAINED WALL DIMENSION LIMITS

METHOD OF OUT-OF-PLANE LOAD RESISTANCE[a]	FOR ULTIMATE DESIGN WIND SPEEDS (mph)	FOR SEISMIC DESIGN CATEGORIES	UNRESTRAINED WALL DIMENSIONS, H[b]		MESH STAPLE SPACINGAT BOUNDARY RESTRAINTS
			Absolute limit in feet	Limit based on bale thickness T[c] in feet (mm)	
Nonplaster finish or unreinforced plaster	≤ 130	A, B, C, D_0	$H \le 8$	$H \le 5T$	None required
Pins per Section AS105.4.2	≤ 130	A, B, C, D_0	$H \le 12$	$H \le 8T$	None required
Pins per Section AS105.4.2	≤ 140	A, B, C, D_0, D_1, D_2	$H \le 10$	$H \le 7T$	None required
Reinforced[d] clay plaster	≤ 140	A, B, C, D_0, D_1, D_2	$H \le 10$	$H \le 8T^{0.5}$ ($H \le 140T^{0.5}$)	≤ 6 inches
Reinforced[d] clay plaster	≤ 140	A, B, C, D_0, D_1, D_2	$10 < H \le 12$	$H \le 8T^{0.5}$ ($H \le 140T^{0.5}$)	≤ 4 inches[e]
Reinforced[d] cement, cement-lime, lime or soil-cement plaster	≤ 140	A, B, C, D_0, D_1, D_2	$H \le 10$	$H \le 9T^{0.5}$ ($H \le 157T^{0.5}$)	≤ 6 inches

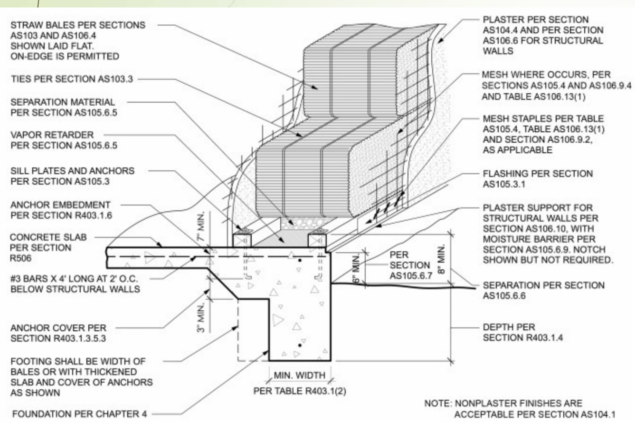
7

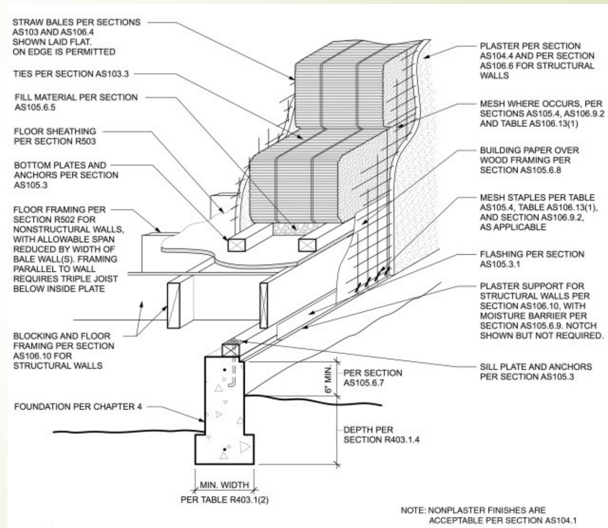
AS105: Walls
General requirements

- **Sill plates** *required at each face*
  - *Raises bales off foundation, reducing potential moisture intrusion*
  - *Provides means of fastening mesh to transfer loads to/from foundation*
- **Pins** *can be used to increase allowable wall height*
  - *must be ½-inch-diameter steel or bamboo, or ¾-inch-diameter wood*
  - *24-inch spacing*
  - *Internal pins must be full height, continuous or overlap by one bale course*
  - *External pins must be tied together every 32 inches and within 8 inches of ends*
- *Water-resistant barriers used only on horizontal surfaces and to separate bales from concrete foundation*

8

AS105: Walls, *Details*





9

AS106: Structural walls
General requirements

- *Loads must be transferred directly from roof to plaster skins, and plaster skins must be continuously supported along bottom edge*
- *2x6 and plywood "box beam" used along top of strawbale wall*
- **Precompression***: Vertical compression of 100 lb/LF before finishing.*
- **Braced wall panels***: Must resist lateral forces per AS106.13.*

10

AS106: Structural walls
Plaster strength

AS106.6.1 Compressive strength.

For plaster on *strawbale* structural walls, the *building official* is authorized to require a 2-inch (51mm) cube test conforming to ASTM C109 to demonstrate a minimum compressive strength in accordance with Table AS106.6.1.

TABLE AS106.6.1MINIMUM COMPRESSIVE STRENGTH FOR PLASTERS ON STRUCTURAL WALLS

PLASTER TYPE	MINIMUM COMPRESSIVE STRENGTH (psi)
Clay	100
Soil-cement	1,000
Lime	600
Cement-lime	1,000

11

AS106: Structural walls
Allowable vertical loads

TABLE AS106.12
ALLOWABLE SUPERIMPOSED VERTICAL LOADS (LBS/FOOT) FOR PLASTERED LOAD-BEARING STRAWBALE WALLS

WALL DESIGNATION	PLASTER[a] (both sides) Minimum thickness in inches each side	MESH[b]	STAPLES[c]	ALLOWABLE BEARING CAPACITY[d] (plf)
A	Clay $1^1/_2$	None required	None required	400
B	Soil-cement 1	Required	Required	800
C	Lime[e] $^7/_8$	Required	Required	500
D	Cement-lime $^7/_8$	Required	Required	800

12

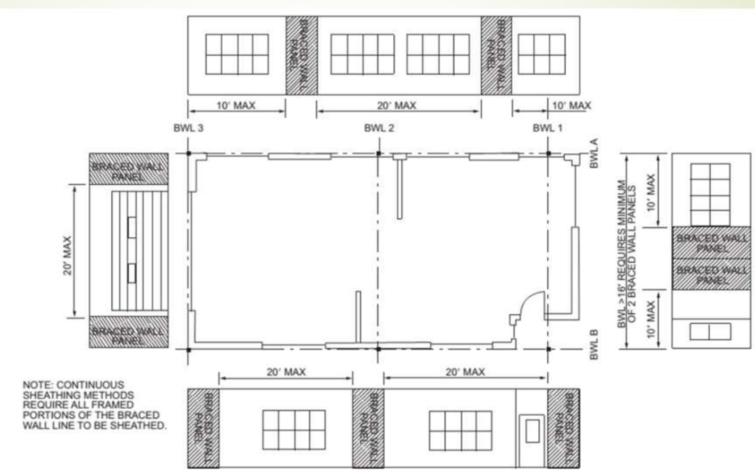
AS106: Structural walls
Braced wall panel types

TABLE AS106.13(1)PLASTERED STRAWBALE BRACED WALL PANEL TYPES

WALL DESIGNATION	PLASTER[a] (both sides)		SILL PLATES[b] (nominal size ininches)	ANCHOR BOLT[c] SPACING (inches on center)	MESH[d] (inches)	STAPLE SPACING[e] (inches on center)
	Type	Thickness (minimum in inches each side)				
A1	Clay	1.5	2 × 4	32	None	None
A2	Clay	1.5	2 × 4	32	2 × 2 high-density polypropylene	2
A3	Clay	1.5	2 × 4	32	2 × 2 × 14 gage	4
B	Soil-cement	1	4 × 4	24	2 × 2 × 14 gage	2
C1	Lime[f]	7/8	2 × 4	32	17-gage woven wire	3
C2	Lime[f]	7/8	4 × 4	24	2 × 2 × 14 gage	2
D1	Cement-lime	7/8	4 × 4	32	17-gage woven wire	2
D2	Cement-lime	7/8	4 × 4	24	2 × 2 × 14 gage	2

13

AS106: Structural walls
Braced wall panel location



For SI: 1 foot = 304.8 mm.

FIGURE R602.10.2.2 LOCATION OF BRACED WALL PANELS

14

AS106: Structural walls, *Braced wall panels*

TABLE AS106.13(2)BRACING REQUIREMENTS FOR STRAWBALE-BRACED WALL PANELS BASED ON WIND SPEED

• EXPOSURE CATEGORY B[d] • 25-FOOT MEAN ROOF HEIGHT • 10-FOOT EAVE-TO-RIDGE HEIGHT[d] • 10-FOOT WALL HEIGHT[d] • 2 BRACED WALL LINES[d]			MINIMUM TOTAL LENGTH (FEET) OF STRAWBALE BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE[a, b, c, d]		
Ultimate design wind speed (mph)	Story location	Braced wall line spacing (feet)	Strawbale-braced wall panel[e] A2, A3	Strawbale-braced wall panel[e] C1, C2, D1	Strawbale-braced wall panel[e] B, D2, E1, E2
≤ 110	One-story building	10	6.4	3.8	3.0
		20	8.5	5.1	4.0
		30	10.2	6.1	4.8
		40	13.3	6.9	5.5
		50	16.3	7.7	6.1
		60	19.4	8.3	6.6
≤ 115	One-story building	10	6.4	3.8	3.0
		20	8.5	5.1	4.0
		30	11.2	6.4	5.1
		40	14.3	7.2	5.7
		50	18.4	8.1	6.5
		60	21.4	8.8	7.0
≤ 120	One-story building	10	7.1	4.3	3.4
		20	9.0	5.4	4.3
		30	12.2	6.6	5.3
		40	16.3	7.7	6.1
		50	19.4	8.3	6.6
		60	23.5	9.2	7.3

15

AS106: Structural walls
Mesh reinforcement is required in plaster…

- *When wall height is taller than ~7.5 feet, unless pins are used*
- *When wall is load-bearing and vertical loads is more than 400 lb/LF*
- *In the portions of walls that are counted as braced wall panels.*

16

AS107: Fire Resistance
AS108: Thermal Insulation

- *1-inch thick clay plaster on 18-inch thick bales with 7.5 lb/ft3 density laid in a running bond qualifies as a one-hour fire rated wall*
- *R-value of 1.55 / inch for bales laid flat (R=28 for 18" bale thickness)*
- *R-value of 1.85 / inch for bales laid on-edge (R=26 for 14" thickness)*

17

Resources

- *Appendix S: Strawbale Construction, in 2018 International Residential Code (IRC), International Code Council (ICC).*
- *Appendix AS: Strawbale Construction, in 2021 IRC,* **free download** *at: https://www.strawbuilding.org/Cart, courtesy of CASBA.*
- *"Strawbale Construction and Its Evolution in Building Codes" by David Eisenberg and Martin Hammer.*
  Accessed at https://www.strawbuilding.org/building-code-evolution
- *Straw Bale Details: A Manual for Designers and Builders, 2001 by Chris Magwood and Chris Walker.*

18