Testing and Codification of Firestorm- and Climate-Safe Monolithic Adobe Walls (Cob)

Oasis Design, The Cob Research Institute, &
Verdant Structural Engineers

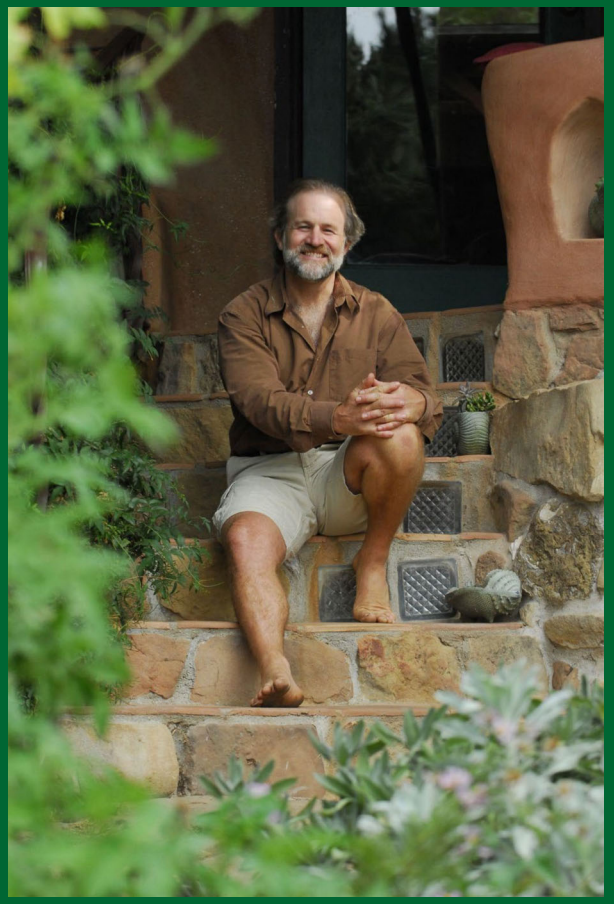
Green Engineering is Good Engineering.

Wildfire Resilie t Structures (WiReS) Conference and Tradeshow
February 8th, 2023 • San Diego, CA

Art Ludwig

Oasis Design

oasisdesign.net



Verdant Structural Engineers

Over 200 Custom Natural Building Projects

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Over 200 Custom Natural Building Projects







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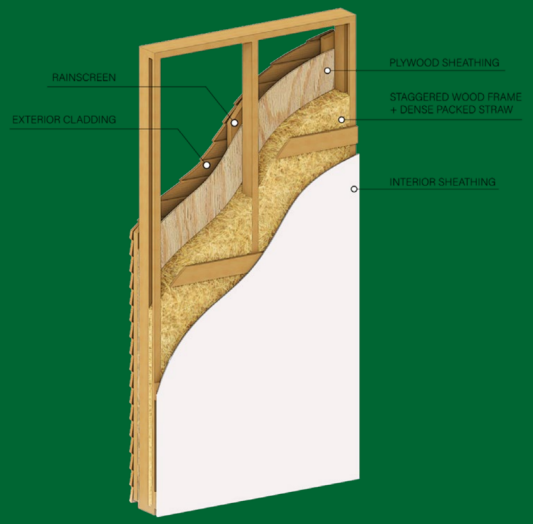
Over 200 Custom Natural Building Projects







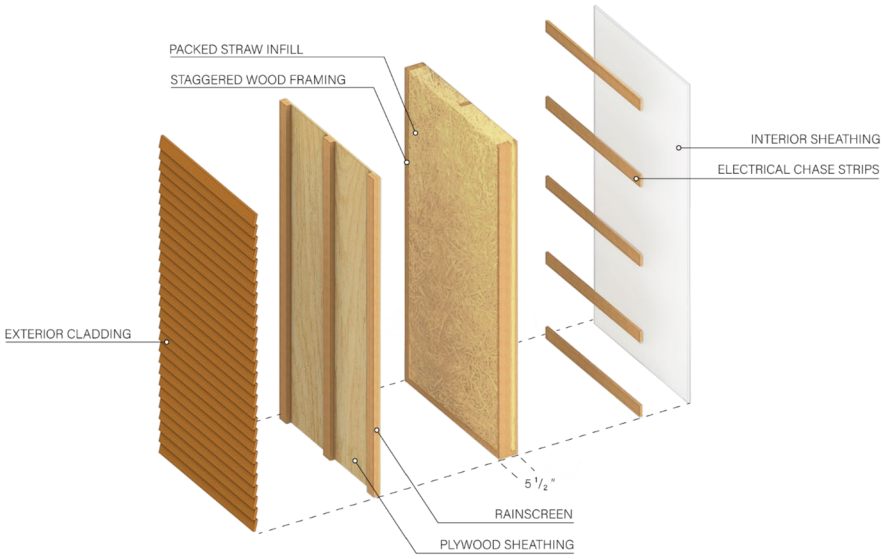


Verdant Building Products

Prefabricated Straw Panel System

VerdantPanel.com

- Panelized Wall Units
- Carbon Storing
- Non-Toxic Materials
- Less waste
- Circular economy
- Biobased: agricultural waste
- Strong Insulator



VERDANT PANEL

EPA SBIR
AMERICA'S SEED FUND FOR
ENVIRONMENTAL INNOVATION

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Cob/Monolithic Adobe

Testing

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Testing & Complications

- **Seismic/Wind, Thermal & Small Scale Testing**
  - **Take the builders & material to the lab or the lab to the builders and materials**

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Testing & Complications

- **Seismic/Wind, Thermal & Small Scale Testing**
  - **Take the builders & material to the lab or the lab to the builders and materials**

Figure 1: Mass Wall Density vs R-Value

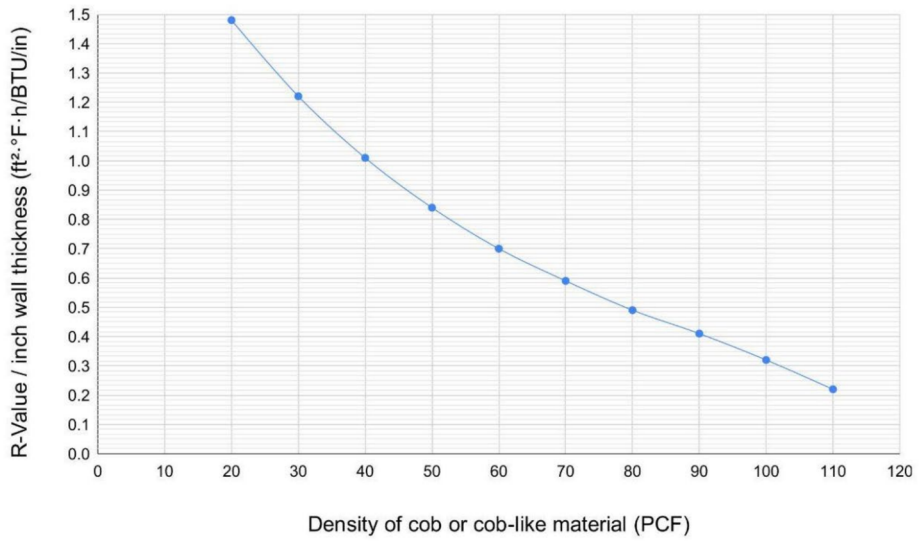

Table 1: R-Value of Mass Earthen Wall[1] per inch of wall thickness[2]

Wall Material	Density (PCF)	R - Value / inch wall thickness (ft²·°F·h/BTU/in)[4]
Light Straw Clay	20	1.48
Light Straw Clay	30	1.22
Light Straw Clay	40	1.01
Light Straw Clay	50	0.84
Cob[3]	60	*0.70*
Cob[3]	70	*0.59*
Cob[3]	80	*0.49*
Cob[3]	90	*0.41*
Cob[3]	100	*0.32*
Cob	110	0.22

[1] Chart values apply to mass walls, defined as walls with a density ≥ 20 PCF

[2] This chart assumes the insulation material is on the exterior of a mass wall.

[3] The R-Values for cob with densities from 60 to 100 has been interpolated from Appendix AU in the 2024 IRC with a cubic fit curve

[4] R-Value data is from Section AU109.2 of Appendix AU in the 2024 IRC and Table AR103.2.3 of Appendix AR in the 2024 IRC

BUILDING CODES

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Adobe In the IBC

SECTION 2109
EMPIRICAL DESIGN OF ADOBE MASONRY

2109.1 General. Empirically designed adobe masonry shall conform to the requirements of Appendix A of TMS 402, except where otherwise noted in this section.

- **International Building Code, Section 2109**
  - **TMS Appendix A is being removed**
  - **TMS Committee for new code has been formed for Adobe/CEB**
  - **Cob/Monolithic Adobe will hopefully follow**

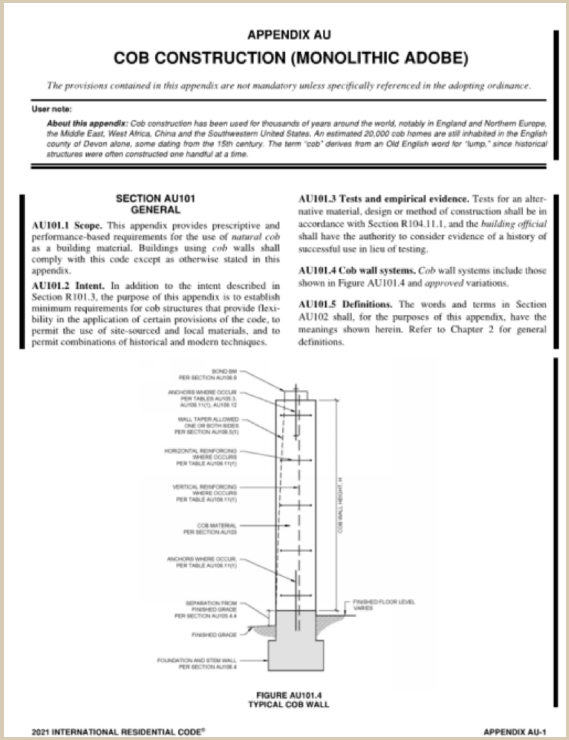
Alternative

[A] 104.11 Alternative materials, design and methods of construction and equipment. The provisions of this code are not intended to prevent the installation of any material or to prohibit any design or method of construction not specifically prescribed by this code, provided that any such alternative has been *approved*. An alternative material, design or method of construction shall be *approved* where the *building official* finds that the proposed design is satisfactory and complies with the intent of the provisions of this code, and that the material, method or work offered is, for the purpose intended, not less than the equivalent of that prescribed in this code in quality, strength, effectiveness, *fire resistance*, durability and safety. Where the alternative material, design or method of construction is not *approved*, the *building official* shall respond in writing, stating the reasons why the alternative was not *approved*.

[A] 104.11.1 Research reports. Supporting data, where necessary to assist in the approval of materials or assemblies not specifically provided for in this code, shall consist of valid research reports from *approved* sources.

[A] 104.11.2 Tests. Whenever there is insufficient evidence of compliance with the provisions of this code, or evidence that a material or method does not conform to the requirements of this code, or in order to substantiate claims for alternative materials or methods, the *building official* shall have the authority to require tests as evidence of compliance to be made without expense to the jurisdiction. Test methods shall be as specified in this code or by other recognized test standards. In the absence of recognized and accepted test methods, the *building official* shall approve the testing procedures. Tests shall be performed by an *approved agency*. Reports of such tests shall be retained by the *building official* for the period required for retention of public records.

IRC Appendix AU (Monolithic Adobe) Construction



APPENDIX AU

COB CONSTRUCTION (MONOLITHIC ADOBE)

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

User note:

About this appendix: *Cob construction has been used for thousands of years around the world, notably in England and Northern Europe, the Middle East, West Africa, China and the Southwestern United States. An estimated 20,000 cob homes are still inhabited in the English county of Devon alone, some dating from the 15th century. The term "cob" derives from an Old English word for "lump," since historical structures were often constructed one handful at a time.*

SECTION AU101
GENERAL

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

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

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

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

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.

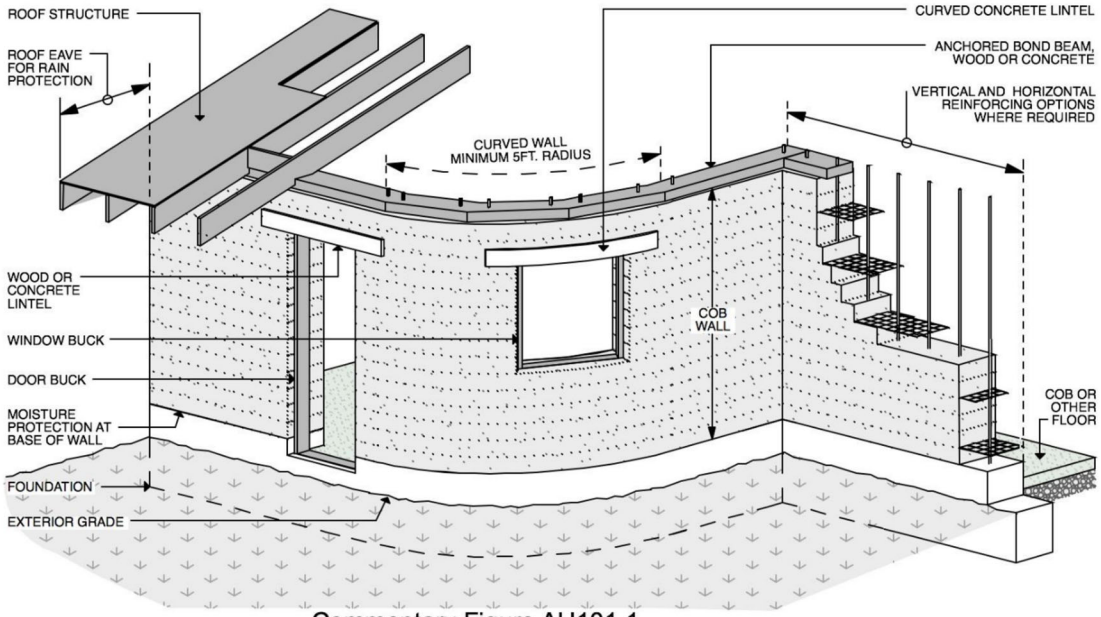
FIGURE AU101.4
TYPICAL COB WALL

2021 INTERNATIONAL RESIDENTIAL CODE®

APPENDIX AU-1

- **2021 International Residential Code, Appendix AU**
  - **First proposal failed due to 1 hour fire rating**

IRC Appendix AU Cob (Monolithic Adobe) Construction



Commentary Figure AU101.1
TYPICAL COB BUILDING COMPONENTS

ASTM E119

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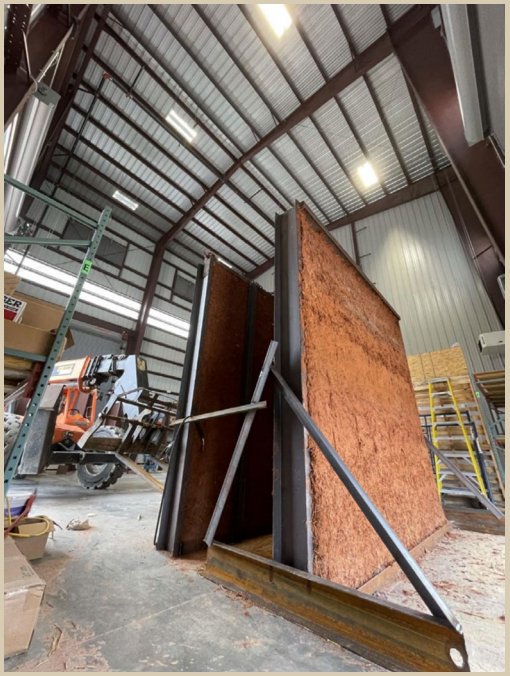
ASTM E119 Cob/Monolithic Adobe

- 2 Hour Fire Rating Test
  - NTA, ICC Testing Lab - Bryan, TX
  - 10’x10’x1’ Sample
  - >5000 lbs
  - 2 Wall Samples
  - Mono-Density & Tri-Density



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ASTM E119 Cob/Monolithic Adobe

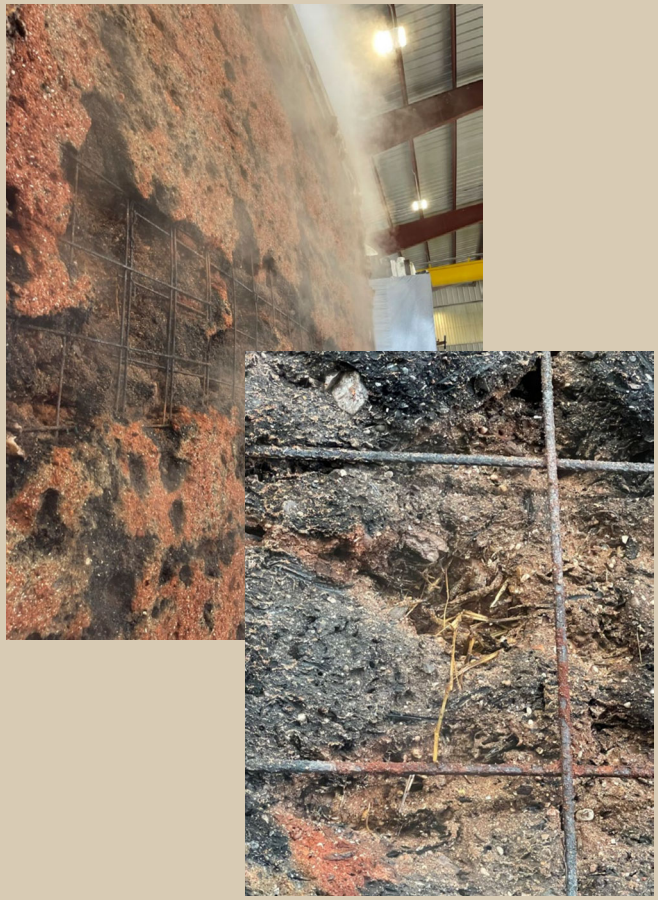
- 2 Hour Fire Rating Test
  - NTA, ICC Testing Lab - Bryan, TX
  - 10’x10’x1’ Sample
  - >5000 lbs
  - 2 Wall Samples
  - Mono-Density & Tri-Density

ASTM E119 Cob/Monolithic Adobe

- 2 Hour Fire Rating Test
  - Interior Face: 2000° F
  - Exterior Face: <5° F
  - 2 minute hose test
  - Optional Compression Test To Failure

ASTM E119 – Cob/Monolithic Adobe

- Fire - ASTM E119



ASTM E1-19 Cob/Monolithic Adobe

Testing What is next

Anchorage:
•Cob
•Top and bot of wall with various interior reinf.
•Ledgering
•Straw Bale When reinforced plaster
•Ledgering
•Earthbag
•Top and bot of wall with various interior reinf.
•Ledgering
•Adobe
•Top and bot of wall with various interior reinf.
•Ledgering

Moisture, Corrosion or degradation
•Steel in Clay
•Wood against clay
•Clay with various stabilizations, lime and cement
•Expanded moisture in straw data
•particularly with various finishes applied
•Moisture in clay & straw per rain event/season
•Depth of penetration, time till release
•Near ground erosion based on climate zones

Seismic and Wind:
•Straw Bale
•Finish FEMA
•Perforated shear walls with reinforced plaster
•Bale on end with studs
•Cob, Adobe, Earthbag
•Various reinf. and microfiber, natural & metal
•Buttressing and rocking shear
LSC, Hemp-Lime (hempcrete)

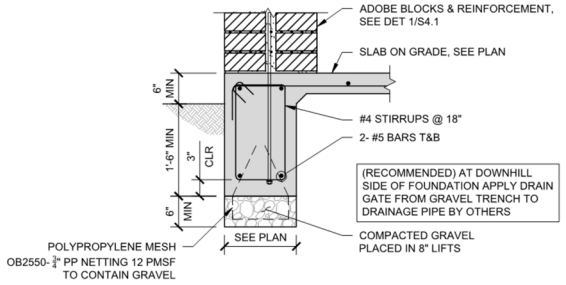
Small Scale/Batch Testing & Means and Methods
•Site compression testing
•Mechanical mixing of cob
•Mix design and specs for Cob, Earthbag, adobe

Thermal, Fire, Acoustics
•Many options for research for all natural bldg materials

Foundations
•Crushed Stone Expansion
•Lime stabilized clay
•Emulsified asphalt stabilized clay
•Earthen floor slabs
•Natural building material (LSC), under slab insulations

Carbon and Global Warming

- **Stabilization**
  - **Natural (none)**
  - **Emulsified Asphalt**
  - **Lime**
  - **Cement**
- **Low Carbon Concrete**
  - **Marin County Low Carbon Concrete Code**
  - **Wide Walls can mean Wide Foundations**
- **Crushed Stone Footings**
  - **AKA Rubble Trench**
  - **2024 International Residential Code Updates**



13 / S4.1 EXTERIOR WALL FOOTING ALTERNATIVE 3/4" = 1'-0"

MIX DESIGN

THE FOLLOWING INFORMATION IS SHARED TO PRODUCE A MIX DESIGN THAT MEETS THE STRUCTURAL REQUIREMENTS OF THE PROJECT AND REDUCES THE POUNDS OF CEMENT PER YARD AS MUCH A POSSIBLE.

SUPPLEMENTAL CEMENTITIOUS MATERIAL (SCM)

A MINIMUM SCM OF 50% REQUIRED AND UP TO 90% SCM ALLOWED. SCM'S MAY INCLUDE BUT ARE NOT LIMITED TO CARBON CURE, SLAG, FLY ASH, NATURAL GLASS POZZOLANS ETC. CONSULT ENGINEER FOR MORE INFO.

CONCRETE TO COMPLY TO REDUCED CARBON CONCRETE LIMITS. ALL MIXES OF THE FOLLOWING STRENGTHS SHALL BE LIMITED TO THE FOLLOWING CEMENT CONTENT (NOTE: THE ASSOCIATED CURE TIMES FOR THESE STRENGTHS AS THEY RELATE TO SPECIFIC STRUCTURAL ELEMENTS ARE LISTED ABOVE):

MINIMUM SPECIFIED COMPRESSIVE STRENGTH, F'C (PSI)	MAXIMUM ORDINARY PORTLAND CEMENT CONTENT, (LBS/YD3)	
	REQUIRED	RECOMMENDED
UP TO 2500	362	GENERAL: 100-150 SLABS: 150-250

OUR REQUIREMENTS DO NOT CERTIFY ANY AESTHETIC OR WORKABILITY OUTCOME OF THE MIX BEYOND STRUCTURAL PERFORMANCE. THIS IS THE RESPONSIBILITY OF THE CONTRACTOR.

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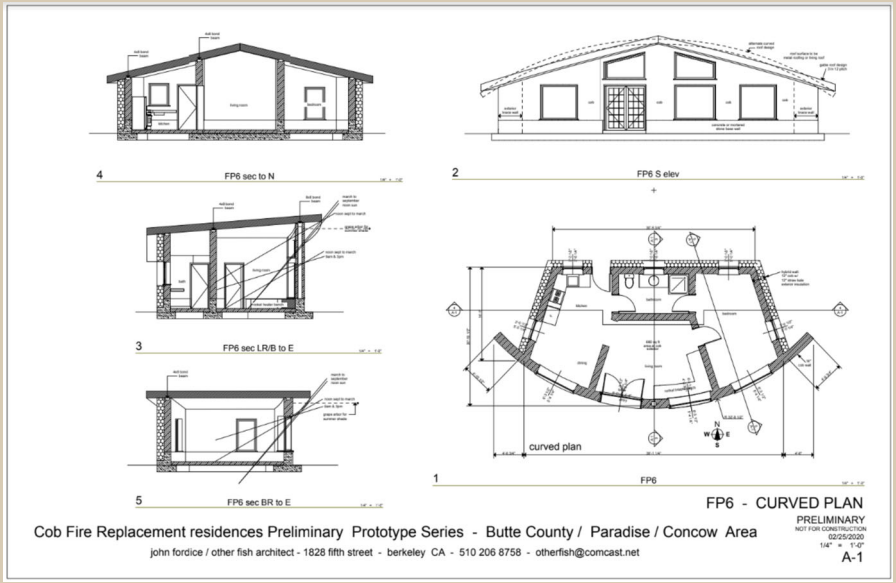
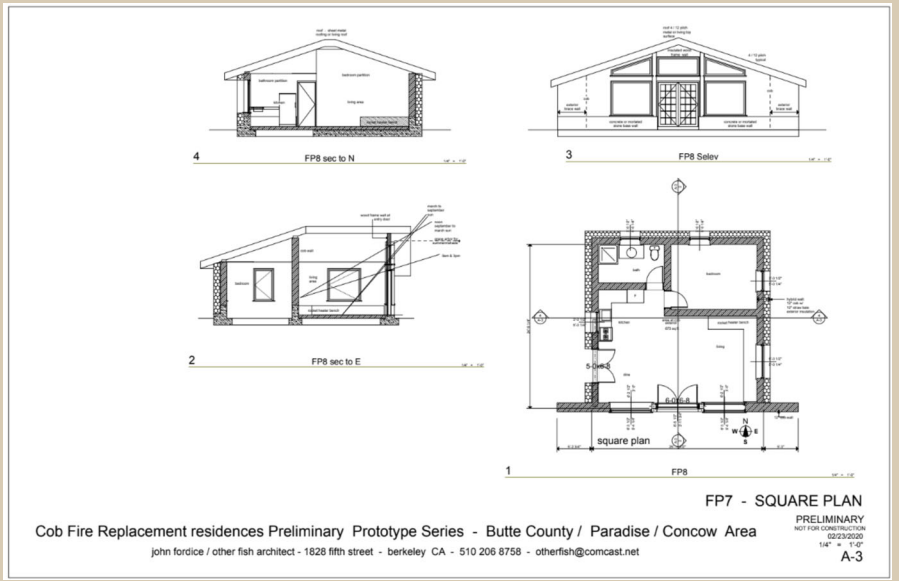
CRI's Fire Rebuild Plans



- **Cob Research Institute Project**
- **Butte County**
- **Support needed**



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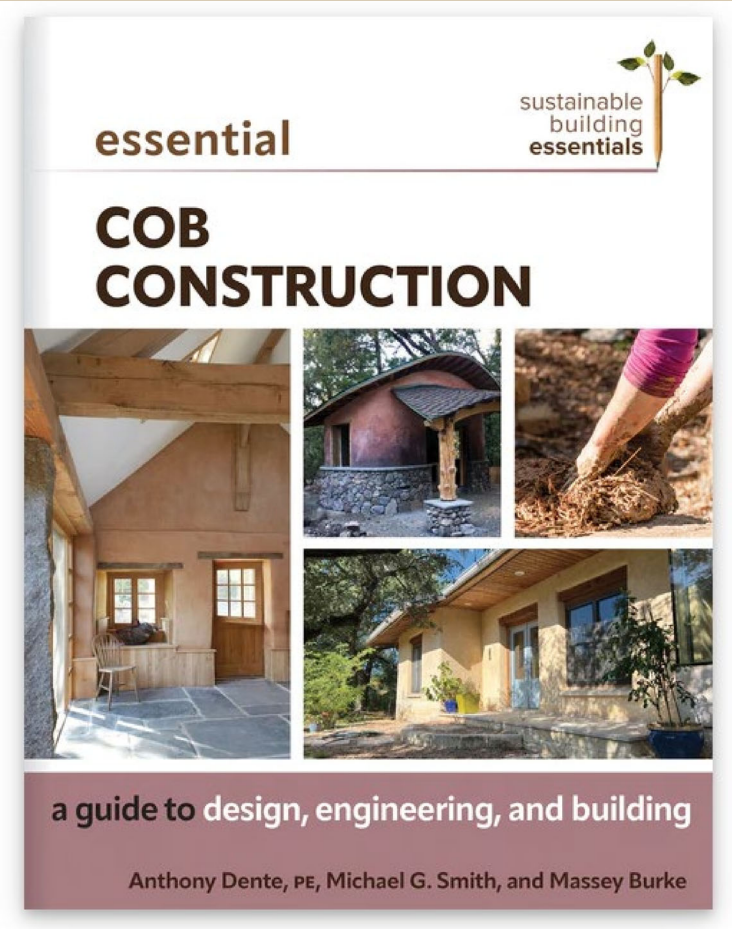
Cob Construction Book



- **New Society Publishing**
- **Big advancements in building science**
- **Estimated publication: January 2024**

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VERDANT
Structural Engineers

More clay, hemp, and straw in buildings = Less carbon in the atmosphere.

Thank you for the opportunity.

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Appendix

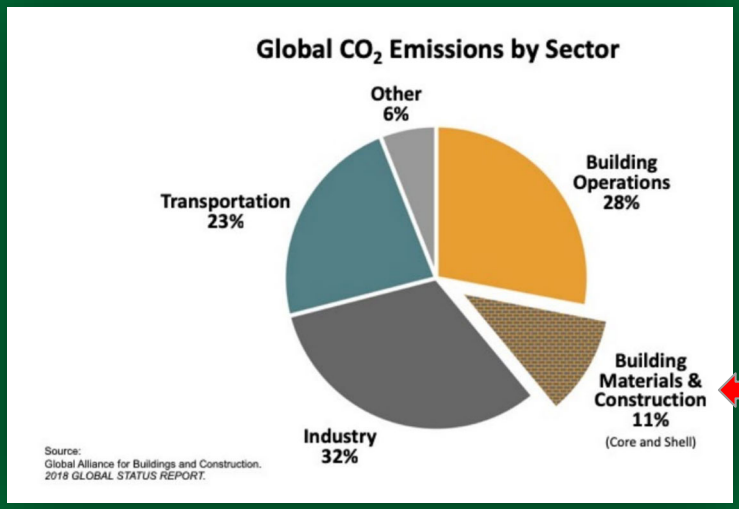
Natural Building Codes

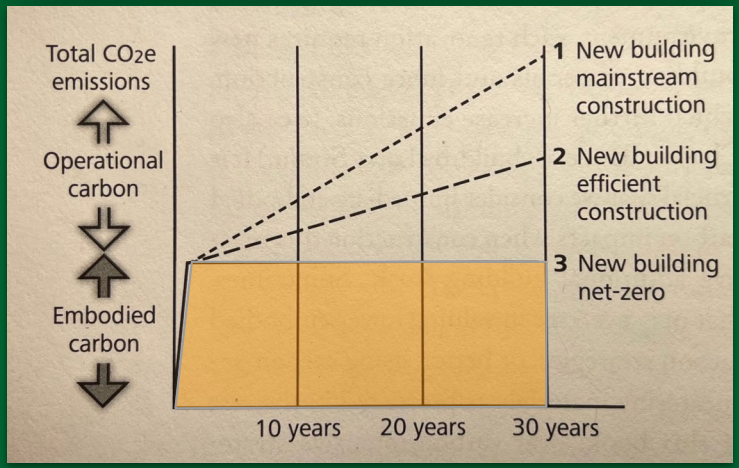
APPENDIX AU

COB CONSTRUCTION (MONOLITHIC ADOBE)

This appendix is informative and is not part of the code.

Problem #1: Building Material Carbon Emissions





- Embodied carbon:
  - Greenhouse gas emissions associated with materials and construction processes
  - Embodied Carbon will be responsible for almost half of the total new construction emissions between now and 2050.[1]

1. Architecture2030. https://architecture2030.org/new-buildings-embodied/

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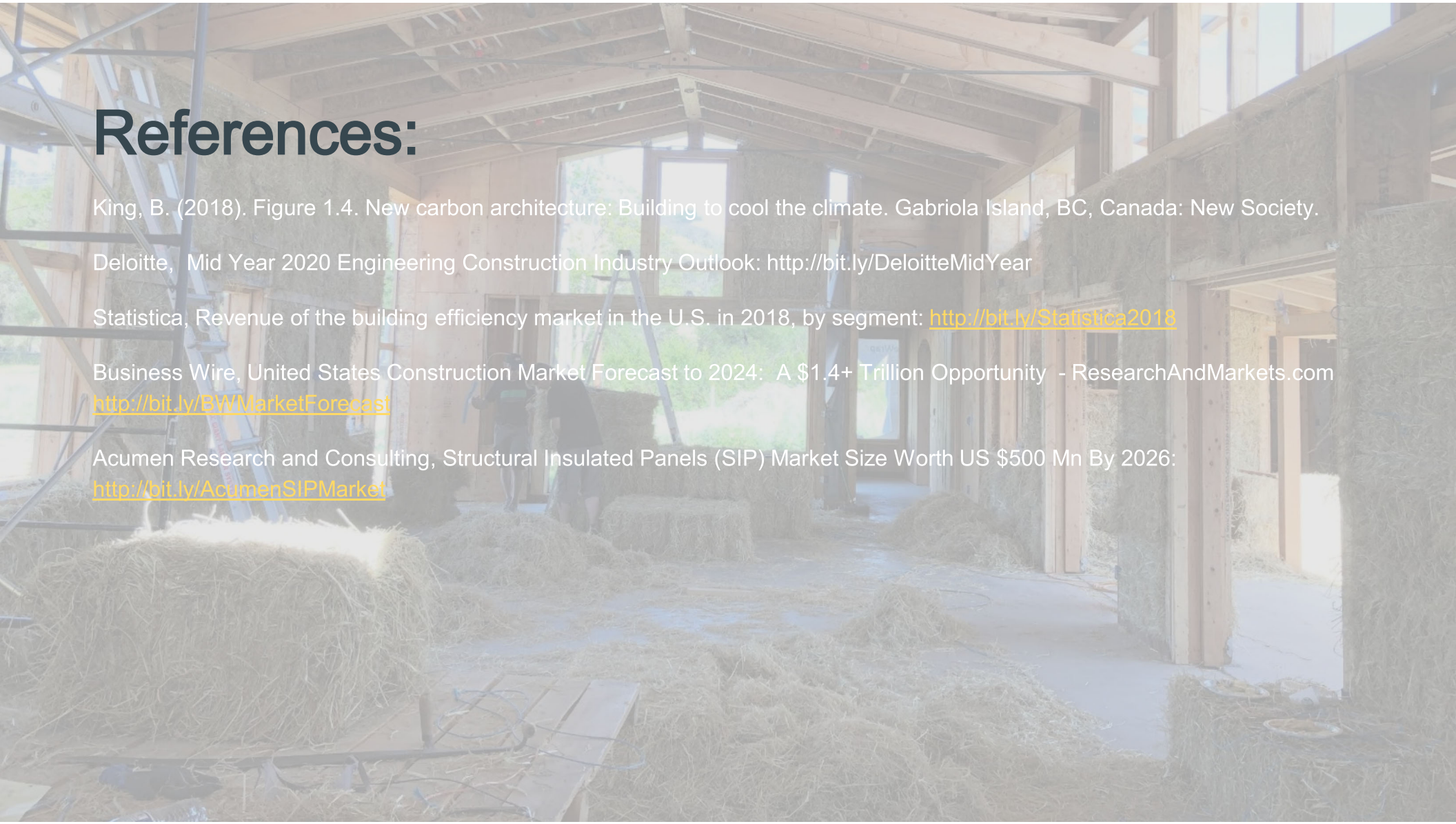

References:

King, B. (2018). Figure 1.4. New carbon architecture: Building to cool the climate. Gabriola Island, BC, Canada: New Society.

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