

Thin-shell Concrete Quasi-spherical Small Buildings: Durable, Low-cost, Low-Earth impact, Global Shelter

World Of Concrete 2026 Las Vegas

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Rev: 16 Jan 26

Juneau, AK 1974: 16' diameter concrete dome: $\frac{1}{2}$ " thick, $\sim \frac{5}{8}$ sphere¹



1974: 4 plies "chicken wire" 20 gauge, 1" mesh stapled to wood form

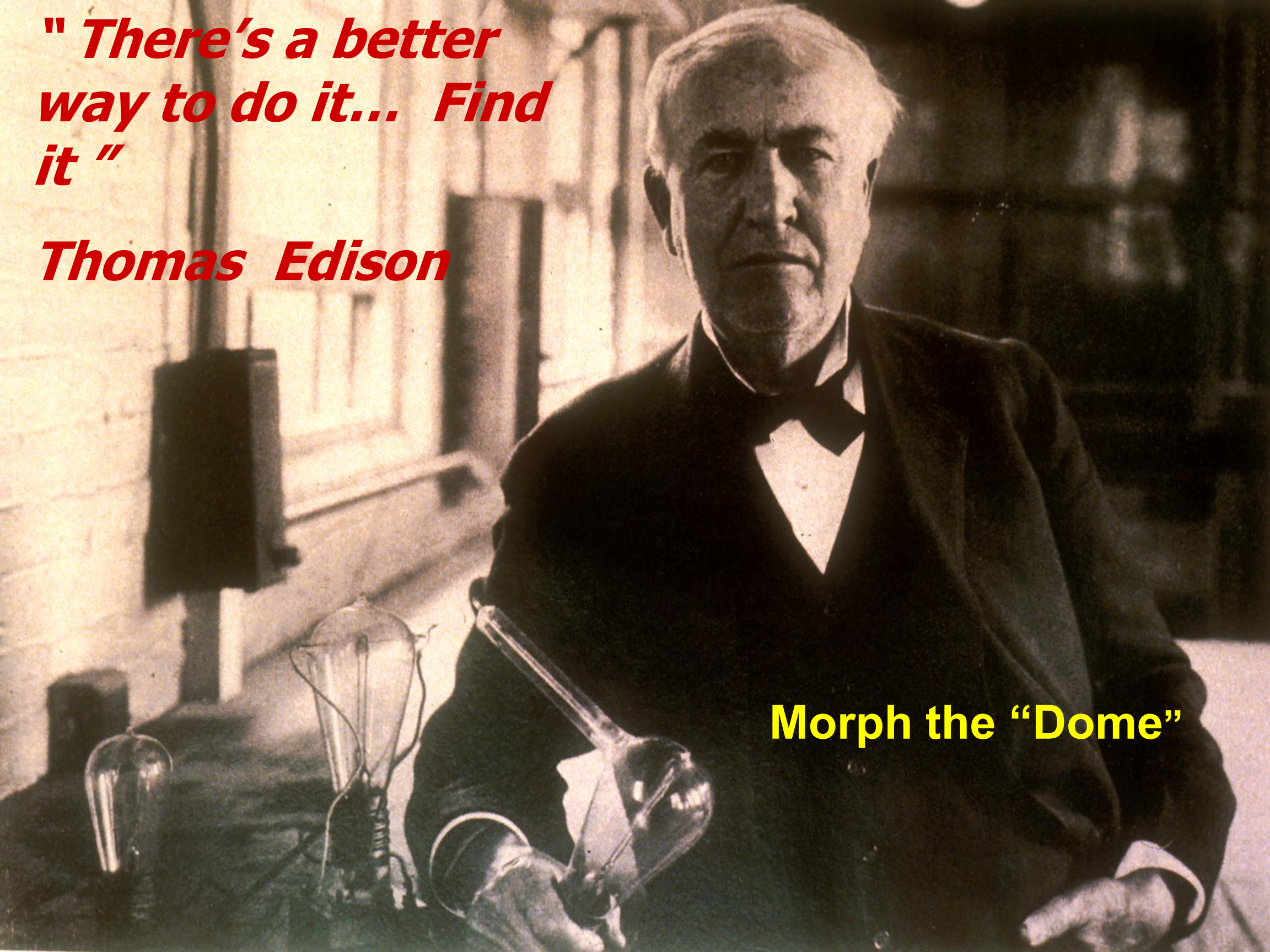


Juneau, AK 1974: 16' diameter concrete dome: $\frac{1}{2}$ " thick, $\sim \frac{5}{8}$ sphere³

***" There's a better
way to do it... Find
it "***

Thomas Edison


Morph the "Dome"





Manufacturing system:

- 1 cm (1/2 ") thick concrete
- Proof-of-concept
- Scale model
- Now, scale-up
- Global market: Mitigation + Adaptation, GCC dangers

A close-up photograph of a thin, grey concrete shell section. The shell is curved and has a rough, porous texture. A yellow measuring tape is placed vertically next to the shell to provide a scale. The tape shows markings for centimeters and inches, with the number '3' clearly visible. The shell is resting on a wooden surface. The background is a plain, light-colored wall.

Thin-shell concrete
envelope section
About 1 cm ($\frac{1}{2}$ ") thick

2,350 pounds
1,070 kg





Robust, insulated shelter -- a prototype for "housing"



**Strength and deflection test: H and V dial indicators inside shell.
1 m sand on top. ~ 0.010" deflection, H and V. Apparently undamaged.**

**2010: Proof-of-concept
Scale model
Juneau, Alaska**



**Seismic test: multiple horizontal shocks to 2.7 g
Undamaged (visually)**

Next nine slides: Welcome home !

Examples and Artists' Concepts

How quasi-spherical thin-shell concrete homes and other small buildings might be:

- **Conceived and Designed**
- **Morphed to quasi-spherical**
- **Quickly tooled and built on-site**
- **Combined in larger structures**
- **Finished**
- **Deployed, proliferated, worldwide**
- **Ideal housing, shelter, school, clinic, storage**
- **Robust, durable, low-cost, low-Earth-impact**
- **Earth-sheltered: bermed or totally buried**
- **Resistant to all Climate Change dangers**

**Quasi-spherical
Thin-shell concrete**



Quasi-spherical Thin-shell concrete

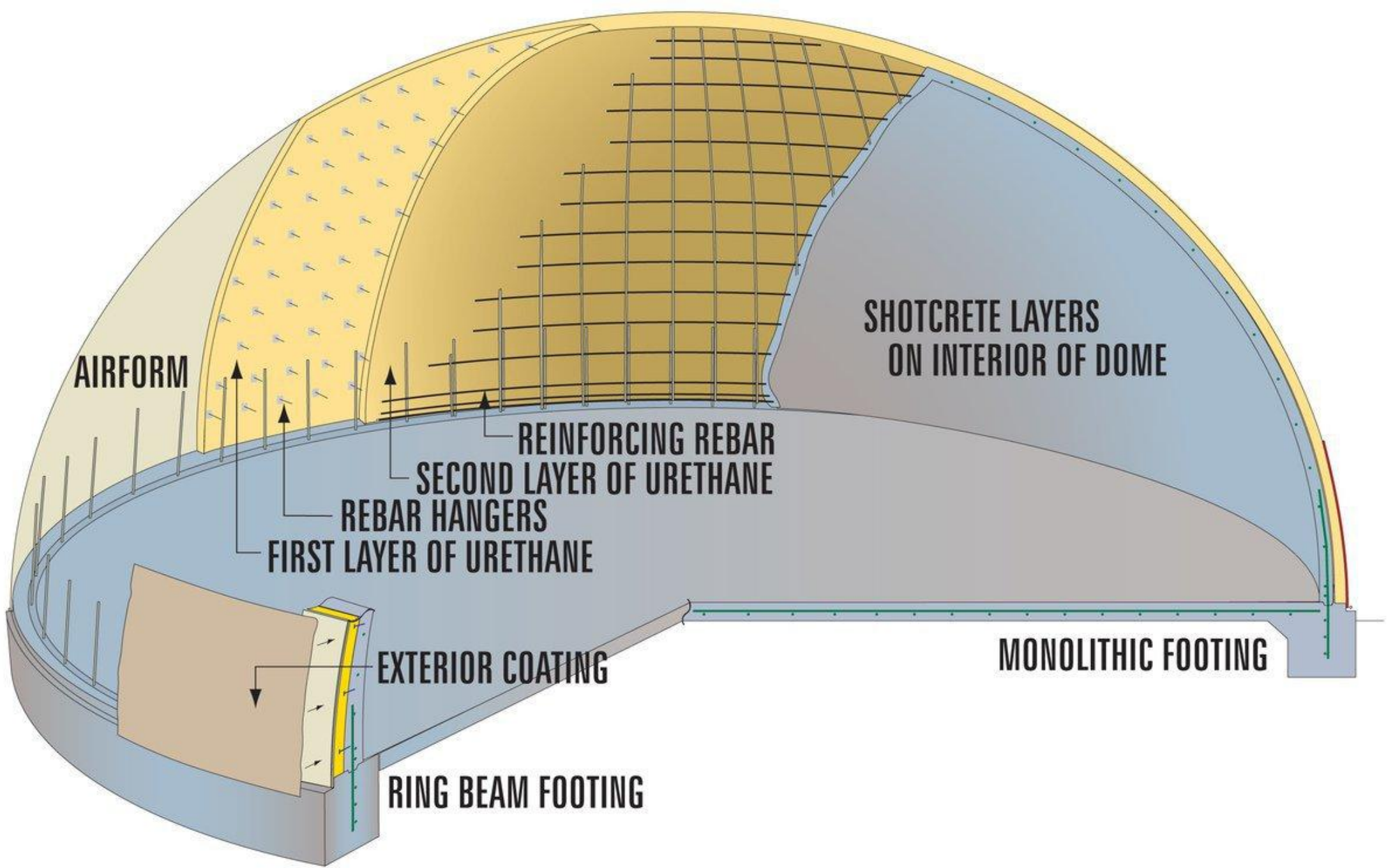




Monolithic Dome Institute
Monolithic Constructors, Inc.
<http://www.monolithic.org/>

**Quasi-spherical
Thin-shell concrete**





Quasi-spherical thin-shell concrete buildings larger than ~ 50 ft (~ 17 m) diameter are best built by this process, evolved by Monolithic Constructors, Inc.

**Quasi-spherical
Thin-shell concrete**



Quasi-spherical thin-shell concrete



Who wants to live in a dome ?

- Afford: people, Earth
- East Kentucky; west NC
- Pakistan; India
- Rebuild Ukraine
- Billions underhoused

Safe

- Storms
- Fire
- Flood
- Tsunami
- Earthquake
- Earth-sheltered
 - Temp extremes
 - War shrapnel, small arms fire
- Rot, vermin, time



Quasi-spherical
Thin-shell concrete

Earth sheltering from extremes: Weather, storms, war

Great potential, flexibility Earth-sheltering thin-shell concrete small buildings





Thin-shell Concrete Small Buildings: Low-cost, Long Life, Low Earth Impact Climate Change Protection Rapid On-site Build

- TRL 4 \$ 600,000 Scale-up ready
 - Alaska Applied Sciences, Inc.
 - Founded May, 1990, C-corp, Juneau, Alaska
 - www.AlaskaAppliedSciences.com
 - No employees
- Earth protection via GHG-emission-free energy, conservation, science education



How we built it:

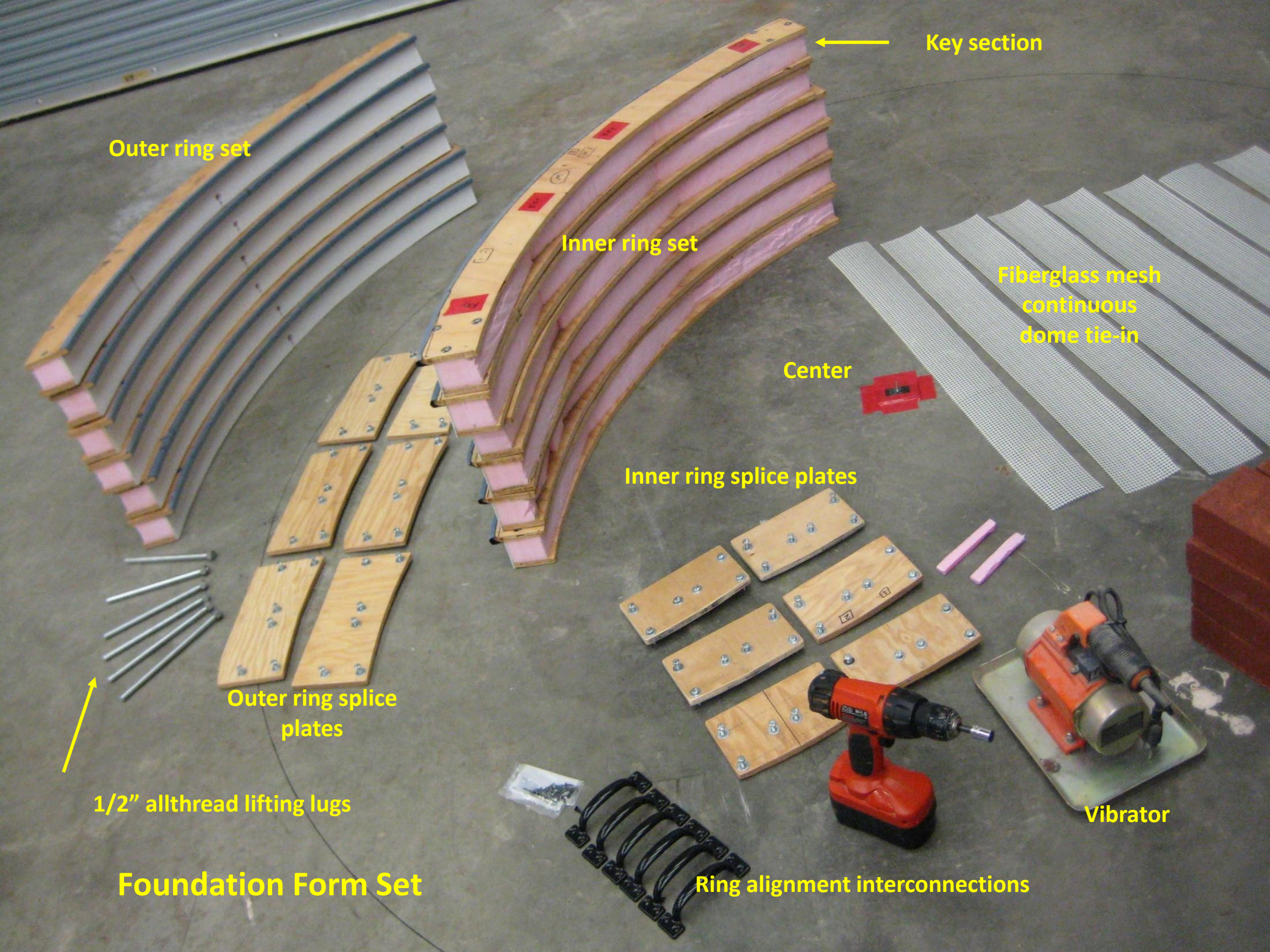
**Scale-model, proof-of-concept
Prototype, ~ 1 cm thick**

Juneau, Alaska 2009 - 2010

On-site Construction Process

Proof-of-concept Scale model

- 2009 – 2010, Juneau, Alaska
- About 1 cm (½”) thick concrete envelope
- About \$ 3,000 total materials, with
 - ~ 1 cm interior spray UR foam insulation
- Proprietary tooling, forms set, and manufacturing process



Key section

Outer ring set

Inner ring set

Fiberglass mesh
continuous
dome tie-in

Center

Inner ring splice plates

Outer ring splice
plates

1/2" allthread lifting lugs

Vibrator

Foundation Form Set

Ring alignment interconnections

¼" foam shim (2 pl)

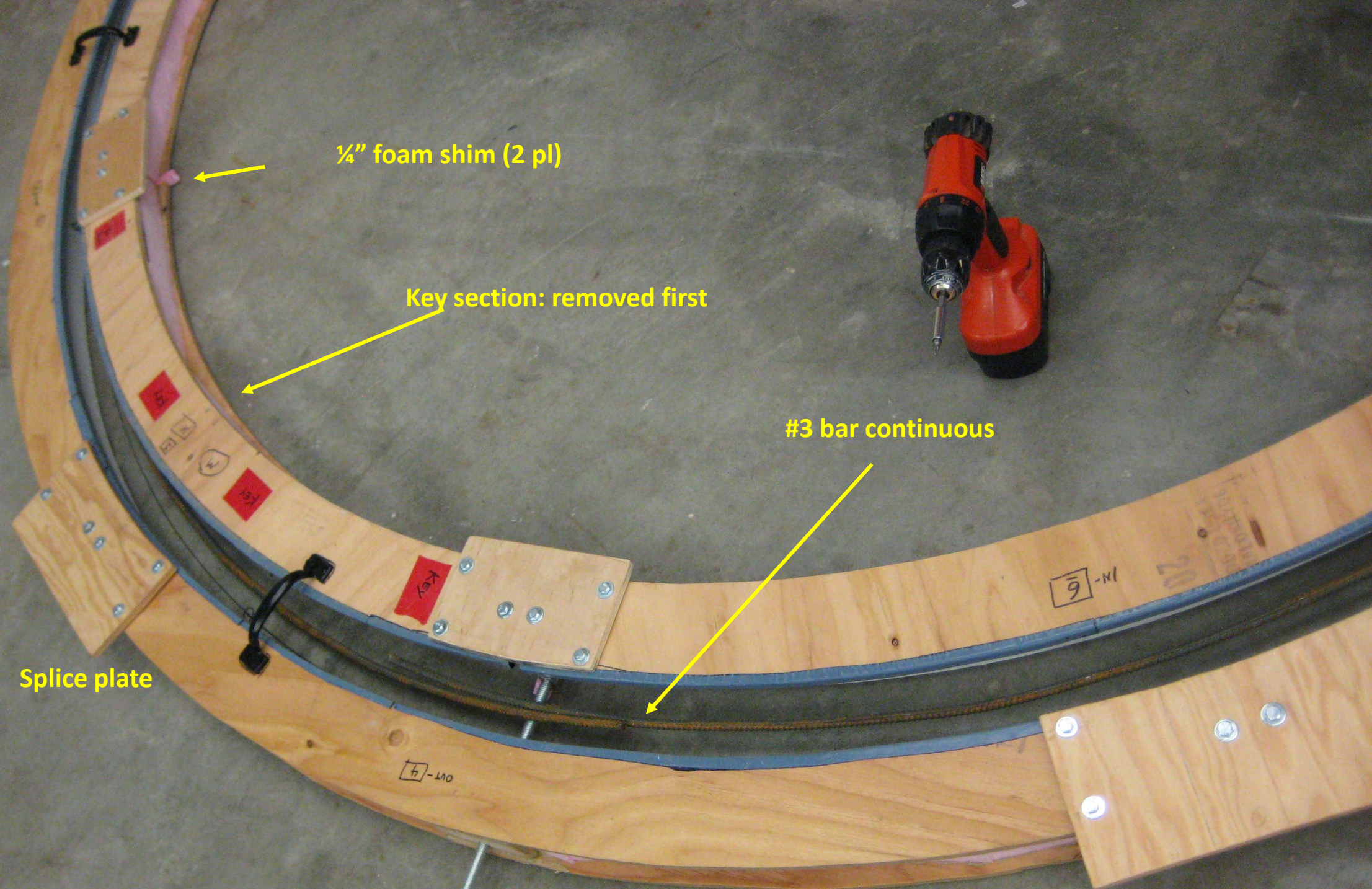
Key section: removed first

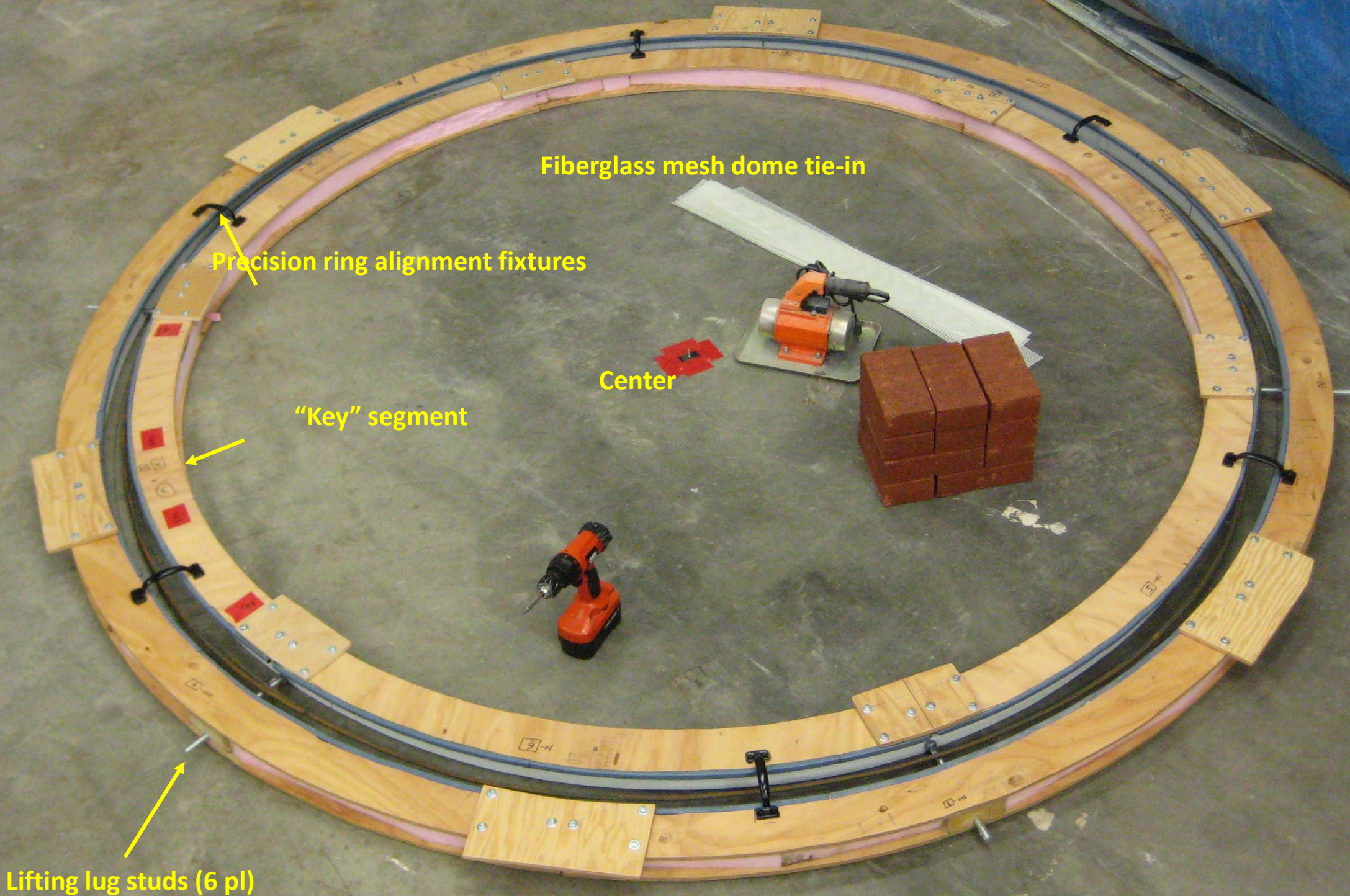
#3 bar continuous

Splice plate

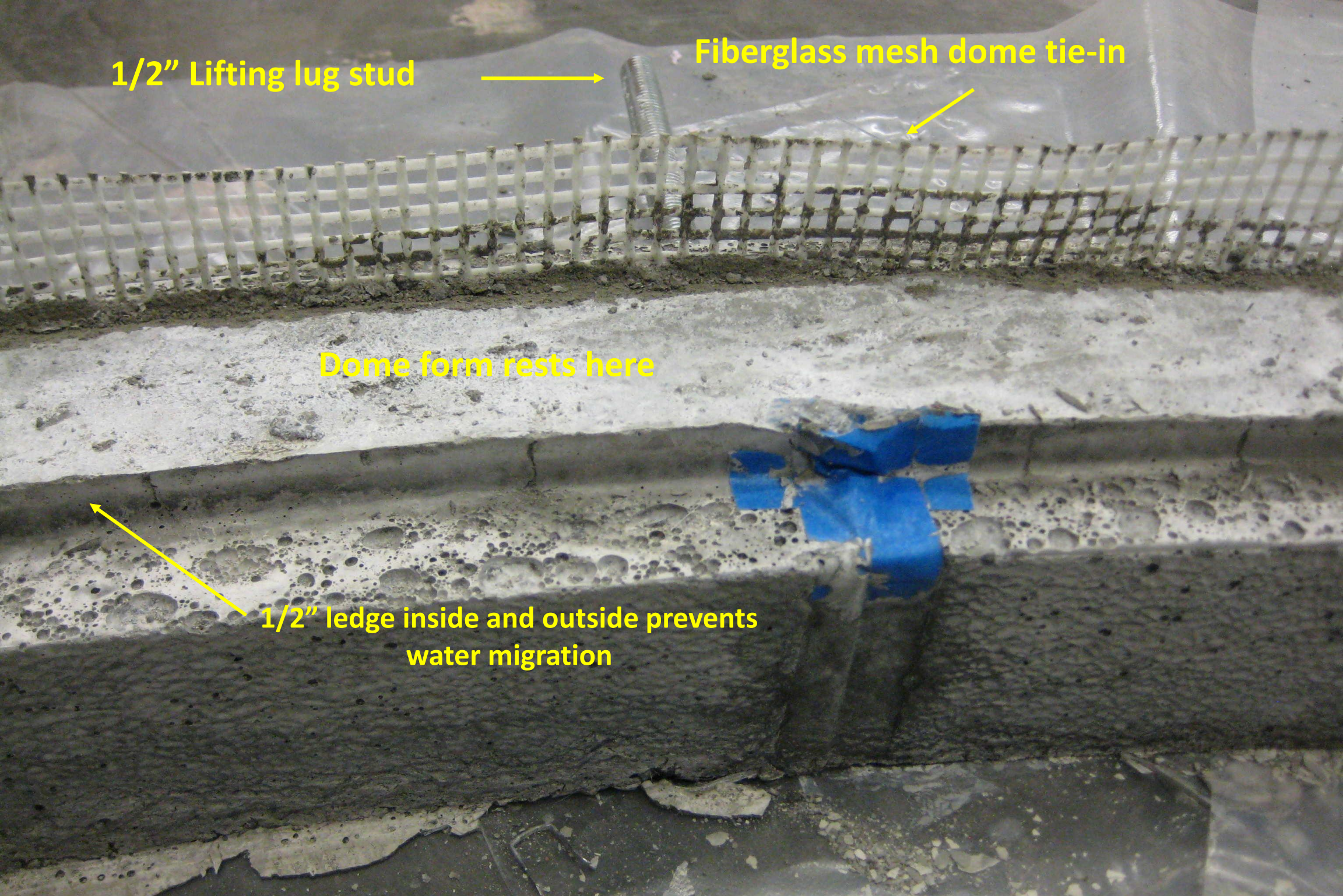
½" allthread lift lug

Assembled Foundation Form





Assembled foundation form, ready for pour



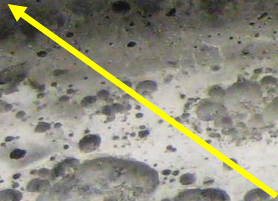
1/2" Lifting lug stud



Fiberglass mesh dome tie-in



Dome form rests here



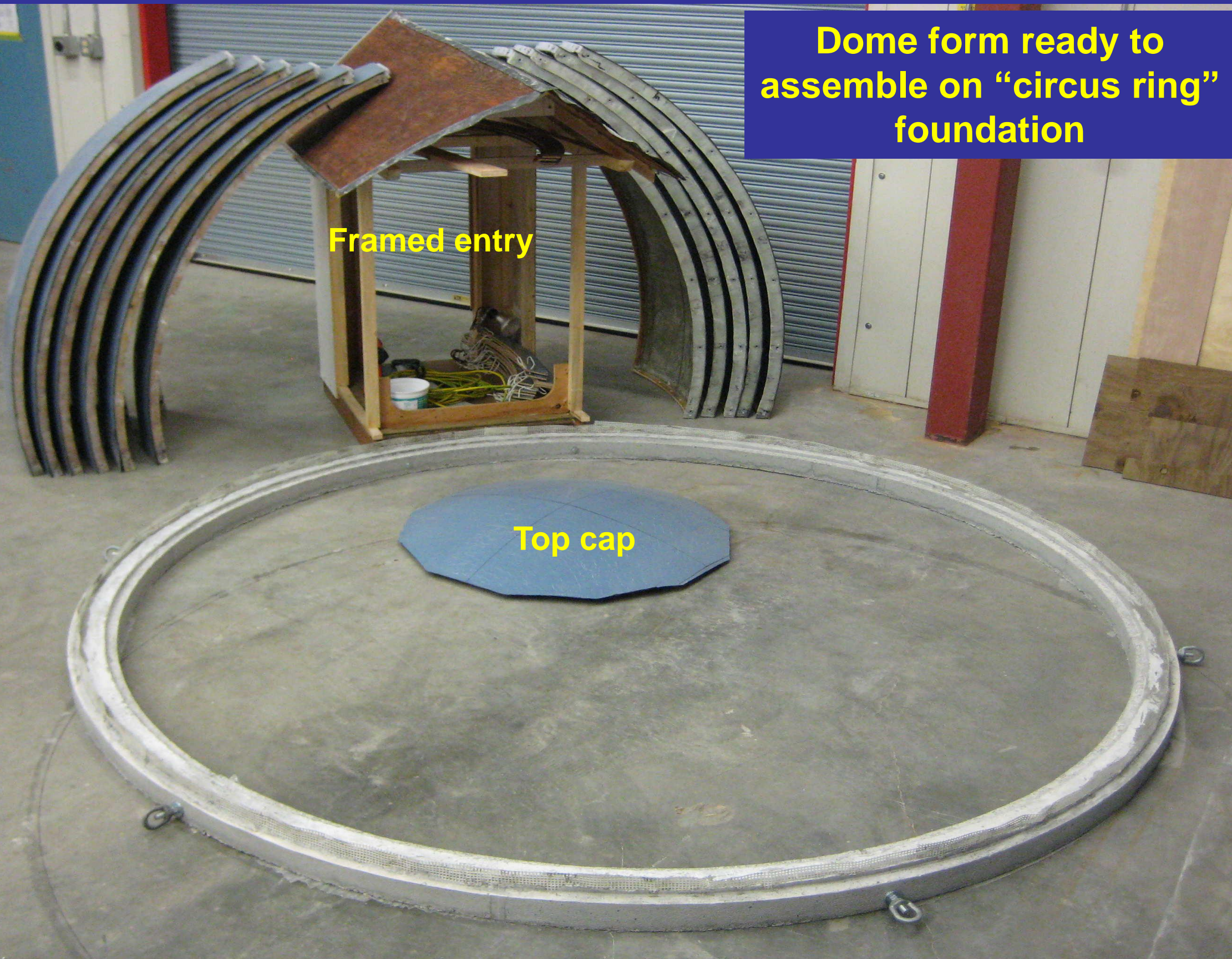
1/2" ledge inside and outside prevents water migration

"Circus ring" foundation: 4" W x 3" H , outward view

Dome form ready to assemble on “circus ring” foundation

Framed entry

Top cap



Begin dome form assembly

Framed entry

Bottom shims

Side wall shim (1 of 12)

Sheet steel skid plates



2

1

Removable side shim: this joint will be covered with 1" blue masking tape



Sto fiberglass mesh continuous dome tie-in: prototype radius too large, requiring too much mortar to encapsulate mesh



Removable sheet steel skid plate, under bottom shim

Removable bottom shim



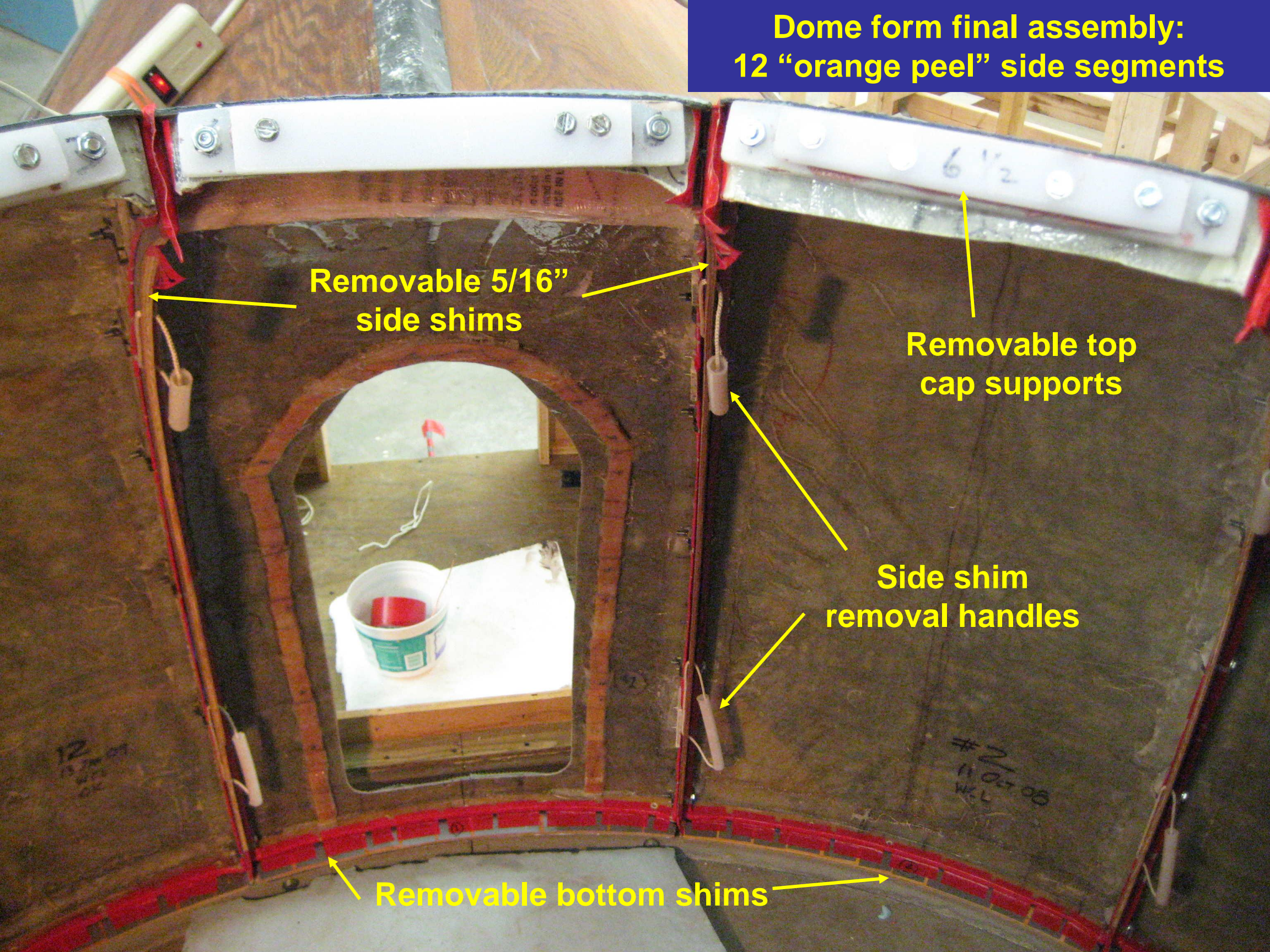
Doorway

Entry floor

Entry-to-foundation bolt joint



**Dome form final assembly:
12 "orange peel" side segments**



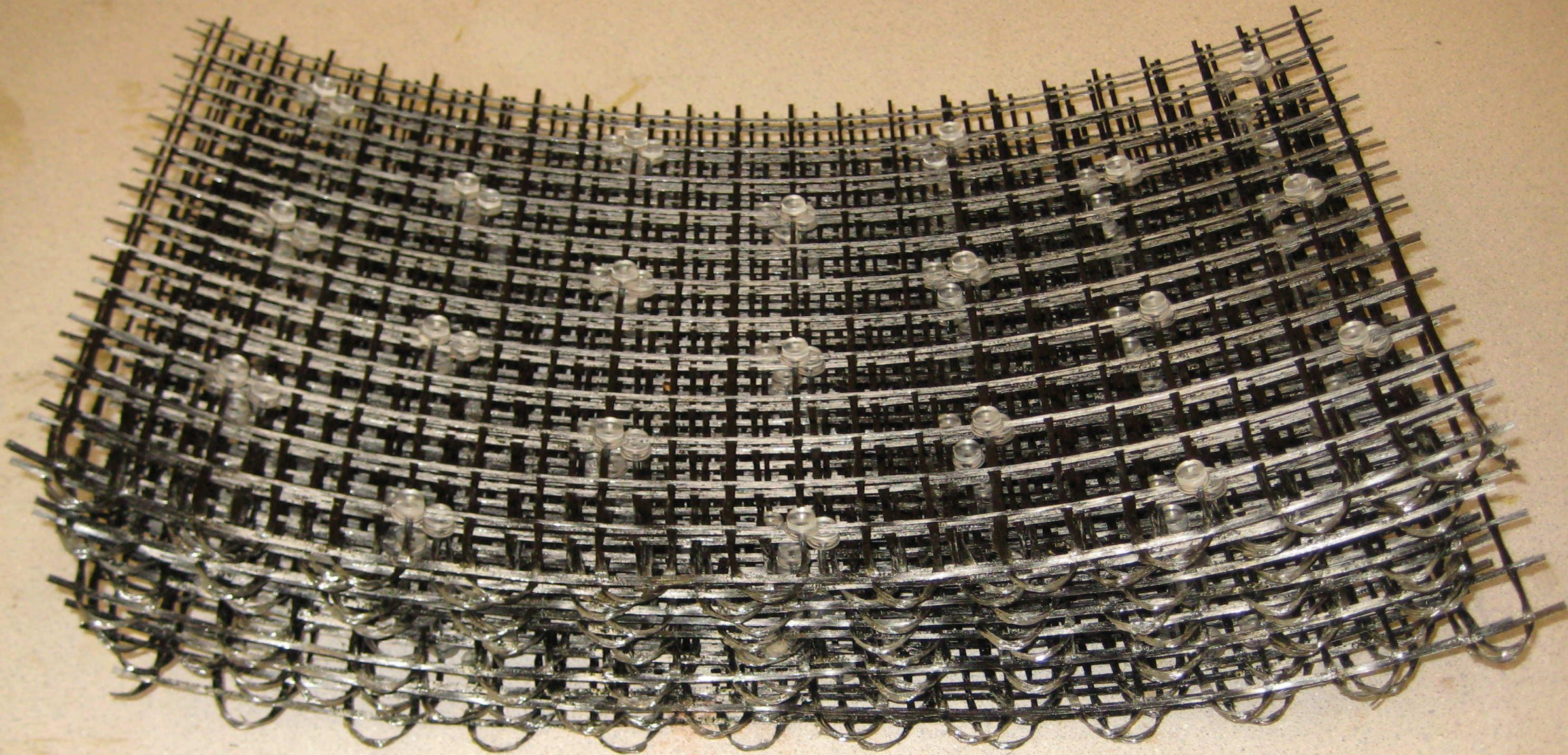
**Removable 5/16"
side shims**

**Removable top
cap supports**

**Side shim
removal handles**

Removable bottom shims

#2
11 Oct 08
WKL



SECOND COURSE
13 @ 12x21 \square

12x21

Second course C-Grid, ready to "tile": 13 pcs @ 12" x 21"

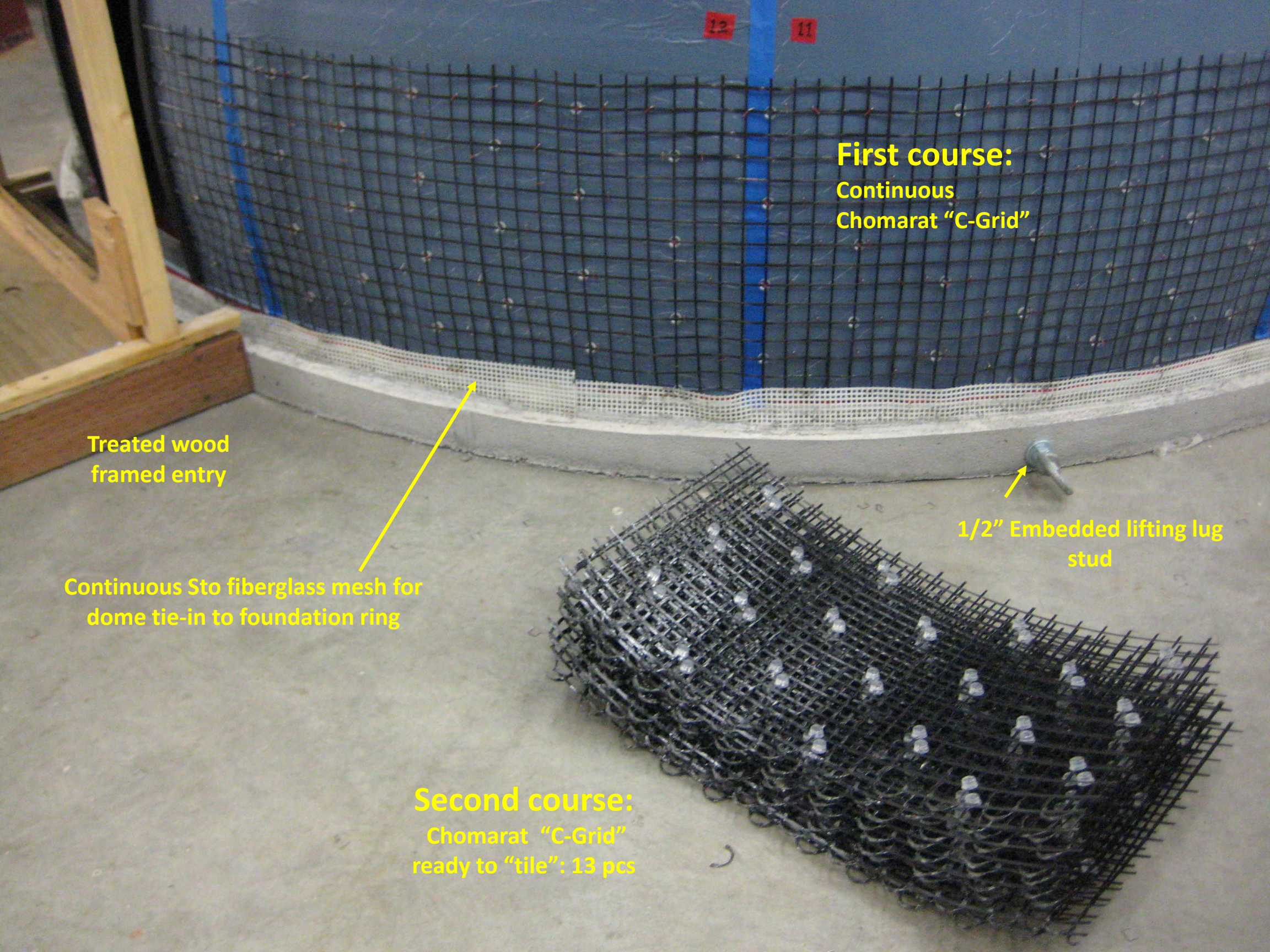
First course:
Continuous
Chomarat "C-Grid"

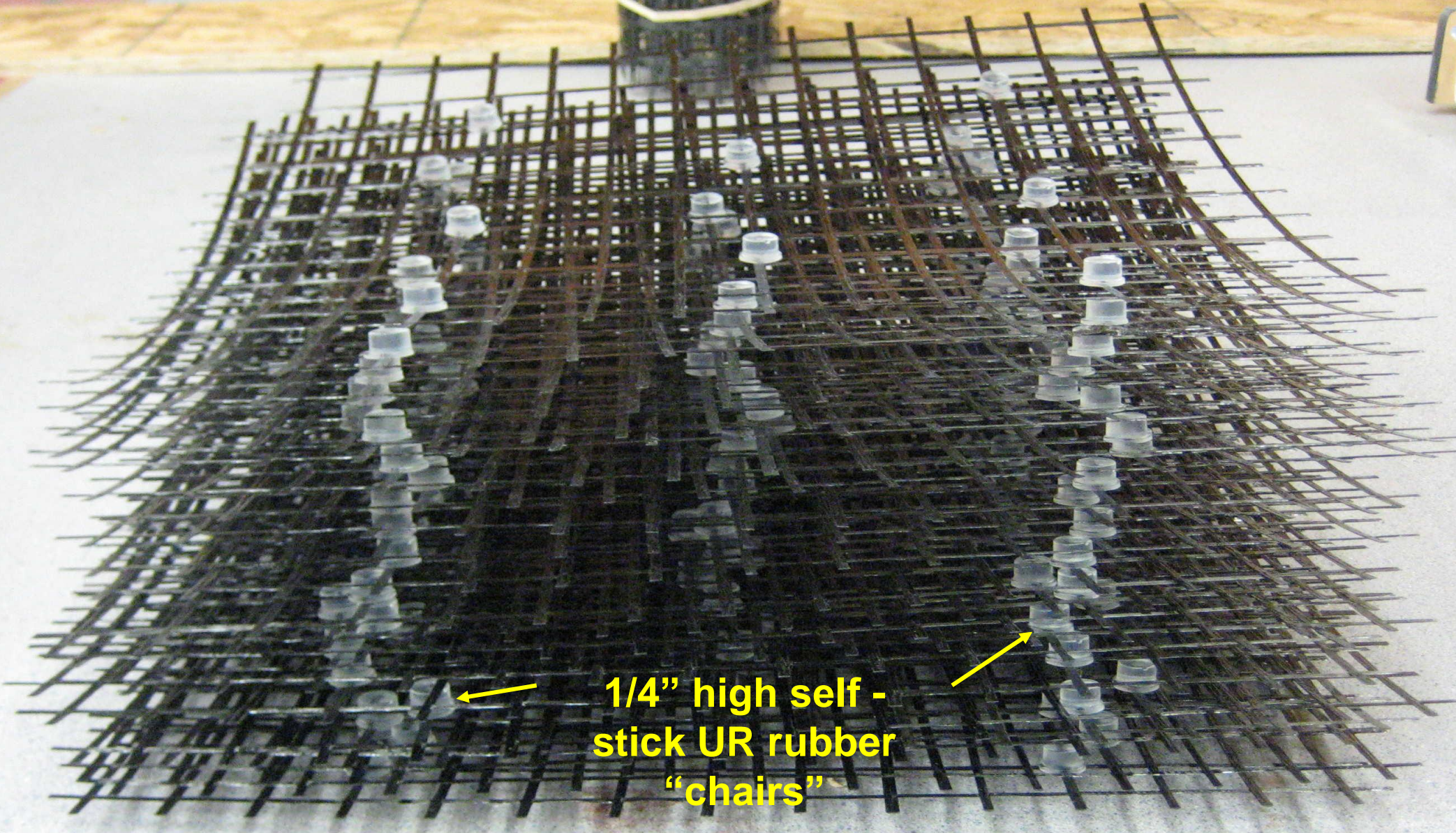
**Treated wood
framed entry**

**Continuous Sto fiberglass mesh for
dome tie-in to foundation ring**

**1/2" Embedded lifting lug
stud**

Second course:
Chomarat "C-Grid"
ready to "tile": 13 pcs





1/4" high self-stick UR rubber "chairs"

THIRD COURSE
11 x 14 \square

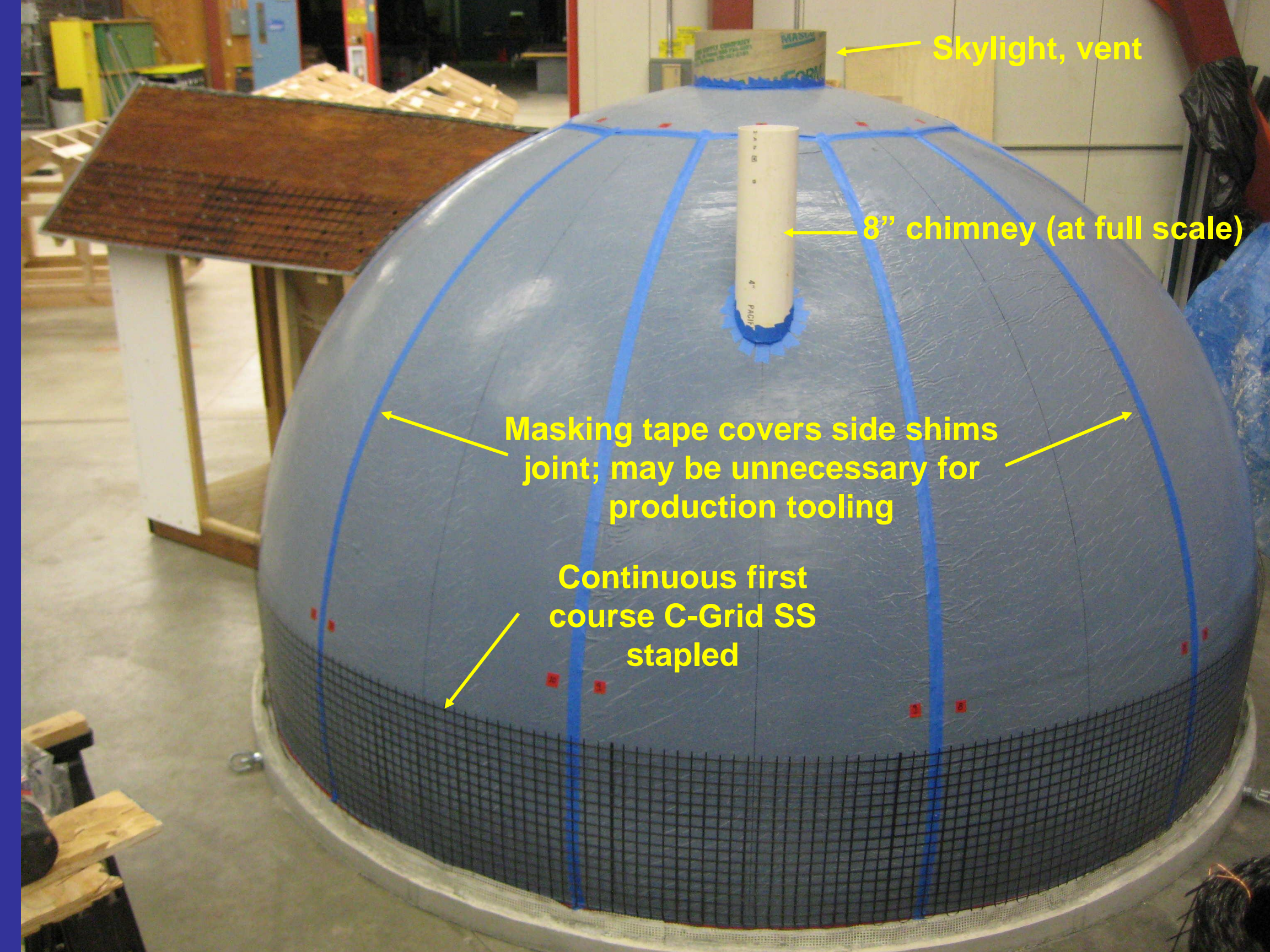
Third course C-Grid, ready for tiling: ~ 20 pcs used

← Skylight, vent

← 8" chimney (at full scale)

← Masking tape covers side shims joint; may be unnecessary for production tooling

← Continuous first course C-Grid SS stapled

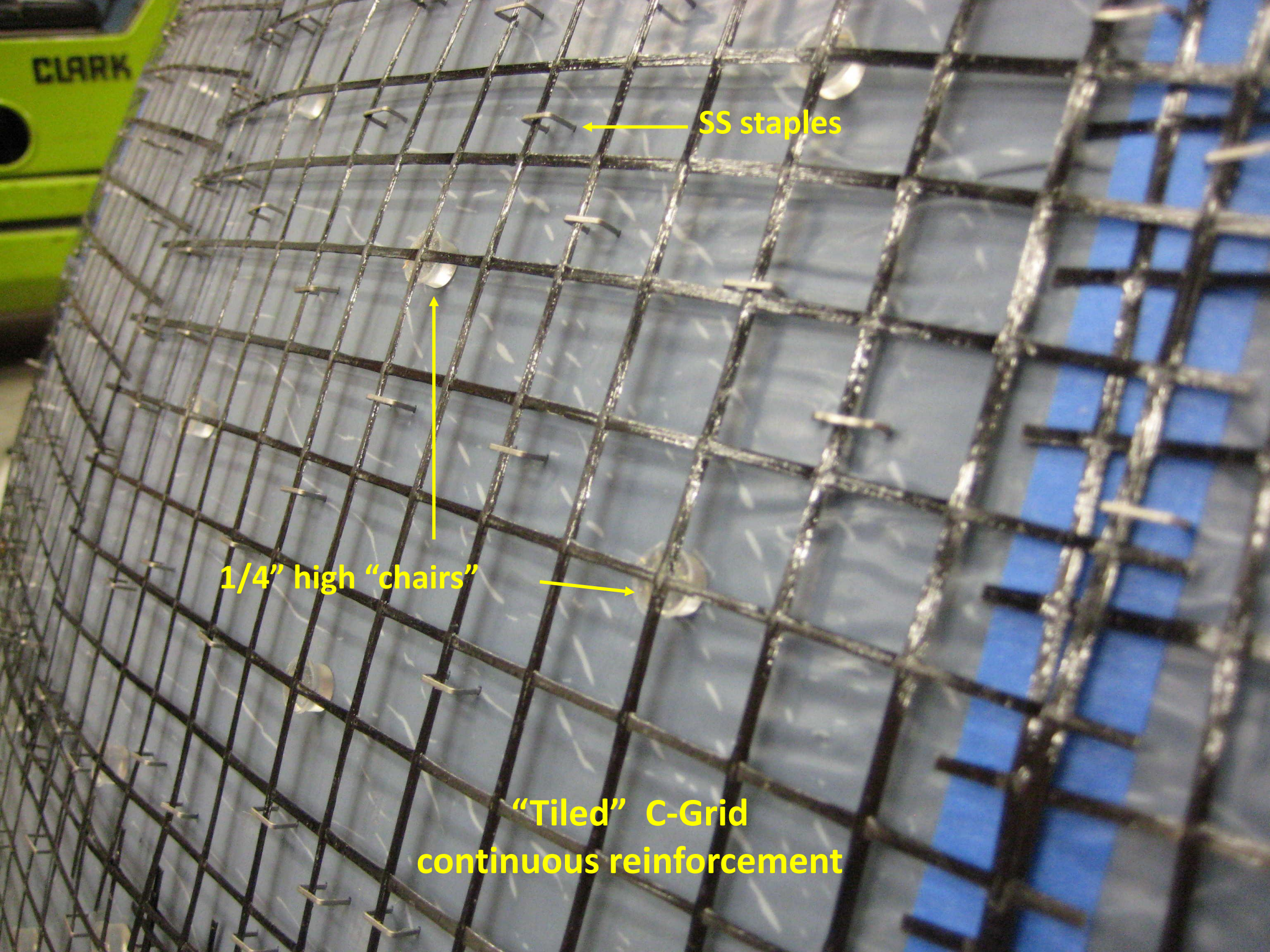


CLARK

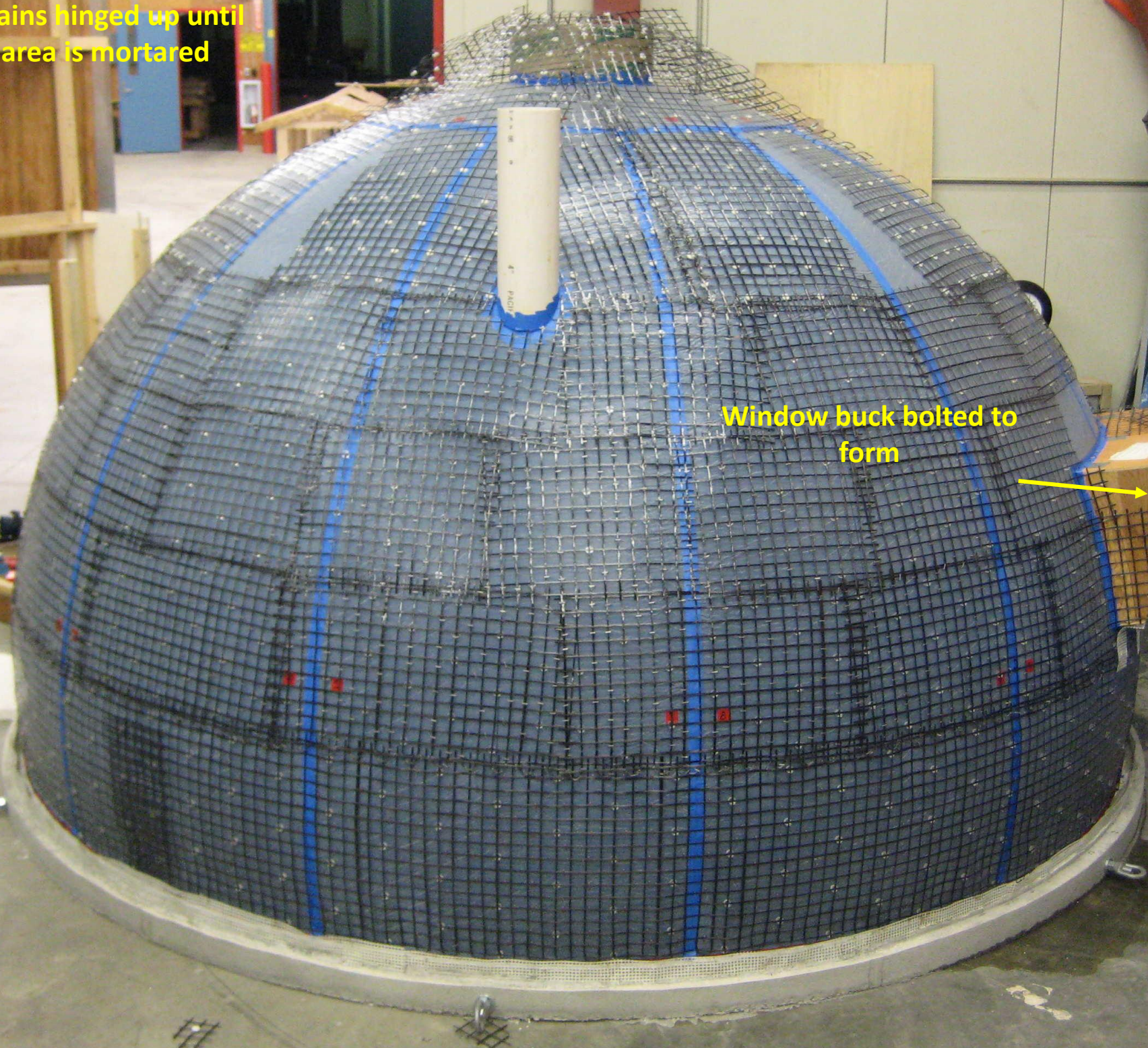
SS staples

1/4" high "chairs"

"Tiled" C-Grid
continuous reinforcement



Entry roof remains hinged up until dome entry area is mortared



Window buck bolted to form

Fifth course C-Grid nearly complete; all C-Grid stapled to form



12 Nov 09

~ 770 lbs mortar used

**~ 0.38" average concrete
shell thickness**

Total mortar time ~ 2 hrs

Note:

- 1. Window buck lightly bolted to form; spans two form sections; unbolt for form removal**
- 2. Poor mortar penetration around window: Sto fiberglass mesh a mistake, a mortar barrier**
- 3. C-Grid conforming adequately to small-radius stapling at skylight, window, chimney**



Hinged Entry roof dropped into place

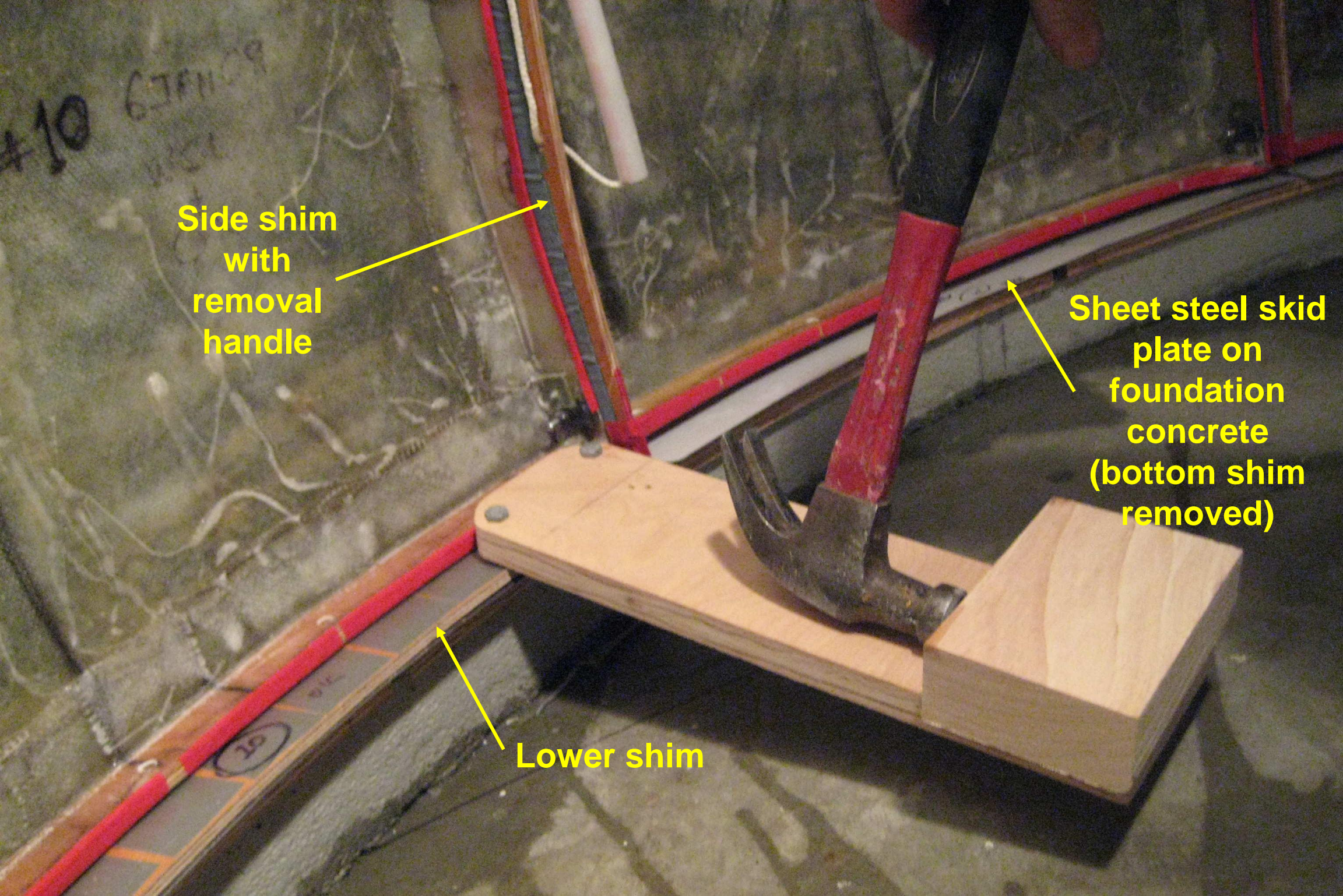
Continuous C-Grid embedded for structural integrity of dome and entry

Removable entry roof form Z-flashing (4 pcs)

Entry roof hinge

After dome ~ 80% mortared, hinged entry roof dropped into place for continuous concrete structural continuity



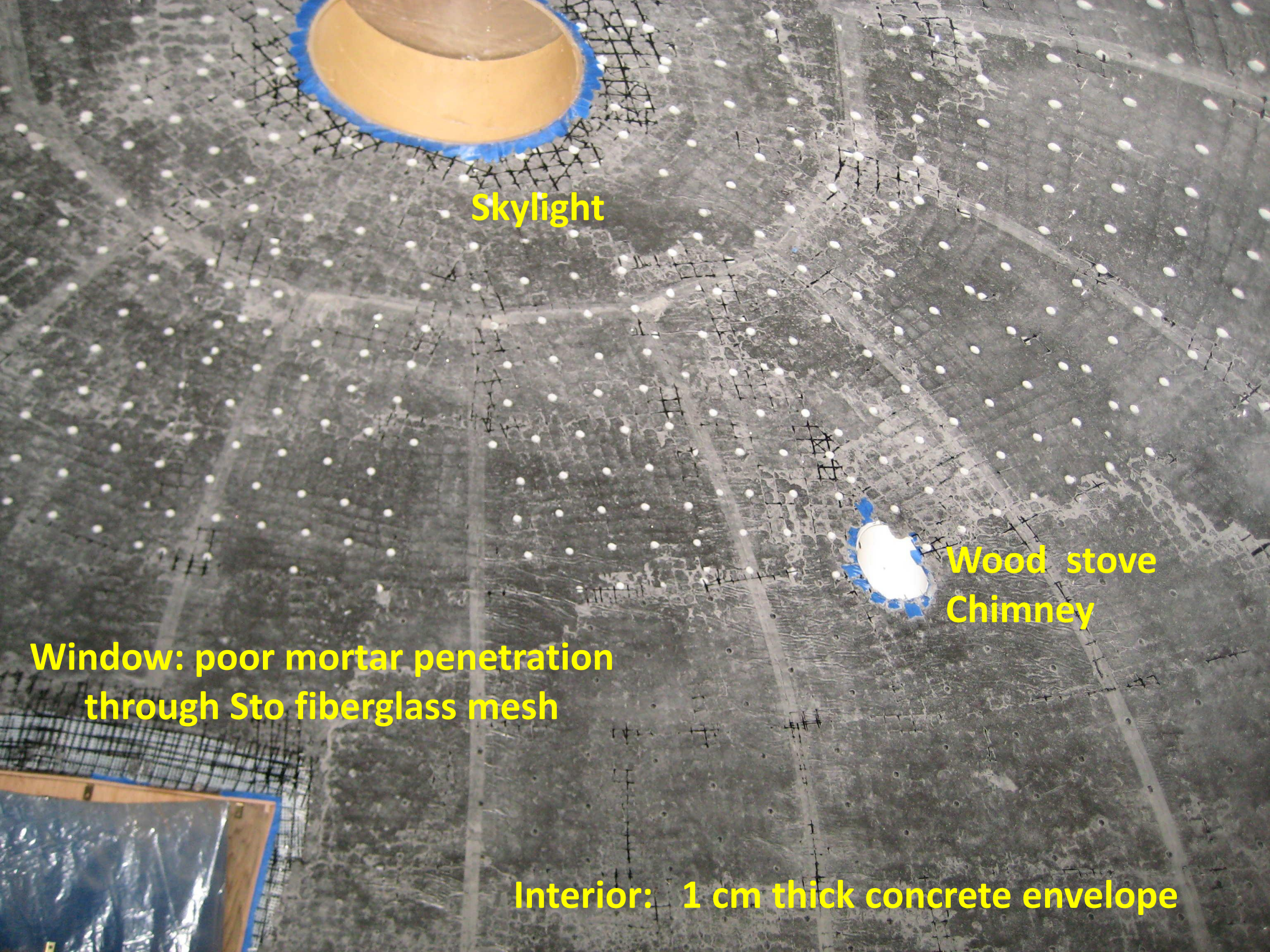


Side shim
with
removal
handle

Sheet steel skid
plate on
foundation
concrete
(bottom shim
removed)

Lower shim

After 30 hours concrete cure: Remove lower shims



Skylight

**Wood stove
Chimney**

**Window: poor mortar penetration
through Sto fiberglass mesh**

Interior: 1 cm thick concrete envelope

Skylight

Scaled plumbing vent

**Scaled
woodstove
chimney**



1 inch interior UR foam + plaster
12 volt LED lighting + USB charging **Sleeps three**



Robust, insulated shelter -- a prototype for "housing"



Scale model prototype in Juneau, Alaska 2010



Scale model prototype in Juneau, Alaska 2010



**Thin-shell Concrete Small Buildings:
 Low-cost, Long Life, Low Earth Impact
 Climate Change Protection
 Rapid On-site Build**

\$ 600 K to scale-up to human-useful size:

- Test, engineer, mature, secure markets
- Add Value: IP, market position, tooling
- Global standard: small buildings

\$ 5 million to commercialize: Business models

Low-cost, Earth impact Fast on-site build
Durable, long-life "housing" Remote sites



13 years in Alaska forest



After 13 years, abandoned, without an entry door, in the Juneau, Alaska forest, we scraped off ~ 3 cm of moss, pressure washed and painted the concrete shell, and finished the restoration.



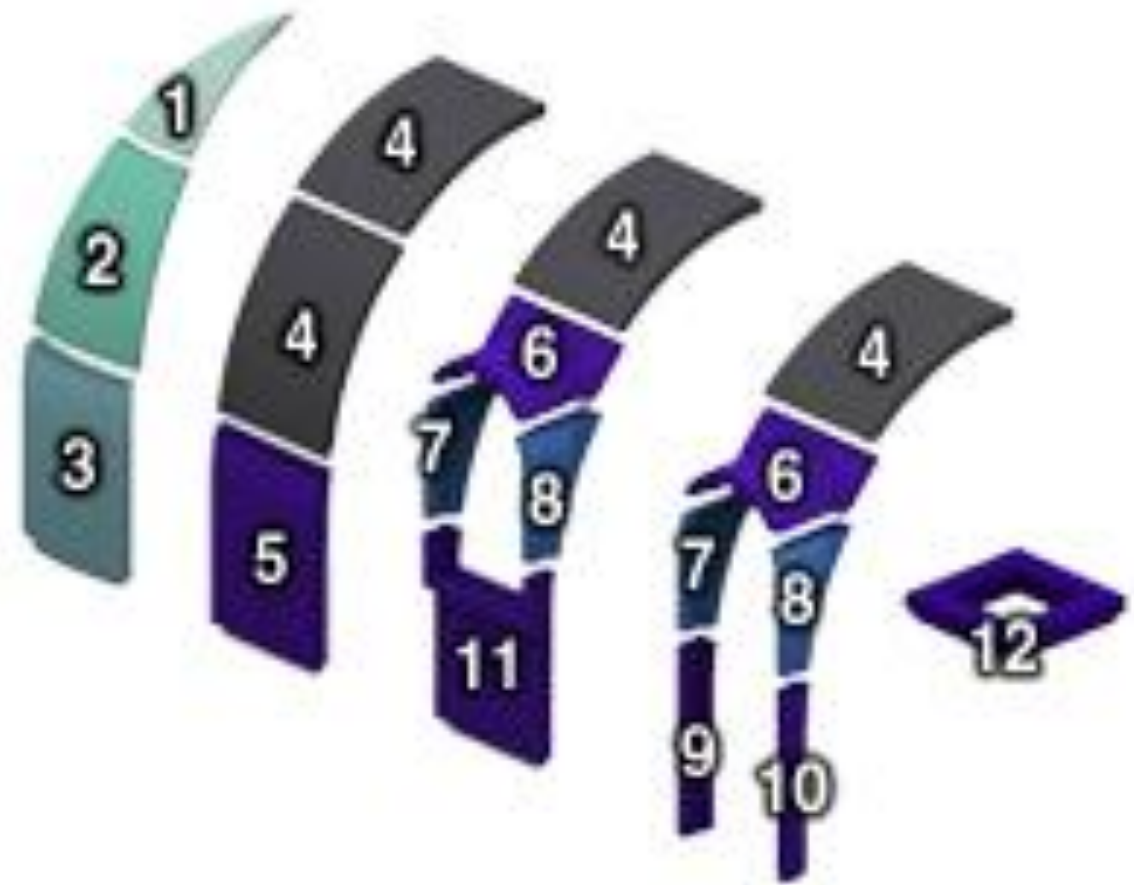
Refurbished: August 2023



Refurbished: August 2023

Refurbished: August 2023



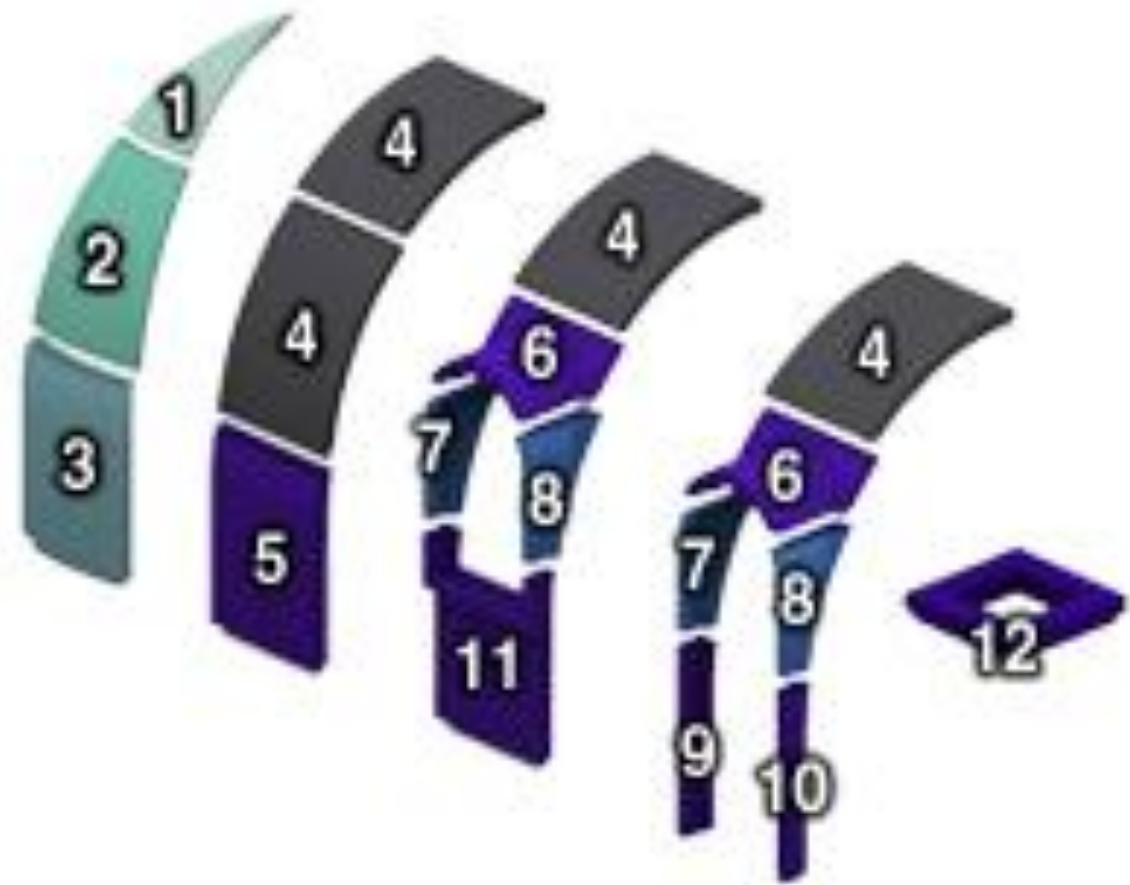


Build on-site:

- Beats factory-made ?
- Transportation cost
- Foundation, floor

Concrete forms set:

- Import → return
- Reusable
- Volume = economy



Assemble on-site

- **Factory-made**
- **Transportation cost**
- **Foundation, floor**

Concrete forms set

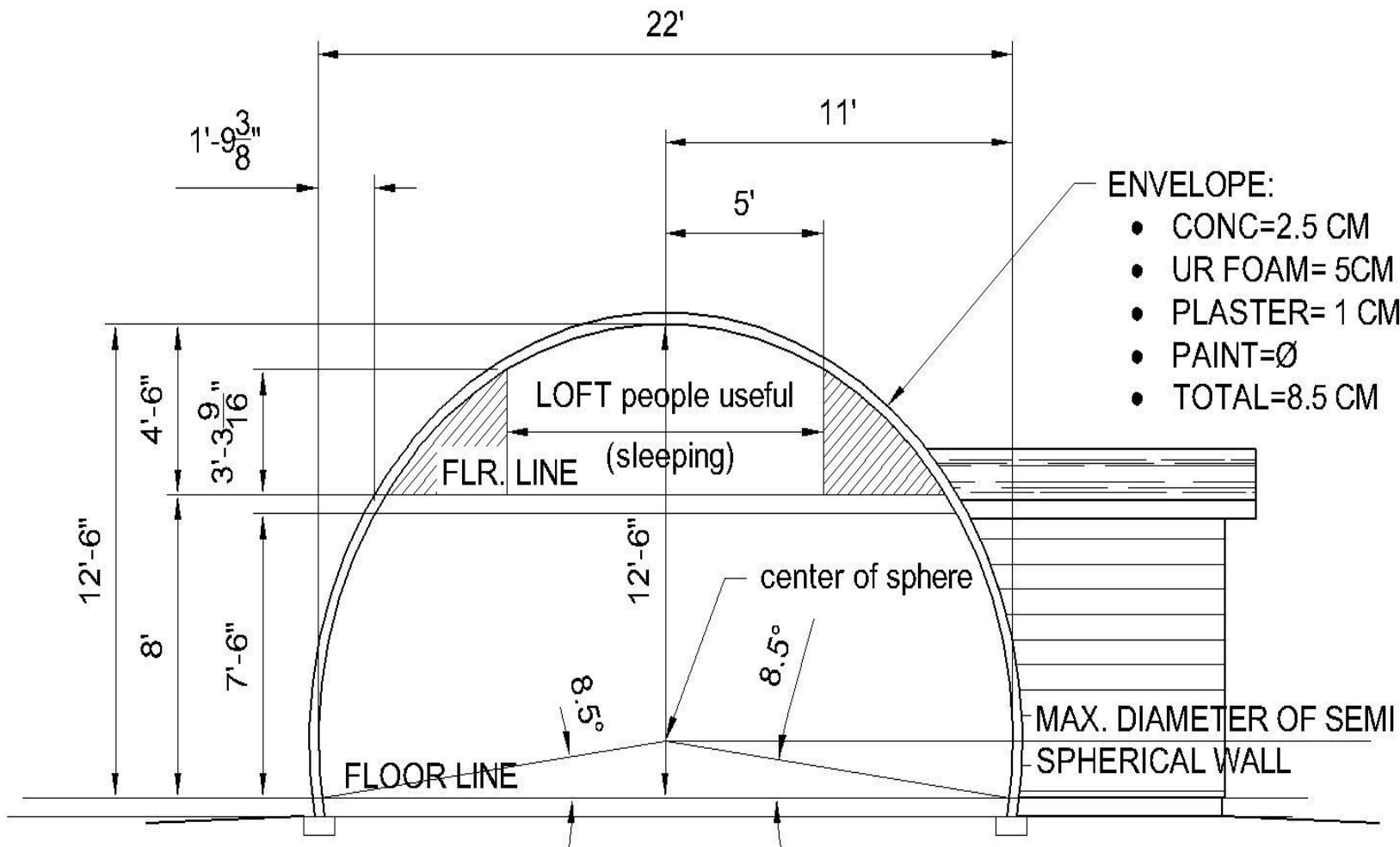
- **Import; return**
- **Reusable**
- **Volume = economy**

“Quasi-spherical”

- Beyond a “dome”
- Stretch to a “sausage”
- Large radii of curvature
- Strong with uniform load
- Only 2 cm (1 inch) thick, full size
- Morph shape
- Many variations possible

Scale-up Prototype to Human-useful size:

- Design + build new tooling
- Build two sets of one-side concrete forms
- Build thin-shell concrete “model homes”: RD&D + customer acquire



BUILDING SECTION

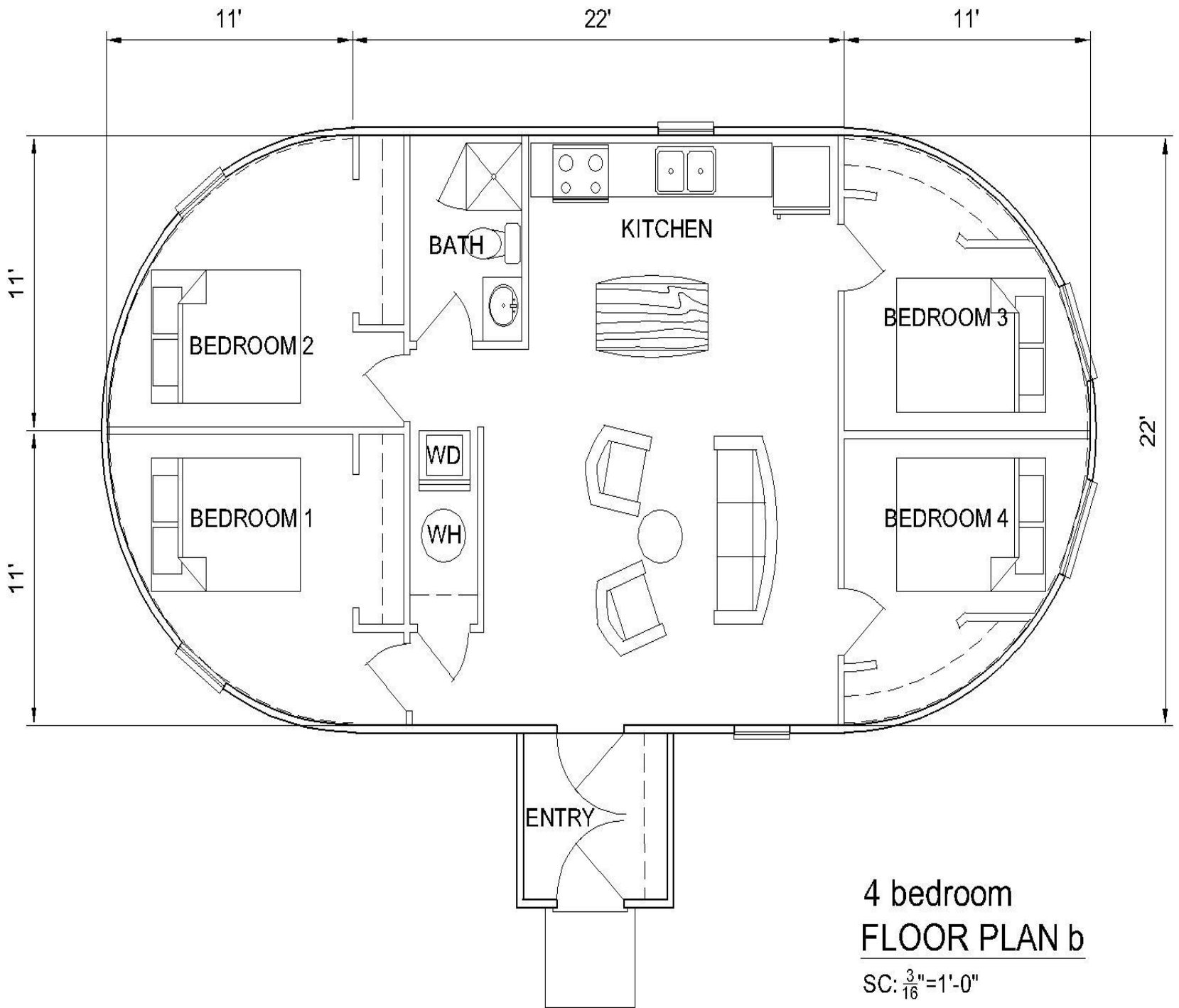
SC: $\frac{3}{16}'' = 1'-0''$

Cross section
Elongated

~ 5/8 sphere,
cylinder

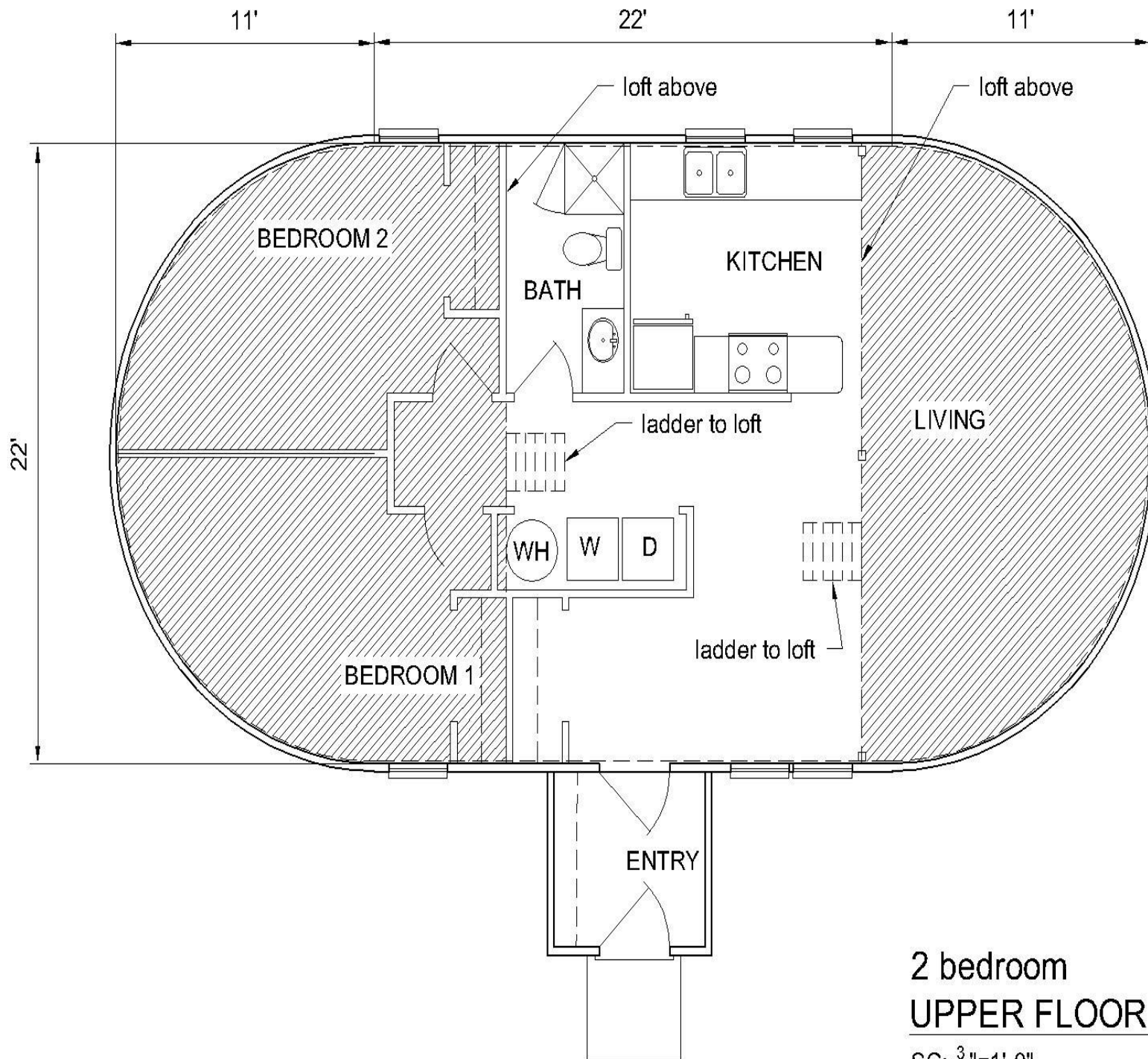
22 x 44 ft

1,055 sq ft
Including lofts



4 bedroom
FLOOR PLAN b
 SC: $\frac{3}{16}'' = 1'-0''$

**Floor Plan Option
 4 bedroom, 1 bath**
 Two half-lofts not shown



**Two Half-lofts
Above main floor**

Sleeping plus storage

Access via ladders:
Fixed or retractable

See Cross Section:
About 4 ft
head room at loft center

2 bedroom
UPPER FLOOR PLAN

SC: $\frac{3}{16}''=1'-0''$



Alaska villages: coastal erosion from GCC

- **Sea ice: Later in Fall, earlier in Spring: Storm waves**
- **Sea level rise**
- **Relocate ~ 12 Alaska villages**



Alaska village housing: rot from within and without



Alaska village housing: replace houses or move village:

- **High cost: isolated, small market**
- **Minimize imports: material, tools, expert labor**
- **Serial production: reusable forms; ~ 4 - 5 day cycle**
- **Alaska, Haiti, Pakistan, KY, NC → world market**



Breakthrough Energy Fellows Concept Paper Pitch Deck

Team: Bill Leighty, Alaska Applied Sciences, Inc., Applicant
Prof Robin Gilcrist, University of Alaska Southeast
Prof Hee-Jeong Kim, University of Arizona
Alan Wilson, Alaska Renovators, Inc.

Applicant: Alaska Applied Sciences, Inc.
Explorer

REV 28 Oct 24

Applicant/Team



William C. Leighty

Bill Leighty will be PI and project manager for Alaska Applied Sciences, Inc.

- BS Electrical Engineering, Stanford, 1965
- MBA, Stanford, 1971
- 1990 - present: Principal, Alaska Applied Sciences, Inc., Juneau, AK
 - C-corp, Founded 1990, Juneau, AK, for diverse R&D for global markets
 - www.AlaskaAppliedSciences.com
- 1985 - present: Director, The Leighty Foundation
 - Small, charitable, family foundation, founded by his father in 1985
 - Co-director, Earth Protection program
 - Co-author of > 100 papers, posters, and panels on renewables-hydrogen energy systems
 - www.LeightyFoundation.org/Earth.php
- 1971 - 75: Program Budget Analyst and Consultant, State of Alaska
- 1972 - 90: Small business owner, construction contractor, cruise ship tourism, R&D, Juneau, AK
- 1966 - 69: Collins Radio Company
 - Assistant Product Line Engineer and Manager, Marketing, Cedar Rapids, IA
 - Field Engineer, Thailand and Vietnam

Applicant/Team



Robin Gilcrist

Professor Gilcrist will provide or approve CAD drawings; contribute to interior design layout, wiring, lighting, and mechanical systems design; lead building permit applications for one or more prototype homes to be built for sale in Juneau, Alaska.

- AAS Sacramento City College 1980
- BA University of Hawaii 1993
- MEd University of Alaska Southeast 2004

Professor of Construction Technology, University of Alaska Southeast, Juneau, 1997 - present:

- Residential Design
- Residential Building Science
- Tools and Materials of the Trades
- Computer Aided Drafting
- Construction Estimating and Scheduling

Site supervisor, construction of small, energy efficient homes, built by university and high school students, sold to modest income families.

Owner, Interline Design, since 1990. Design and construction documents for new homes, remodels, and additions. This requires continuous professional development as building codes, materials, tools of the trades, and construction methods evolve.

Applicant/Team



Professor Hee-Jeong Kim

Professor Kim will test concrete mortar samples for mechanical strength, workability, and freeze-thaw properties; design mortar mix for the prototype houses in Alaska or elsewhere; perhaps supervise building one or more prototype homes for sale in Arizona.

Assistant Professor, University of Arizona, Tucson:

- Department of Civil and Architectural Engineering & Mechanics
- Department of Materials Science & Engineering
- Department of Mining & Geological Engineering

Ph.D. Civil and Environmental Engineering - Korea Advanced Institute of Science and Technology (KAIST), Deajeon, South Korea

M.S. Civil and Environmental Engineering - Korea Advanced Institute of Science and Technology (KAIST), Deajeon, South Korea

B.S. Civil and Environmental Engineering - Korea Advanced Institute of Science and Technology (KAIST), Deajeon, South Korea

Postdoctoral research at the Department of Civil and Environmental Engineering, MIT

Her area of expertise is the multi-scale chemo-mechanical characterization of advanced materials in civil engineering:

- Improving the sustainability and resilience of civil infrastructure,
- Designing and developing new construction materials based on advanced multi-scale computational modeling and experimental characterization,
- Utilization of digital fabrication, including large-scale printing in the development and application of new construction.

Applicant/Team

Alan Wilson



Mr. Wilson's company will build one or two prototype foam-insulated thin-shell concrete homes for sale in Juneau, Alaska. He will contribute to interior design and to electrical and mechanical designs; assist in building permit applications in Juneau, Alaska.

President, Alaska Renovators, Inc., since 1998

Board and Founding member, former Board Chair, Cold Climate Housing Research Center, Fairbanks, Alaska

Board member, Alaska Heat Smart, Juneau, Alaska

State of Alaska, General Contractor License # CONG26864

- 2019 Building Code Advisory Committee, Juneau, Alaska
- 2015-2020 Board member, Alaska Housing Finance Corporation, served as Vice-chair
- 2016 Affordable Housing Summit, University of Alaska Anchorage
- 2007-2012 Affordable Housing Commission, Juneau, Alaska
- 2003-04 President, Southeast Alaska Home Building Association, Juneau, Alaska
- 2003 Alaska State Home Building Association Builder of the Year
- 2003 Board member, Housing First, Juneau, Alaska
- 2002 Builder of the Year, Juneau Home Builders Association
- 2000 President, Alaska State Home Building Association
- 1998-2000 Owner, True Blue Construction, Juneau, Alaska
- 1997 Alaska State Home Building Association Builder of the Year
- 1997 President Juneau Home Builders Association
- 1991 Planning Commissioner, Crescent City, CA
- 1990-92 Board Member, Del Norte Economic Development Corp, Del Norte County, CA
- 1988 Obtained California General Contractors License - Class B

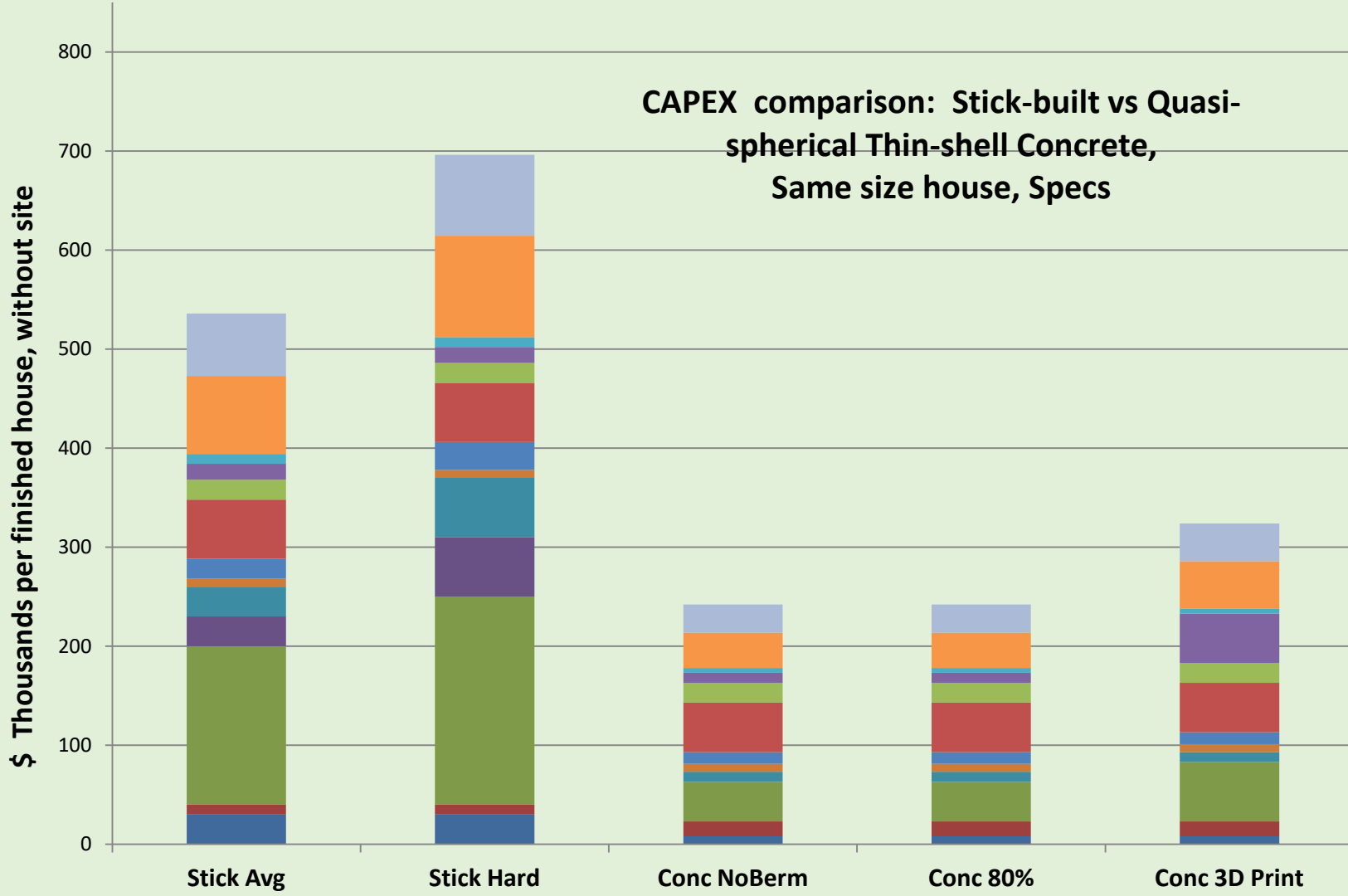
Techno-Economic Analysis: (TEA)

Compare quasi-spherical thin-shell concrete house to:

- Standard stick-built house: status quo
- “Hardened” stick-built
- 3D printed concrete: competition

		Stick-built; Hardened (FL code); Superinsulated	Quasi-spherical; Thin-shell concrete; No Earth berm or bury	Quasi-spherical; Thin-shell concrete; 80% Earth bermed	Quasi-spherical; 3D-printed concrete; no Earth berm or bury
Extraordinary differences: Advantages; Limits; Features	Stick-built; Average USA code				
Fast envelope closure: uninsulated	No	No	Yes	Yes	Yes
Fast envelope closure: insulated	No	No	Yes	Yes	Yes
Earth-shelterable: berming to 3 ft	No	No	Yes	Yes	Yes
Earth-shelterable: total burial	No	No	Yes	Yes	Yes
Super-insulation: no thermal bridge	No	Yes	Yes	Yes	Yes
Non-combustible exterior	No	No	Yes	Yes	Yes
Load-bearing interior walls: unlimited	Yes	Yes	No	No	No
Load-bearing interior walls: lofts only	No	No	Yes	Yes	Yes

- Foundation
- Insulate + protect
- Kitchen + bath modules
- Contractor Profit
- Floor
- Doors + windows
- Equipment rent, use, maint
- Struct shell
- Interior walls
- Consumables
- Roof + attic
- Plumb, wire, fixt, lights
- Contractor Overhead

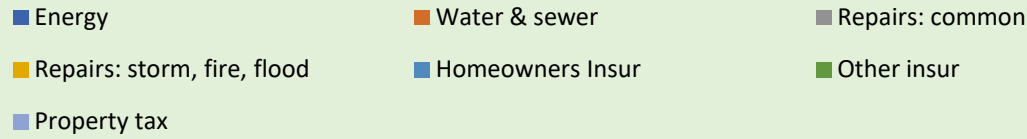


Techno-Economic Analysis
Compare to:

- Standard Stick-built
- 3D printed concrete

X-axis:

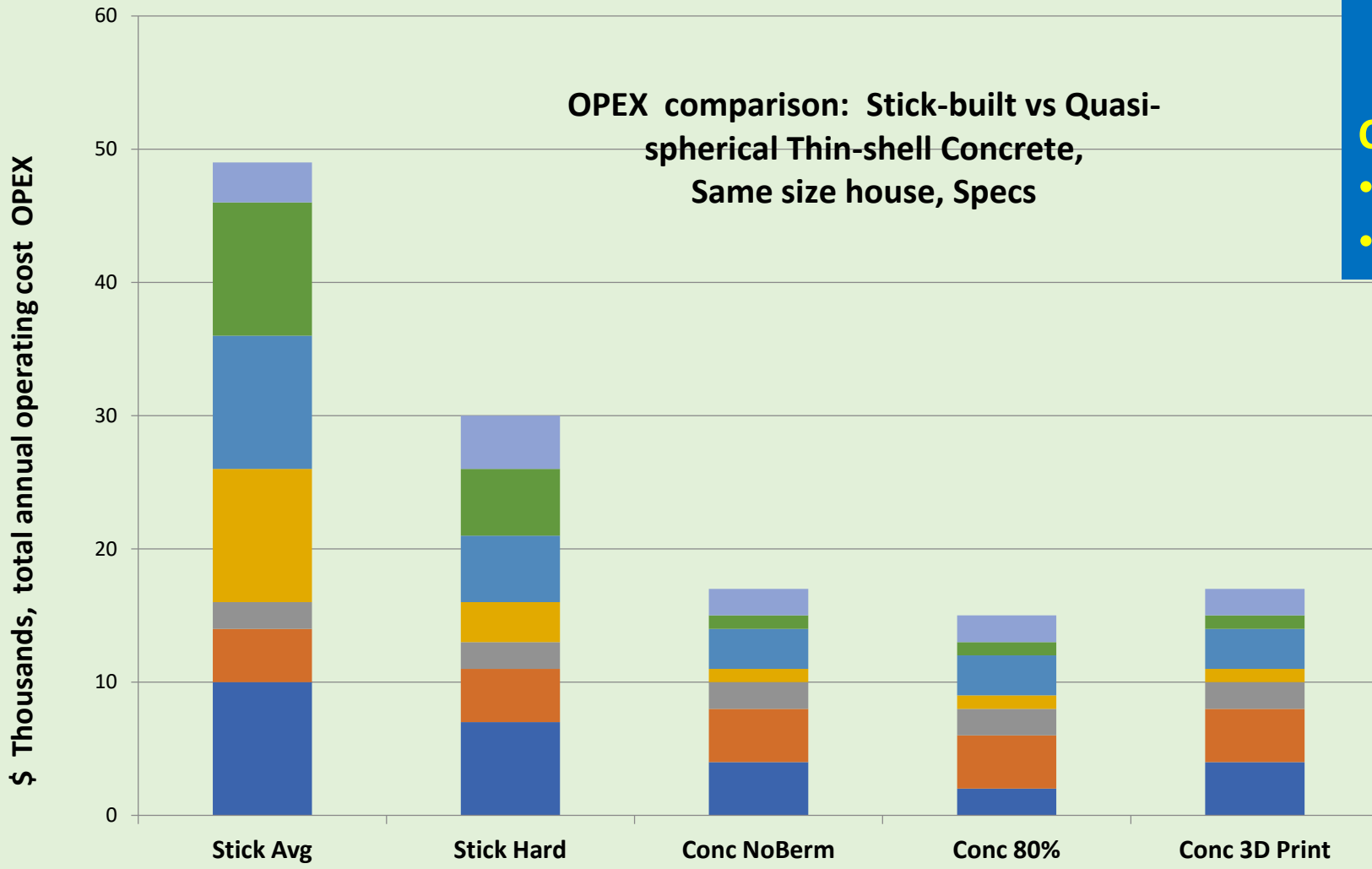
- Stick Avg: Stick-built house, per typical, average building code specs
- Stick Hard: Stick-built house, per South Florida building code, hardened for hurricane resistance
- Conc NoBerm: Quasi-spherical thin-shell concrete without exterior Earth berming
- Conc 80%: Quasi-spherical thin-shell concrete with Earth berm to 80% of building height
- Conc 3D Print: Quasi-spherical thin-shell concrete built with 3D printer, no primary reinforcement



OPEX comparison: Stick-built vs Quasi-spherical Thin-shell Concrete, Same size house, Specs

Techno-Economic Analysis
Compare to:

- Standard Stick-built
- 3D printed concrete



X-axis:

Stick Avg	Stick-built house, per typical, average building code specs
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Conc 3D Print	Quasi-spherical thin-shell concrete built with 3D printer, no primary reinforcement

Technology Context & Key Metrics

- > Best-in-class incumbent: Super-insulated, hardened, stick-built, detached single family home
- > Competition: 3D-printed concrete: rectangle, walls-only, or 5/8 quasi-sphere by volume

Key Metric	Description of Key Metric	Best in Class Incumbent	Your Solution Today	Your 24-month Target	Your long-term goal
Embodied GHG	Embodied energy: (materials + construct) per m ²	~ 200 kg CO ₂ e / m ² / year	70	65	60
CAPEX: depends on "finish" degree	Occupancy-ready detached dwelling, 100 m ² plus loft	\$ 1,000 / m ²	\$ 400 / m ²	\$ 300 / m ²	\$ 200 / m ²
Annual OPEX, global average	Heat + cool @ \$.10/kWh + maintenance + repair	\$ 900 / year	\$ 400	\$ 300	\$ 200
Useful life, years	Includes low-probability disaster damage, destruction	40 - 60	80 - 100	100 +	150 +
Durability: general maint + damage	Survive severe weather; repair cost avoid = 0	Merit = 4 (High= 10, Lo= 0)	8	9	10
War protection, Earth burial, seismic survive	Total burial or berm: strength + waterproof to survive bldg lifetime	Merit = 2 (High= 10, Lo= 0)	8	9	10
Remote site response time, economy	Time + cost to move in/out mat'ls, tools, expert labor	Merit = 3 (High= 10, Lo= 0)	6	7	8

Project Plan:

Many activities simultaneous: total elapsed = 12 months; budget \$ 600 K

Milestone	Milestone Description	Proposed Budget	Milestone Duration
1	Tooling CAD drawings set; quotation from Janicki Industries; contract sign	\$ 20,000	2-3 months
2	Production tooling built: Janicki	\$ 300,000	2-3 months
3	Concrete mortar mix design; samples test; FEA building analysis + design	\$ 20,000	2-3 months
4	Two sets forms built for thin-shell concrete envelope: Janicki	\$ 60,000	2 months
5	Prototype building # 1 built for test, architect + enrg design improve; CAD	\$ 50,000	2 months
6	Prototype # 1 finish, test, engineering and architect design, CAD drawings set	\$25,000	2 months
7	Achieves strength, durability spec: enrg testing; calcs review; "stamped"	\$15,000	1 month
8	Building permit issued, from CAD and engineering calcs, for prototype #2	\$ 5,000	1 month
9	Customers identified: business plan(s) drafted; Team effort + consultant	\$ 5,000	2 months
10	Prototype # 2 built, sold at profit; bldg permit; bank construct loan, mortgage	\$ 0	3 months

Value Proposition

Status quo: Most small buildings, housing and other, in USA and the world, are “stick-built” with attached sloped roof; made of many pieces of woody materials; vulnerable to weather extremes, fire, earthquake, flood, war, rot and vermin; difficult to seal and insulate; time-consuming to build. Many pieces of large amounts of materials and tools must be imported; semi-skilled workers hired, trained. High CAPEX, OPEX.

Low lifecycle cost: novel tech is ~ one-third CAPEX, OPEX; one-fourth build time; several times life of “stick-built”. Non-combustible, fireproof, Earth-shelterable. Minimum materials, tools, export labor import, to remote or to any sites. No foundation or slab required: monocoque. Easy super-insulation; no thermal bridge. Use local sand, water, labor. ~ 2-3 cm thick one-piece concrete shell envelope.

Estimated costs for 100 m² ground floor, small, simple, insulated, plumbed + wired “house”, with two lofts. Assume Midwest USA prevailing labor + material costs; ready for optional Earth berm or burial:

- Envelope with windows and door, 3 cm UR foam interior insulation, materials + labor \$US 50,000
- Interior finish: plumb, wire, partition walls, modular kitchen +bath, HVAC, M&L \$US 60,000
- Total building cost, on-site build, occupancy ready, with loft; no land or site cost \$US 110,000

Technologies competing with ours are higher cost and Earth impact; less durable; readily burn; vulnerable to roof blowoff + collapse; slower to build; cannot be Earth-sheltered; hard to insulate well; need urban materials access:

- Stick-built or block-built roofed boxes: foundation + complex, bulky, heavy, large materials import
- Factory built kits: many pieces to import; difficult to harden and insulate; costly transport from factory
- 3D printed concrete: no primary reinforcing; seismic risk; large concrete volume; costly printer + move-in

Global Problems Solved – GCC *

* Global Climate Change dangers increase

1. Stick-built obsolete: Hurricanes Helene and Milton, and hundreds of tornados and severe storms, prove affordable wood houses and other small buildings inadequate:
 - a. Weak: Storms, seismic, roofs blow off → collapse
 - b. Ruined by floods: sheet rock, insulation, mold, rot
 - c. Flammable: wood frame and roof
 - d. Complex, costly: Many pieces; many trades; much labor
 - e. Poorly insulated: Thermal bridging by framing lumber
2. Concrete embodied energy + GHG: Greatly reduce the very high embodied energy and greenhouse gas (GHG) emissions -- as we now make and use it -- Mitigation requires:
 - a. Use less concrete, by mass and volume;
 - b. Batch (mix) with novel (non-portland) GHG-emission-free cementitious materials;
 - c. Minimize energy and transportation costs to jobsite; on-site mix, place, finish, cure.
3. Housing cost high: Reduce both long-term CAPEX and OPEX for small buildings; increase long-term durability and protection; faster and better response to disasters, especially those remote.
4. Tough site access: Builders deployment costs. Our novel on-site manufacturing process is ideal; minimum import of materials, tools, equipment, expert labor. Reusable forms sets: 100 buildings
5. Optimum tech and econ on-site manufacturing process: Quasi-spherical thin-shell concrete small buildings for rapid enclosure + finish; durable; super-insulated; Earth-shelterable; no roof

Global Problems Solved – BENEFIT : COST

Juneau, Alaska 2009 - 2024

Thin-shell concrete building system: proof-of-concept, scale model -- 14 year Alaska field test

1. Rapid, low-cost, on-site-built housing and other small buildings, anywhere in the world
2. Survive storm, flood, fire, earthquake
3. CAPEX ~ 1/3 stick-built: fast enclosure; no roof; no foundation; spray UR foam insulation
4. OPEX ~ 1/2 stick-built: super-insulated; Earth-bermed or - buried; non-combustible
5. ~ 2 cm thick quasi-spherical envelope: variable shape and size

With probable long-term advantages vis-a-vis conventional construction:

1. For small buildings, probably < 150 m² floor, in low density communities:
 - a. Residential detached single-family or duplex
 - b. School, clinic, workshop, small factory
 - c. Shelter, storage
2. Higher survivability, with lower rehab costs, from severe weather, fire, seismic, flood, tsunami, and war
3. One-fourth embodied energy: built with novel low-GHG-emission cementitious materials (“cement”)
4. One-third CAPEX, depending on finish level
5. One-fourth OPEX, mostly energy savings, especially if Earth-bermed or Earth-sheltered (buried)
6. Three to ten times expected service lifetime; very low envelope maintenance
7. Ten times war zone protection: small arms fire, shrapnel, explosions -- if completely Earth-sheltered

Problem Statement

As Global Climate Change (GCC) and conflict dangers increase, humans need far more durable, inexpensive, low-Earth-impact small buildings for shelter, housing, school, clinic, storage. Obsolete stick-built, roofed structures: little protection from extreme heat, storm, fire, flood, earthquake, war.

- a. Reduce both long-term CAPEX and OPEX for small buildings;
- b. Increase long-term durability and protection.
- c. Respond faster and better to disasters, especially those remote.
- d. For low-density communities and regions where small buildings prevail, the roofed box obsolete:
- e. Expensive, vulnerable to damage, difficult to insulate and to Earth-shelter from extremes.

The thin-shell concrete building system we have demonstrated at proof-of-concept, scale model, in Juneau, Alaska from 2009 – 2023, can produce on-site housing and other small buildings, anywhere in the world, at approximately these long-term advantages vis-a-vis conventional construction:

- One-third or less of embodied energy: build with novel low-GHG-emission cementitious materials (“cement”)
- One-third CAPEX, depending on finish level
- One-fourth OPEX, mostly as energy savings, especially if Earth-bermed or completely Earth-sheltered (buried)
- Three to five times expected service lifetime
- Much higher survivability, with lower rehab costs, from severe weather, fire, seismic, flood and tsunami events
- Probably ten times the protection from small arms fire and shrapnel, if completely Earth-sheltered
- For small buildings, probably < 150 m² floor, in low density communities: residential detached single-family or duplex

Core Technology Innovation

See slides after “Project Plan”. Prototypes prove:

1. Strong, durable “monocoque”: unitized thin-shell concrete structure
2. Very robust, durable: many decades service life
 - a. Survive storms, fire, flood, tsunami, war; no roof; strong monocoque resists high isotropic loads
 - b. Capable of Earth berming or full burial: protection from climate extremes, storm, fire, flood, war;
 - c. Seismic-resistant: tested at repeated ~ 2.7 g horizontal shocks
 - d. Corrosion-free: carbon-fiber-epoxy primary reinforcement; no steel; paintable exposed surfaces
 - e. Floodproof: Easy cleanup: no sheetrock or insulation rot; hose-wash interior and exterior
3. Fast – an enclosed envelope every four days, built on-site, using novel forms sets + a few special tools
4. Low-cost – about one-fourth cost of stick-built for an insulated envelope, per unit volume and floor space
5. Low-Earth-impact – full-size concrete shell ~ 2 -3 cm thick; low embodied energy; prototypes ~ 1 cm thick
 - a. Use novel emissions-free cementitious materials (cements)
 - b. Carbon-fiber-epoxy primary reinforcement stapled to form, overlapping tiles; no steel, no corrosion
6. Flexible configuration for envelope, interior, and mechanical:
 - a. Stretch to “sausage” by adding barrel-vault form midsection; windows + doors anywhere
 - b. Interior open-span; no load-bearing walls; privacy spaces; simplify plumbing, kitchen, HVAC
7. Scale-up ready: production method and materials ideal for all aspects of Problem Statement
8. Large enough for housing, schools, clinics, shelter, storage; limited only by concrete form panel size
9. Maximize use of local sand, water, semi-skilled labor; minimize imports of materials, tools, expert labor
10. Now need full-size tooling, for forms sets manufacture: easily shipped worldwide, reusable 100 times

Emissions Impact: Prevent 500 MMT / year CO₂

Every small, quasi-spherical, thin-shell concrete, house or other building larger than $\sim 200 \text{ m}^3$ interior volume, with $\sim 100 \text{ m}^2$ floor area, will prevent CO₂ emission of approximately: (MT = metric ton = 1,000 kg)

- 5 MT embodied energy, one time, during construction
- 10 MT / year OPEX from prevented heating + cooling energy and maintenance efforts

Larger buildings will save more: approximately linear with envelope surface area

Assume annual OPEX CO₂ emission $\sim 200 \text{ kge CO}_2 / \text{sq m} / \text{year} = \sim 10 \text{ MT} / \text{year}$

Assume worldwide construction, at technology maturity, of 1 million of this size building per year, for first 10 years:

- Year 1 CO₂ savings = $(5 + 5 \text{ MT}) \times 1 \text{ million} = 10 \text{ million MT CO}_2 \text{ emission}$
- Year 10 cumulative CO₂ savings = $(5 + 10 \text{ MT}) \times 10 \text{ million} = 550 \text{ million MT CO}_2 \text{ emission}$
- Total annual CO₂ savings, year 11 and beyond, if building stops = **1,000 million MT CO₂ emission / year**

Potential global build rate is far greater than 1 million structures per year, magnifying CO₂ emission savings.

Far longer expected building service life will improve these estimates, by reducing periodic rebuild CAPEX.

Earth-sheltering will also improve estimates for OPEX, via improved isolation from ambient T and weather, plus longer building service life.

Global Climate Emergency

Stick-built, Gable-roof

- Vulnerable, weak, combustible
- Costly: many pieces, high labor
- Hard to super - insulate
- Cannot Earth-shelter: berm, bury
- Insurable ?
- Obsolete ? GCC dangers



Thin-shell concrete

- Quasi-spherical
- Strong monococque structure
- Housing, shelter, school
- Fast on-site build
- Low CAPEX, OPEX
- Low Earth impact
- Far less material: ~ 2 cm thick
- C-neutral concrete compatible
- Durable, long-life, secure
- Non-combustible envelope
- Resists, survives fire, storm, rot, flood, seismic, tsunami, war
- Earth-shelterable: berm, bury
- Disaster recover: remote site
- Flex configurable: shape, size

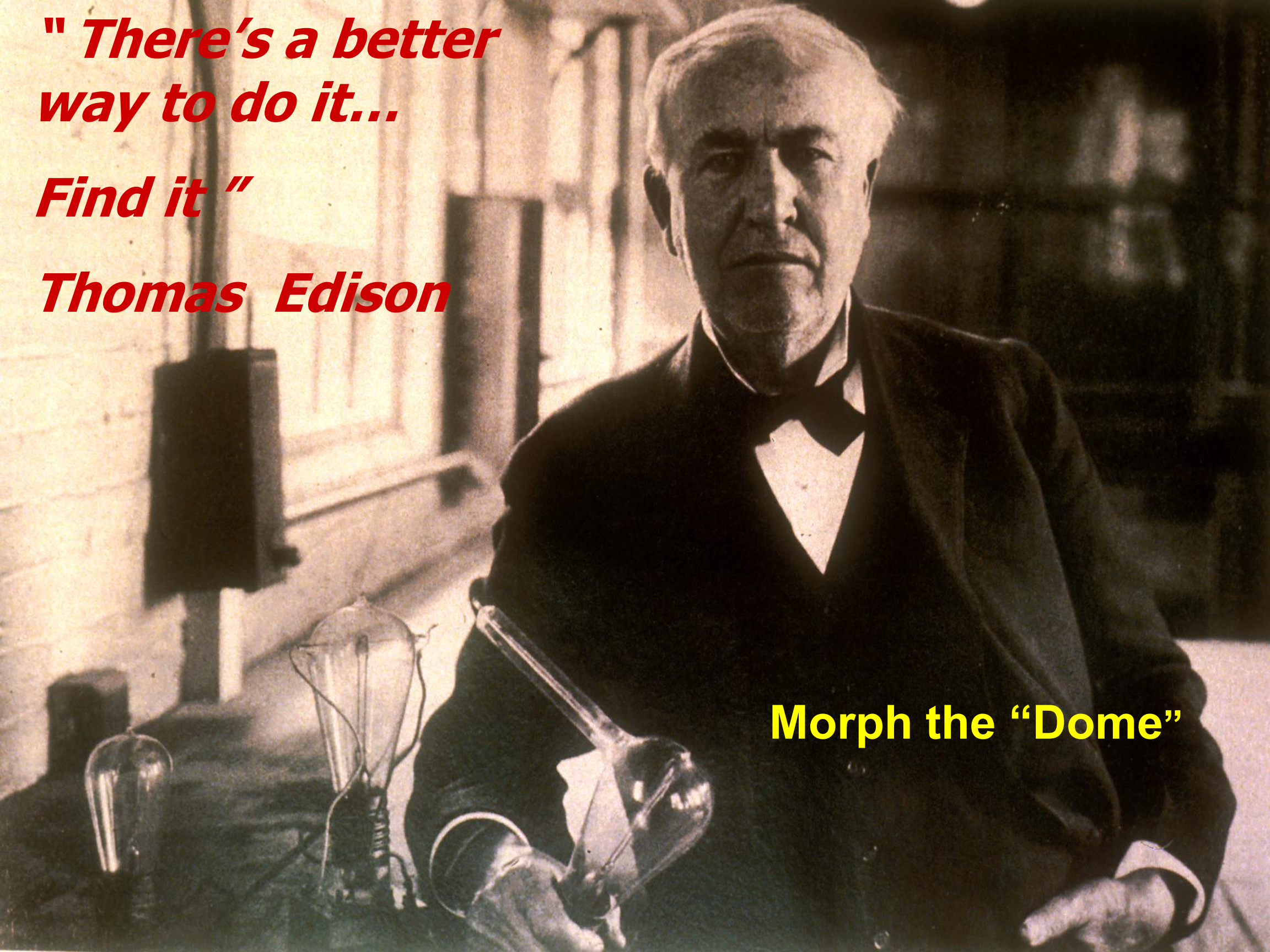


***" There's a better
way to do it..."***

Find it "

Thomas Edison

Morph the "Dome"



**Thin-shell concrete dome for housing, classroom, clinic, storage:
46% scale model, proof-of-concept prototype**

2009 - 2010

**Alaska villages
Afghanistan development
Haiti rebuilding**

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**Foundation ring
form set**

**Dome form set:
5/8 sphere**

Ring beam



Thin-shell Concrete Quasi-spherical Small Buildings: Durable, Low-cost, Low-Earth impact, Global Shelter

World Of Concrete 2026 Las Vegas

Bill Leighty, Principal
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Juneau, Alaska
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Rev: 16 Jan 26

Juneau, AK 1974: 16' diameter concrete dome: ½" thick, ~ 5/8 sphere 80

END: World Of Concrete 2026

Following slides are supplemental

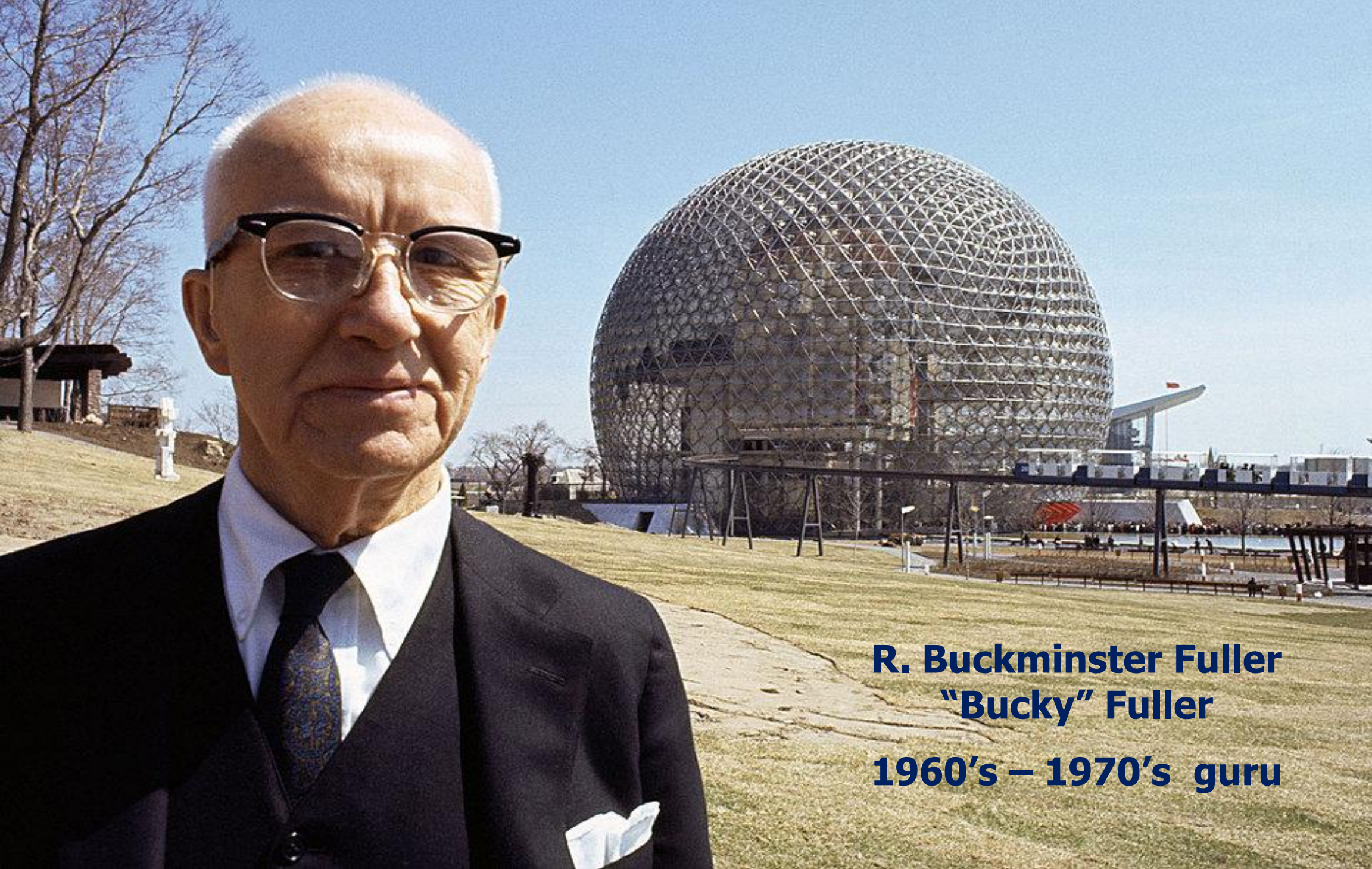
R. Buckminster “Bucky” Fuller

**1960’s: Invent, design, and
commercialize the “geodesic* dome”**

*** “Earth geometry”**

**The triangle and circle are the only
stable two-dimensional shapes.**

**Thin-shell concrete is ideal
for smaller buildings**



**R. Buckminster Fuller
“Bucky” Fuller
1960’s – 1970’s guru**

Geodesic Dome: Triangle is LGCD

Lowest Geometric Common Denominator



Isotropic* loading of thin shell: chicken egg is strong !

*** uniform, omnidirectional**



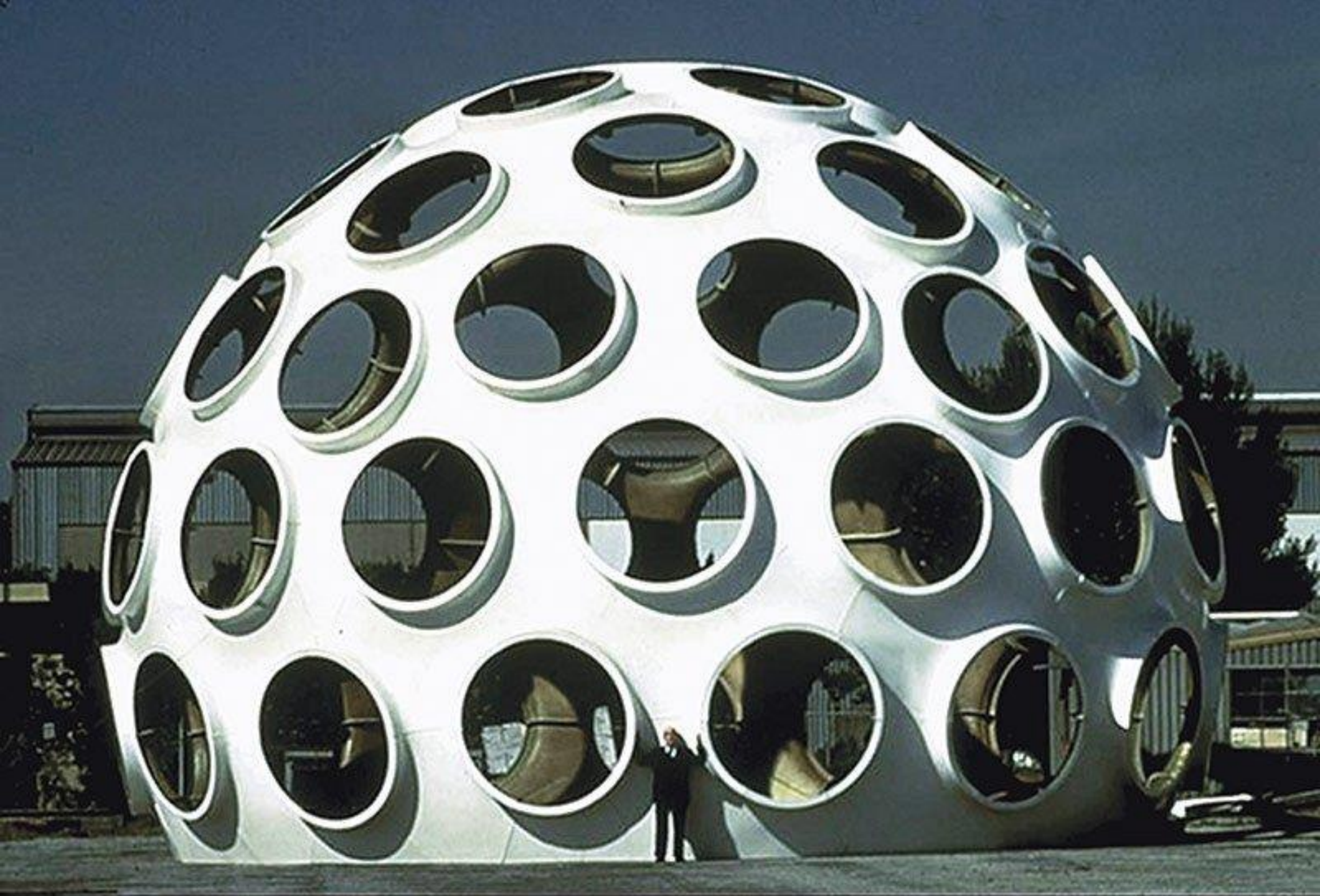
“Dome” -- New Age





Quasi-spherical structures:

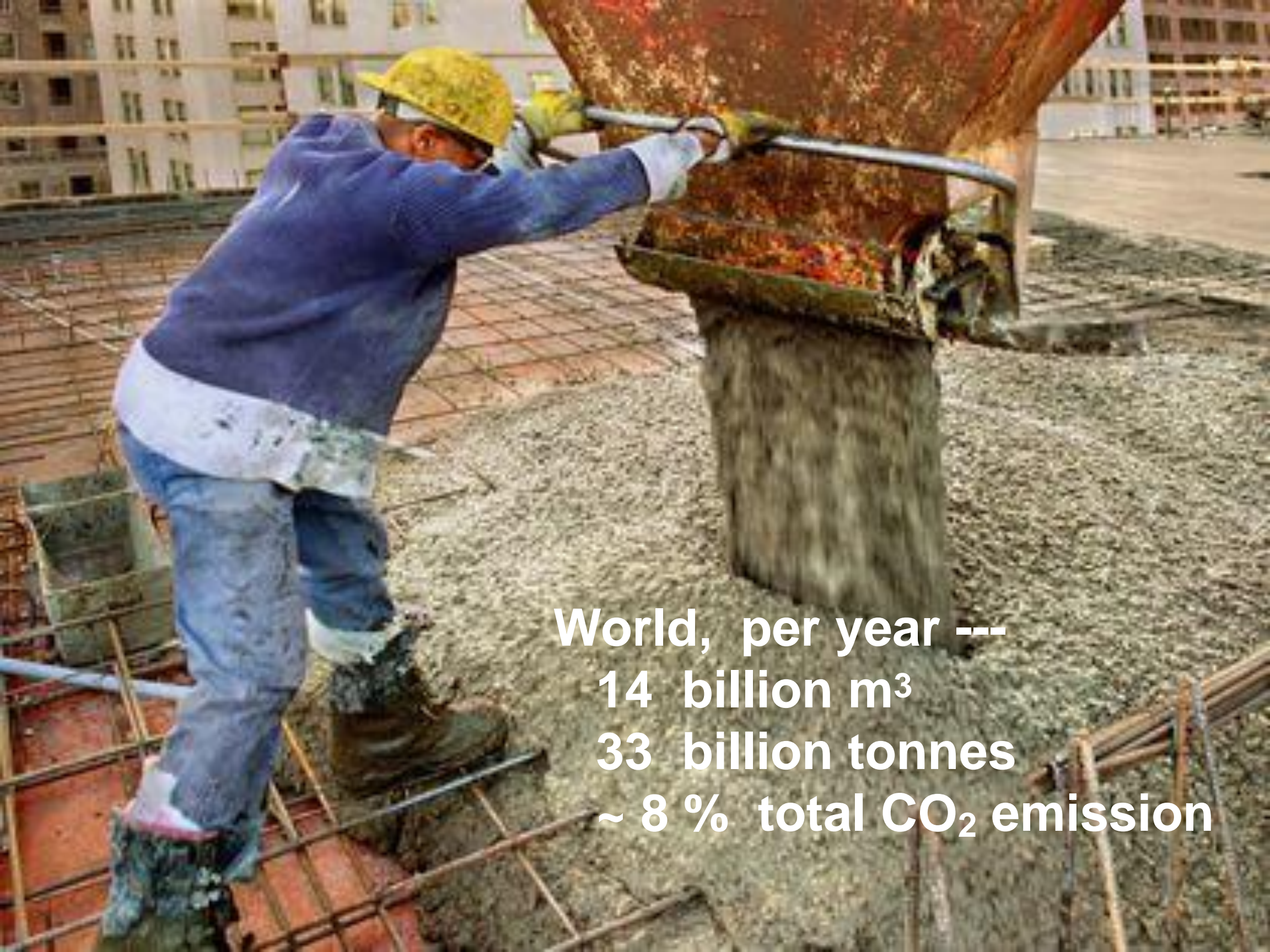
- **Strong, Resilient**
- **Isotropic loading: wind, water, snow, seismic, Earth-berm**
- **Minimum material / volume, area**
- **Large curvature radii, Low stress concentration**
- **“Geodesic dome” triangle, Earth**



Large radii, Low stress concentration, Modular



**Many thin concrete shells on Earth
Sydney Opera House**



**World, per year ---
14 billion m³
33 billion tonnes
~ 8 % total CO₂ emission**

Concrete: Most-used composite: Material, mass, money

- **Composite: synergistic materials use**
- **Abused: ~ 5% global CO₂ from “cement” manufacture**
- **Cheap reinforced mass: liquid rock**
 - **Portland cement**
 - **Aggregates: gravel, sand**
 - **Water**
 - **Primary reinforcement:**
 - **Rebar: steel, fiberglass, basalt**
 - **Grid: steel, fiberglass, carbon fiber epoxy “C-Grid”**
 - **Secondary reinforcements: fibers, plastic, steel**
 - **Additives, amendments: water reducer, acrylic, air entrain, curing post-placement**



Thin-shell Concrete Small Buildings: Low-cost, Long Life, Low Earth Impact, Climate Change Protection, Rapid On-site Build

Unique: to scale-up to human-useful size → housing

- **\$ 600 K outside investment now**
- **Prototypes to demo “model homes” → paradigm shift**
- **Credible, appealing, profitable “home”**
- **Test, engineering, design maturity →**
 - **Construction Costs, Long-term benefits**
 - **Building permits,**
 - **Assessors, mortgage lenders, insurers**
- **Pre-commercial: customers, biz plans, bankable, prep for growth**

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wleighty@earthlink.net **206-719-5554** **Juneau, Alaska**



Thin-shell Concrete Small Buildings: Low-cost, Long Life, Low Earth Impact, Climate Change Protection, Rapid On-site Build

- RD&D discovery: design, build prototypes, markets
- Equity partners, collaborators welcome
- Unique process → global market position
- Low costs, long life, flexibility, small structures
- Will it scale: “housing” ? Will it sell ?
- Which biz strategy ? Easy competitor entry ? IP ?
- 35-year company history: RD&D → energy, education
- No contracts, awards, funding: DOE FOA Full Applications; others
- Recommendations, referrals welcome

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wleighty@earthlink.net 206-719-5554 Juneau, Alaska



**Thin-shell Concrete Small Buildings:
Low-cost, Long Life, Low Earth Impact,
Climate Change Protection, Rapid On-site Build**

Unique: \$ 600 K now for scale-up, demo, prototypes, test, pre-commercial

- Interest, but no customers: “Show me”
- Quasi-spherical small buildings
- Housing, shelter, school, clinic, storage
- Flexible and adaptable building shape, size: quasi-spherical, thin-shell
- Very low CAPEX, OPEX, Earth impact
- Durable, long-life -- Climate Change adaptation
- Minimum import of materials, tooling, tools -- remote sites, or anywhere
- Fast on-site build: Disaster recovery, MIL bases, new neighborhoods
- Earth-shelterable: berm to total
- Super-insulation capable: interior seamless UR spray foam + protective plaster
- C-neutral, GHG-emission-free , novel “cementitious” compatible ?

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Designed for:

- **Housing, classroom, clinic, storage: Alaska village, global**
- **Permanent structures built on-site**
- **Minimum**
 - Embodied energy, CO₂ emission
 - Operating energy: UR foam superinsulation, closed-cell
 - First cost CAPEX
 - LCC, OPEX
- **Minimum imported**
 - Tooling and tools, forms set
 - Materials
 - Expert labor
- **External structural shell**
 - Durable
 - Waterproof
 - Fireproof
 - Impervious to corrosion, vermin
 - Earth-shelterable
- **Rapid replication of shell: ~ 4 - 5 day cycle**
- **Reusable male form; long life**

Proof - of - Concept Prototype

Slide 1 of 3

- **46% scale model of 18' ID full-size concrete dome**
- **~ 5/8 sphere (volume)**
- **8' 6" equatorial ID (concrete shell)**
- **< 1/2" thick concrete shell**
 - **Need engineering to confirm adequate structurally at full scale**
 - **FEA necessary for stress concentrations**
 - **Integral waterproofing: no coating needed**
 - **Earth berming or burying compatible**
- **Unique, reusable tooling**
- **Mortar:**
 - **Rich, portland cement**
 - **Sand only aggregate**
 - **High-fiber**
- **Reinforcement:**
 - **Primary: Chomarat C-Grid**
 - **Secondary: Fibermesh 150**
- **13-part dome form (12 side + top cap)**
- **Teflon dome form release surface**
- **UR foam insulated + protection layer**

Proof - of - Concept Prototype

Slide 2 of 3

- **46% scale model of 18' ID full-size concrete dome**
- **~ 5/8 sphere (volume)**
- **8' 6" equatorial ID (concrete shell)**
- **< 1/2" thick concrete shell**
 - **Need engineering to confirm adequate structurally at full scale**
 - **FEA necessary for stress concentrations**
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- **Teflon dome form release surface**
- **UR foam insulated + protection layer**

Proof - of - Concept Prototype

Slide 2 of 3

- **Prototype mortared:**
 - 12 Nov 09
 - Hand troweled; no vibration
 - Dome form removed 14 Nov
- **No shrinkage cracking in dome; cracks in entry roof**
- **Concrete form sets:**
 - Foundation, dome sets
 - Hand-made tooling
 - Reusable; many cycles → refurbish
 - Teflon release surface
- **“Circus ring” minimal foundation: 3” x 4” cross-section**
- **5/8 sphere (volume) dome**
 - Shim- assembled dome: unique
 - Easy assembly, removal: team of two
 - Easy removal from cured shell
 - Staples captured by outer rubber plies
- **Foundation + dome + entry = integrated structure**

Proof - of – Concept Prototype

Slide 3 of 3

- Shoestring R+D project
- No engineering: concept only. Anecdotes, little data.
- Simple load testing:
 - Prototype not representative: poor mortar application QC
 - Establish protocol
- Concrete Form Sets: Hand-made tooling
 - Foundation: plywood + foam + “Integument” Teflon
 - Dome:
 - Wet-layup epoxy glass: 12 + 1 pieces
 - 60 mil EPDM roofing
 - 30 mil butyl PSA
 - 5 mil Teflon
- Non-ferrous, non-corroding reinforcements
 - C-Grid primary (carbon-epoxy fiber grid)
 - SS staples tile rectangles to form
 - 1/4” self-stick rubber chairs
 - Fibermesh 150: 1/4 “ + 3/4 “ cut, in mortar mix
- Easy mortar application:
 - Sand-only aggregate
 - Trowel
 - Spray
 - Shotcrete
- Ideal for superinsulation:
 - Minimum surface area for volume
 - No thermal bridging through structural elements
 - Easy UR foam and interior finish spray application



Details: Breakthrough Energy Fellows Concept Paper Pitch Deck

Team: Bill Leighty, Alaska Applied Sciences, Inc., Applicant
Prof Robin Gilcrist, University of Alaska Southeast
Prof Hee-Jeong Kim, University of Arizona
Alan Wilson, Alaska Renovators, Inc.

Applicant: Alaska Applied Sciences, Inc.
Explorer





Proposal Overview

Durable, low-cost (CAPEX, OPEX), low-Earth-impact (GHG emission, embodied energy) construction system for small buildings (shelter, housing, storage): quasi-spherical thin-shell concrete (1-3 cm thick) envelope, for rapid on-site construction with minimum imported materials, tools, and expert labor. Neither foundation nor roof is required, to endure the looming Global Climate Change weather extremes of temperature and storms, with a great saving in concrete volume and mass per enclosed floor and loft area and volume.

We achieved scale model proof-of-concept in 2010 in Juneau, Alaska, including the following 13-year weather exposure with minimal damage. We tested simply for full-Earth-burial strength and seismic shock endurance for disaster recovery and war zone survival as well as for new low-cost shelter and housing, anywhere, for global markets.

We're ready now for scale-up to human-useful size, for further design advances and testing for building codes and permitting; to build demonstration “model homes”, for discovering interior space use and finish details, and for building markets.

We now require \$ 600,000 of external investment cash; \$ 500,000 from Breakthrough, please, by which we can leverage the rest.



REFERENCES:

<https://vimeo.com/880814295>

Pitch deck, Breakthrough, 2023

Short Answers, Breakthrough, 2023

NSF-SBIR-Phase 1-Research-Applic

Thin-shell concrete shelter prototype refurbish 2023 Juneau, AK

<https://alaskaappliedsciences.com/wp-content/uploads/23-Nov6-Breakthrough-ThinShellConc-Pitch-AASI.pdf>

<https://alaskaappliedsciences.com/wp-content/uploads/23-Nov13-Breakthrough-ShortAnswers.pdf>

<https://alaskaappliedsciences.com/wp-content/uploads/24-Jan19-Combined-PHOTOS-Cover.pdf>

Thin-shell Concrete Structures: Low-cost, Low Earth Impact, Fast Build, Ready for Scale-up to Human-useful Size

Here's our scale model, proof-of-concept, quasi-spherical, thin-shell concrete prototype, built in Juneau, Alaska thirteen years ago at the University of Alaska Southeast Tech Center. Its concrete envelope is only 1 cm thick (1/2 inch), requiring only one-third yard of sand-only-aggregate concrete.

Concrete primary reinforcement is rust-free carbon fiber epoxy grid or basalt grid.

After thirteen years' exposure to Southeast Alaska weather, we refurbished it in 2023 to demonstrate its ruggedness, and that our small company, Alaska Applied Sciences, Inc., is ready to invest in new tooling -- to scale-up to human-useful size -- by which to build sets of one-sided concrete forms on which to build small, low-cost, long-life, strong, durable, fire-and-weather-resistant, small buildings for shelter and housing, schools and clinics and storage, anywhere on Earth -- especially in remote areas and for disaster recovery, where we must minimize the amount of imported materials, tools, and expert labor.

This scale model prototype is insulated with ~ 3 cm (1.5 inch) of closed-cell urethane foam, sprayed onto the thin concrete shell interior, with a thin plaster overcoat to protect people and foam from each other. Even at this small scale, it's a robust, lockable shelter in which a homeless person may feel secure in person and possessions; body heat alone will keep the resident or two warm enough to survive.

The 12-volt DC PV-battery electric system provides LED lighting and phone charging, and operates the automatic ventilation system to prevent dangerous CO2 concentration inside.

We are looking for \$ 600,000 of external investment for our company's scale-up project, to prepare humanity for the Climate Change driven severe weather ahead: no roof to blow off; strong enough to be Earth-bermed or completely Earth-sheltered; protection from storms, temperature, fire, tsunami, earthquake, corrosion, vermin, rot, and war -- from small arms fire and shrapnel, if the house is totally Earth-buried.

Many creatures survive, Earth-sheltered; it's our turn.



Transform World's Largest Industry

On-site manufacturing system:

- Quasi-spherical, thin-shell concrete, small buildings
- Mitigation + Adaptation
- Global markets
- Rapid advance: GCC many dangers
- Now: Scale-up to human-useful size \$ 600,000



Transform World's Largest Industry

Global Climate Emergency

Responsibility, Opportunity

Transform entire human enterprise: Mitigation + Adaptation

- **Energy: 85 % Fossil → 100 % GHG-emission-free**
- **Manufacturing: on-site, method, process, system**

Quickly: 2030, 2050

- **Prudently: Disruptive, don't destroy**
- **Profitably: Large capital flows only to high reward-to-risk**



Transform World's Largest Industry

Thin-shell Concrete Small Buildings: Morph !

- **Housing, school, clinic, shelter**
- **BOTH mitigation, adaptation**
- **Manufacturing system: Alaska**
- **Quasi-spherical: large radii of curvatute**