PUTTING THE PIECES TOGETHER

A PROJECT CASE STUDY INVOLVING PRECAST, POST-TENSIONED CONCRETE FOUNDATION ELEMENTS IN THE REMOTE ARCTIC

2026 MNSEA Annual Seminar and Trade Show

Cory Brett

Simpson Gumpertz & Heger

Senior Project Manager

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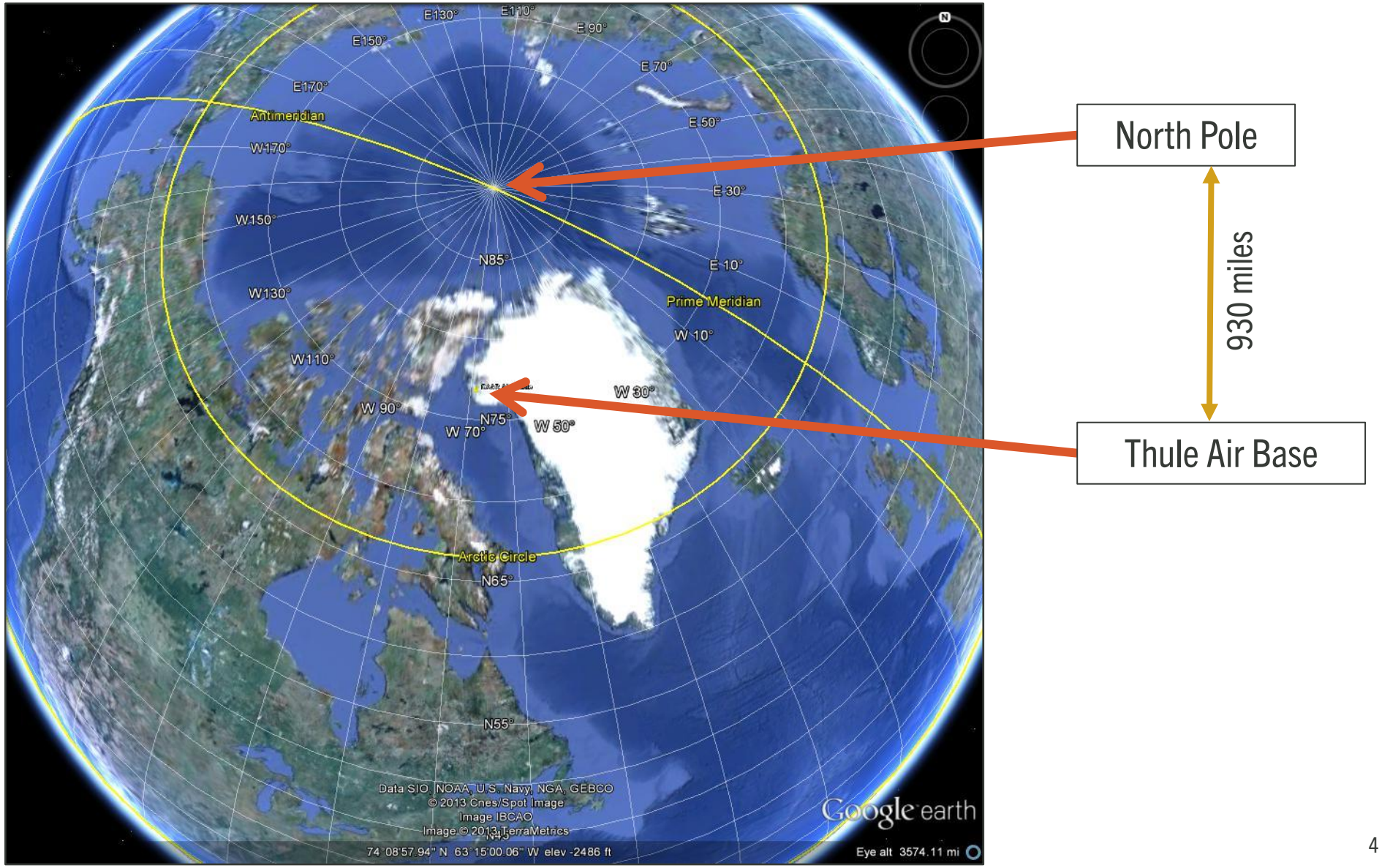
OUTLINE

- Project Background
- Arctic Considerations
- Foundation Design
- Construction Season No. 1
  - Fabrication and Transportation
  - Foundation Construction
- Construction Season No. 2
  - Superstructure Erection
  - Temporary Envelope Installation
- Construction Season No. 3
  - Permanent Envelope Installation
- Summary

PROJECT BACKGROUND

PROJECT BACKGROUND – LOCATION



PROJECT BACKGROUND – OBJECTIVE

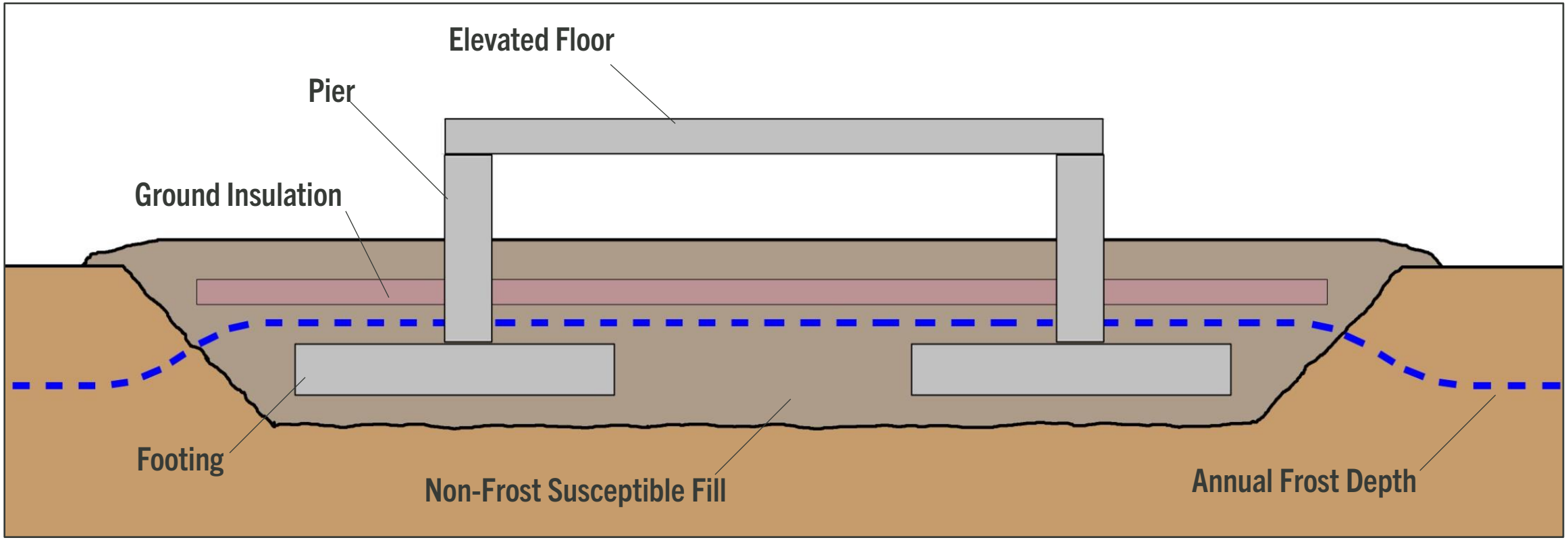
- Replace aging radar tower and 2 radar support buildings
- New 40 ft tall radar tower
- New 2700 ft^2 radar facility building

ARCTIC CONSIDERATIONS – OVERVIEW

- 3-month construction season (long construction days!)
- Permafrost
  - 6 ft annual thaw depth
- Air Temperature Range
  - -40°F to 70°F
  - 12°F mean annual
- Escarpment (500 ft tall)
  - V = 135 mph
  - K_{zt} = 2.5

Project Site

ARCTIC CONSIDERATIONS – PERMAFROST



Section – Elevated Building Floor and Foundation

ARCTIC CONSIDERATIONS – BUILDING MATERIALS

Steel Materials:

- Reinforcing bars: ASTM A706, Gr. 60
- Steel shapes: ASTM A992, Gr. 50
- Steel plates: ASTM A572, Gr. 50

Precast Concrete Foundation and Elevated Slab:

- Lack of batch plants and concreting equipment
- Construction Schedule
- Quality control during fabrication

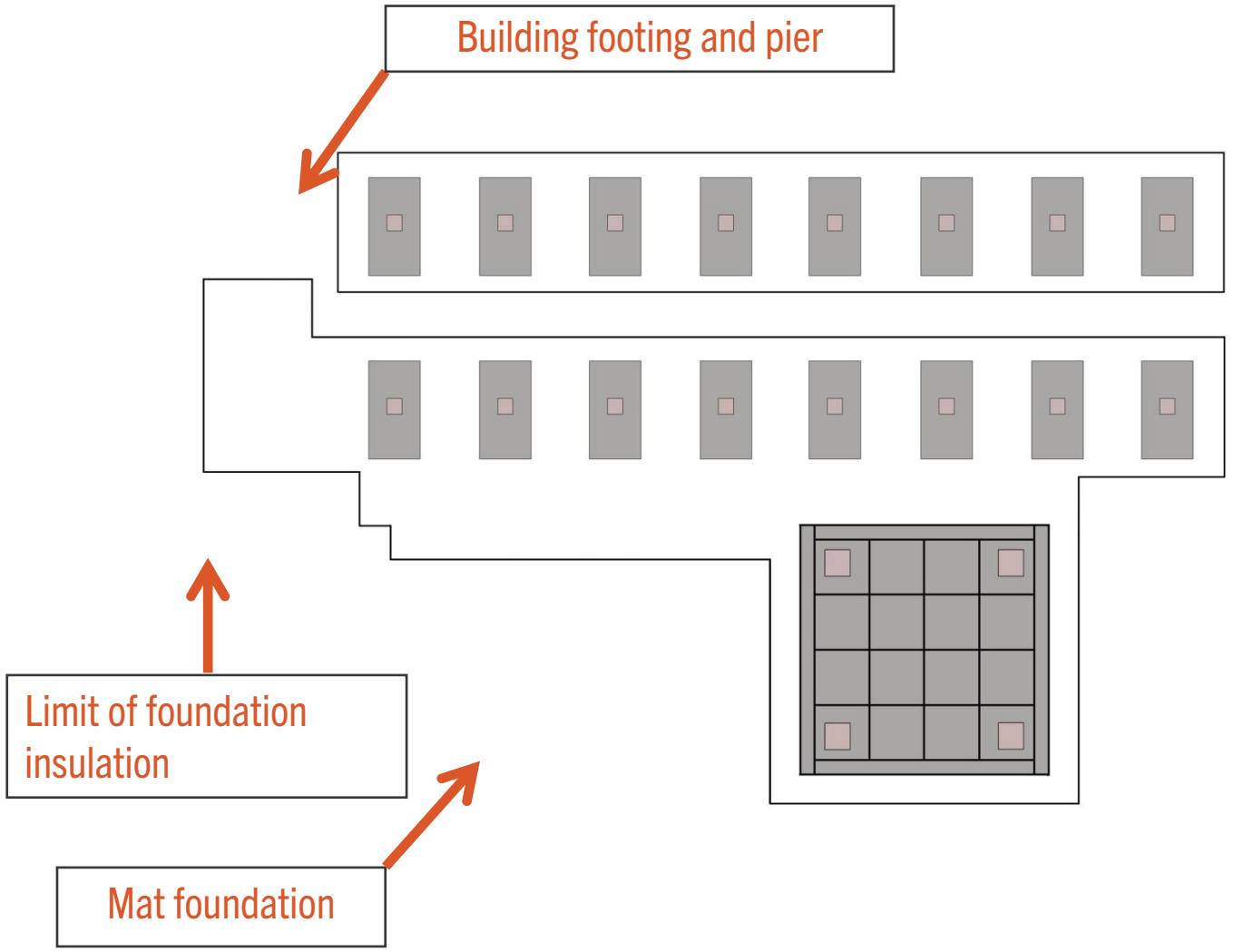
FOUNDATION DESIGN

FOUNDATION DESIGN – DELIVERY CONSTRAINTS

- February 2011
  - Designing foundations for construction in June 2011
- Engaging a precaster
  - Domestic Vs. Overseas / Local to our office vs. local to shipping port
  - Expedited shop drawing review and fabrication / Q/A
- Hired Unistress in March 2011
- 2 months to complete the design/details and release the pieces for fabrication
- 6 weeks to fabricate and deliver over 100 pieces to Norfolk, VA

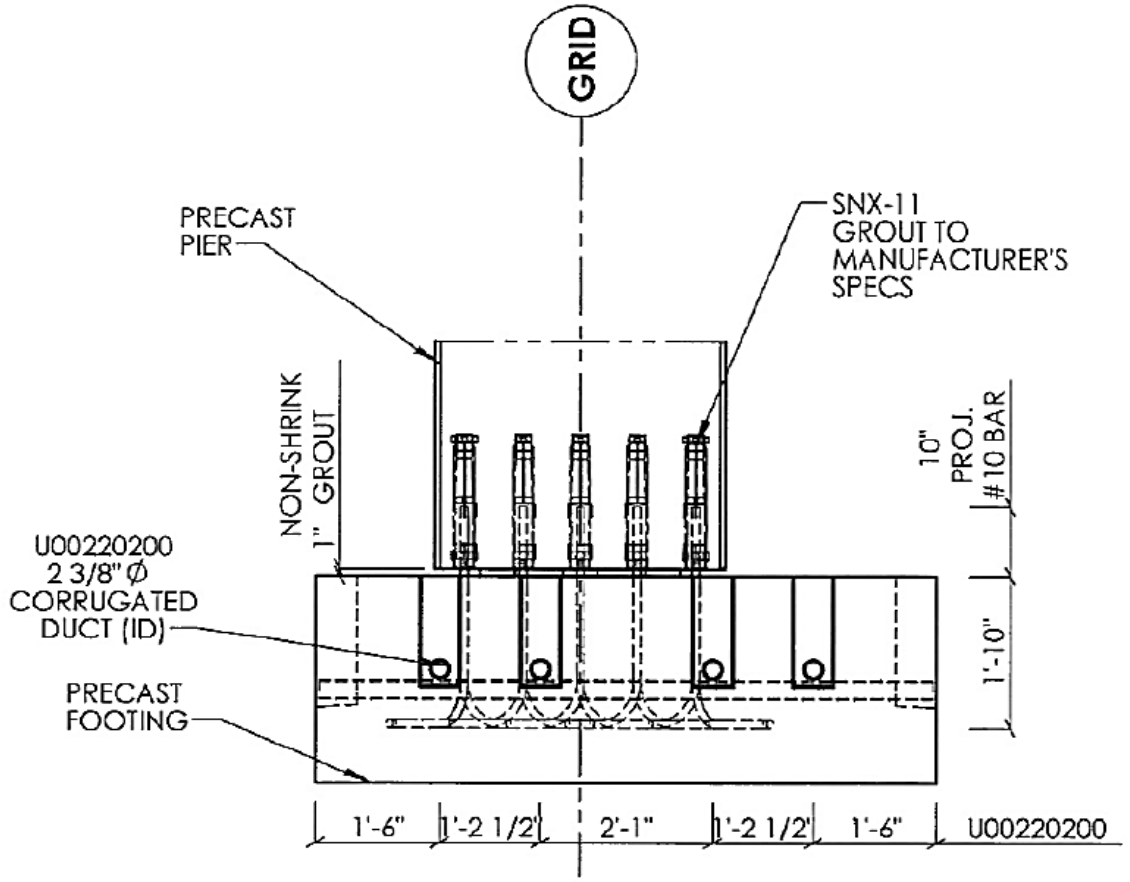
FOUNDATION DESIGN – HOW TO DISCRETIZE?

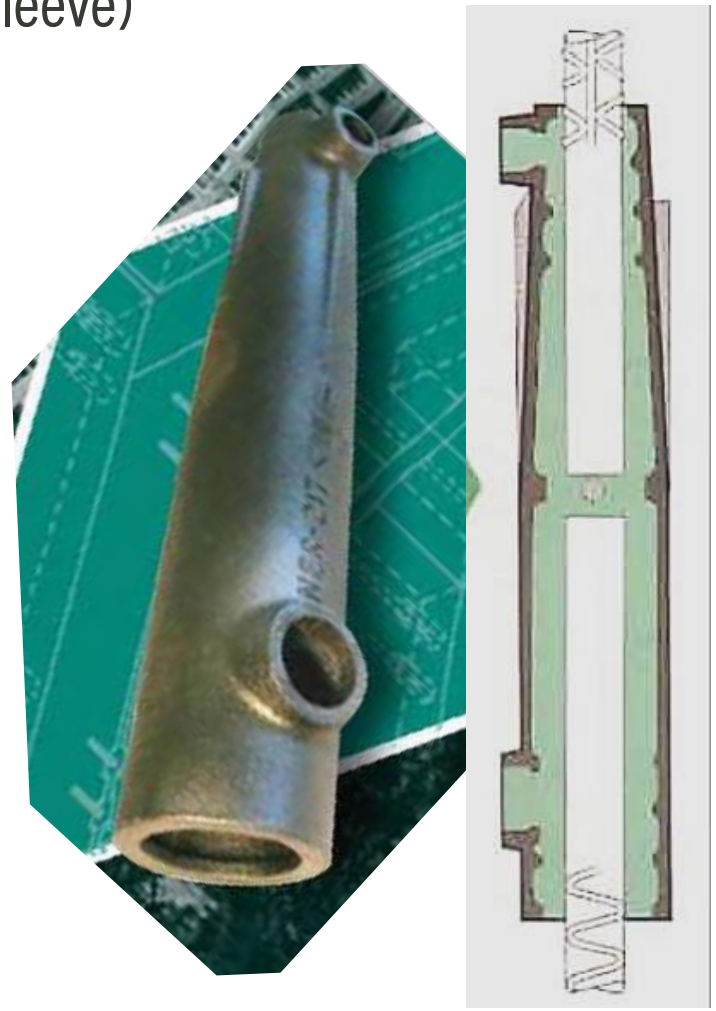
- Fit into 8 ft wide cargo container
- Weigh less than 28,000 lbs each
- Building foundations:
  - 2 pieces each
  - 16 pairs of spread footing/pier
- Mat foundation
  - 16 square pieces
  - 4 border pieces
  - 4 piers
- Maximum piece dimension
  - 7 ft-6 in.
- Maximum piece weight
  - 27,300 lbs



FOUNDATION DESIGN – BUILDING

- Precast Pier to Foundation
  - NMB Splice Sleeve – Type 2 Splice (grouted splice sleeve)





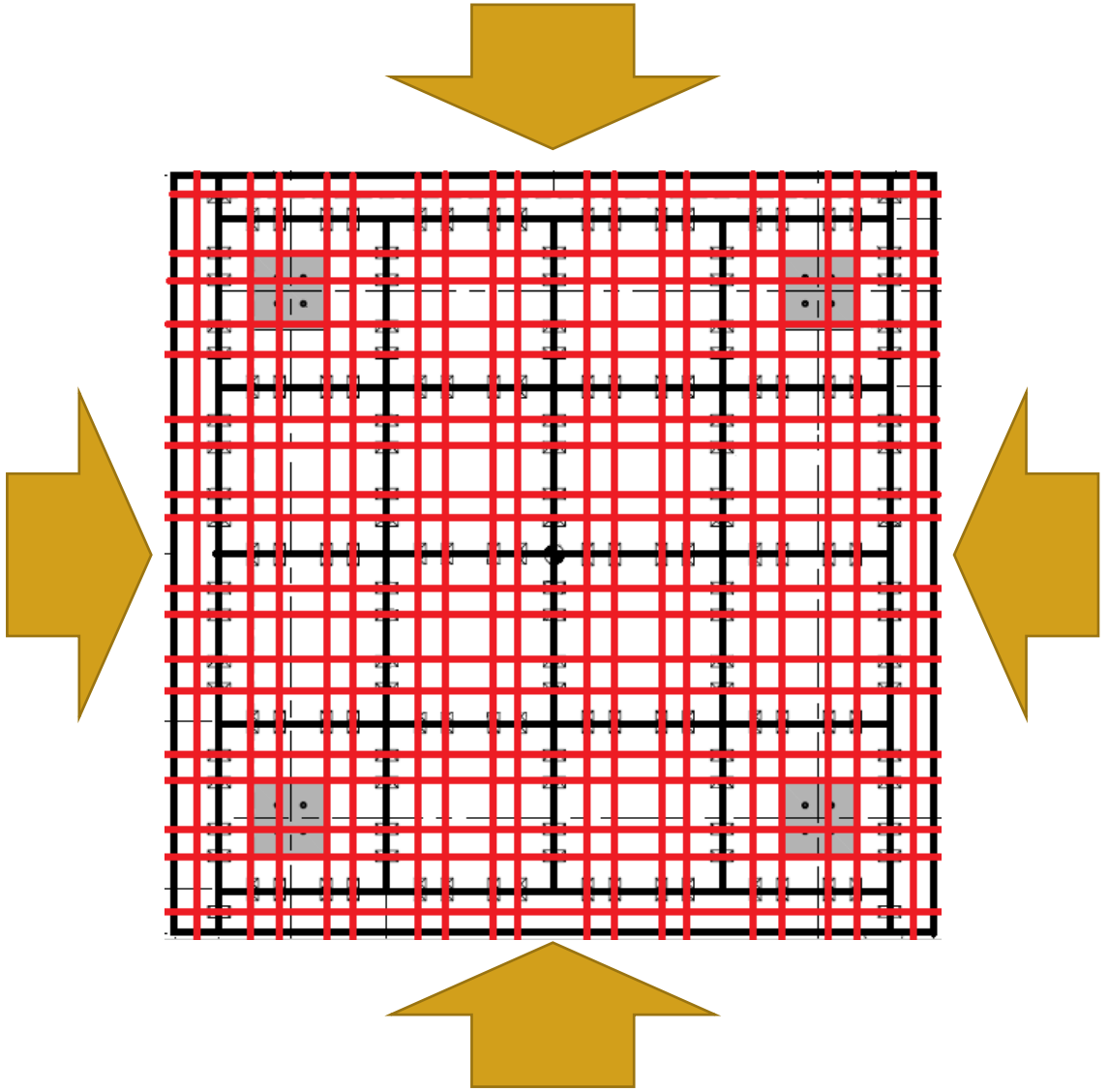
www.splicesleeve.com

FOUNDATION DESIGN – BUILDING

FOUNDATION DESIGN – BUILDING

FOUNDATION DESIGN – MAT

- Sized for stability and bearing pressure
- No time for match-casting
- Segments post-tensioned with 36 – 1.25” bars in two directions (grouted tendons)
- PT ducts spliced with rubber sleeves
- PT ducts oversized to improve bar installation
- **Design Objective:** Precast joints remain closed under ASD load combinations considering PT losses



FOUNDATION DESIGN – CAN IT BE BUILT?

- Horizontal adjustability
  - Oversized NMB splice sleeves
    - Building Piers: No. 11 sleeves for No. 9 dowels
    - Tower Piers: No. 11 sleeves for No. 10 dowels
  - Oversized anchor rod holes
    - 5/16 in. at elevated building floor framing
    - 3/4 in. at tower base plate
  - Minimum total horizontal adjustability: 1-3/8 in.
- Vertical adjustability
  - 2 1/2 in. grout pads at top of building piers
  - 3 in. grout pads at top of tower piers

2011 CONSTRUCTION SEASON

2011 – BUILDING FOUNDATION CONSTRUCTION

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2011 – MAT FOUNDATION CONSTRUCTION

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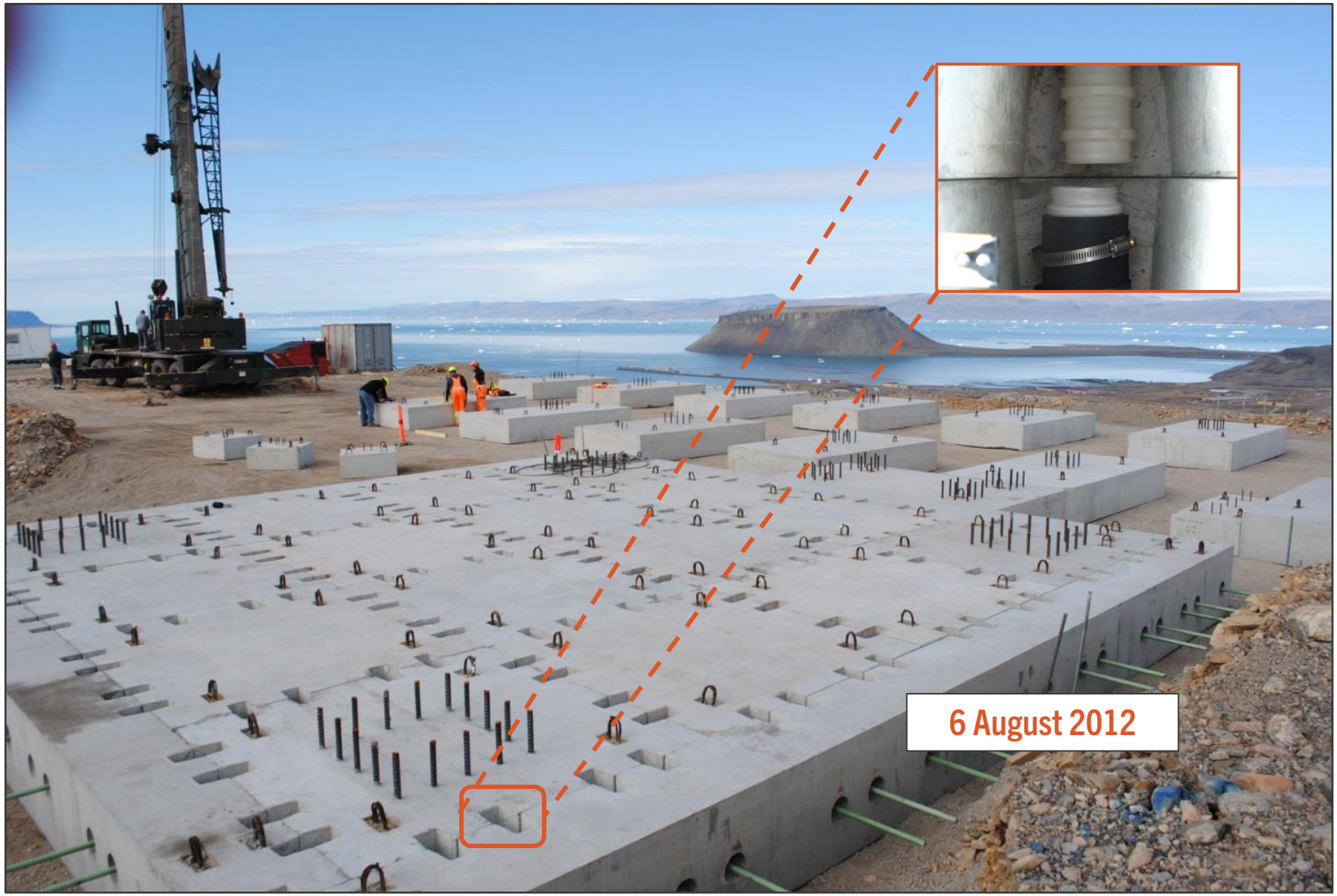


2011 – MAT FOUNDATION PT BARS

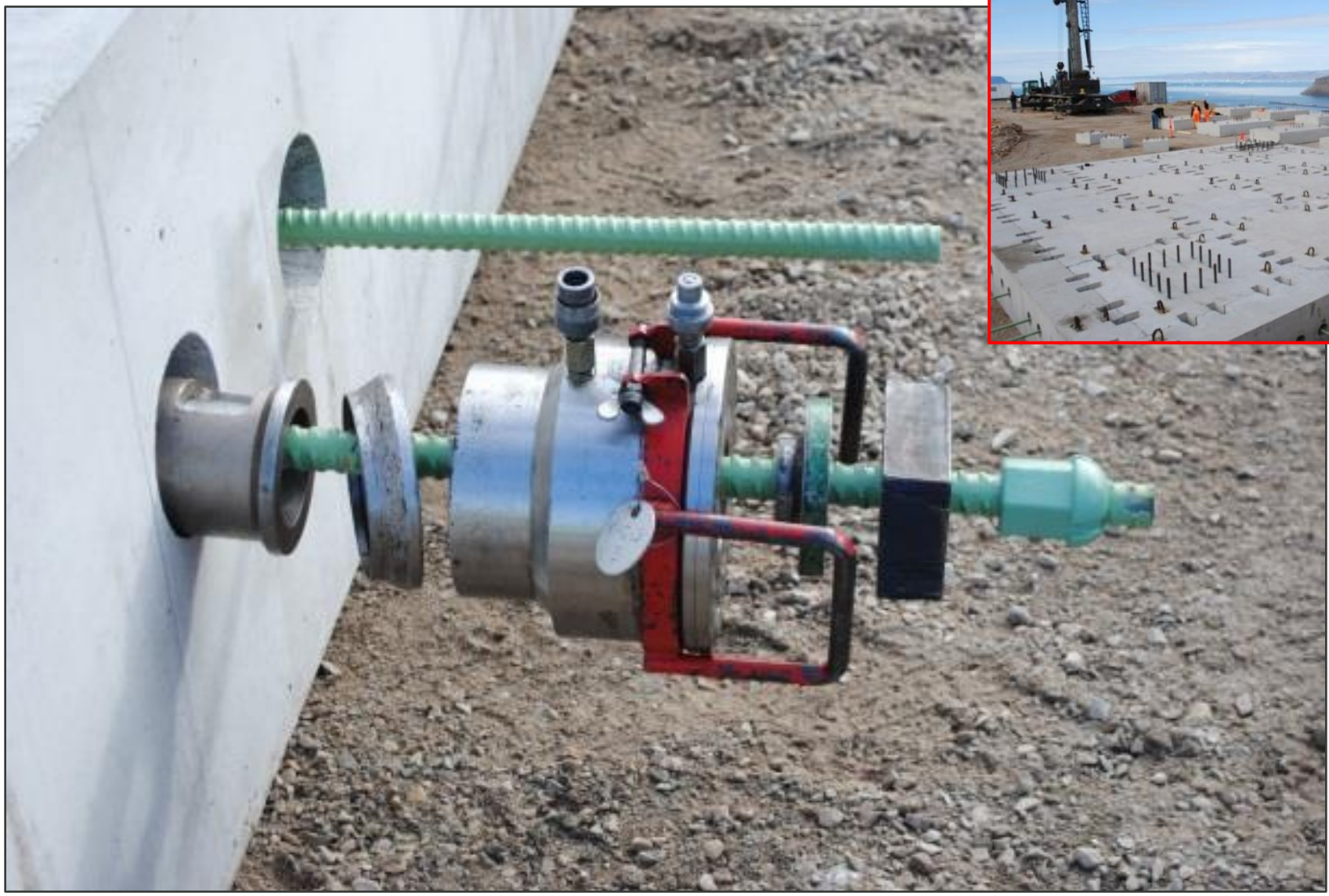
Bundle of PT bars in precast yard

Bundle of PT bars in Thule

2011 – MAT FOUNDATION PT BARS

2011 – MAT FOUNDATION PT BARS

2011 – MAT FOUNDATION TENSIONING



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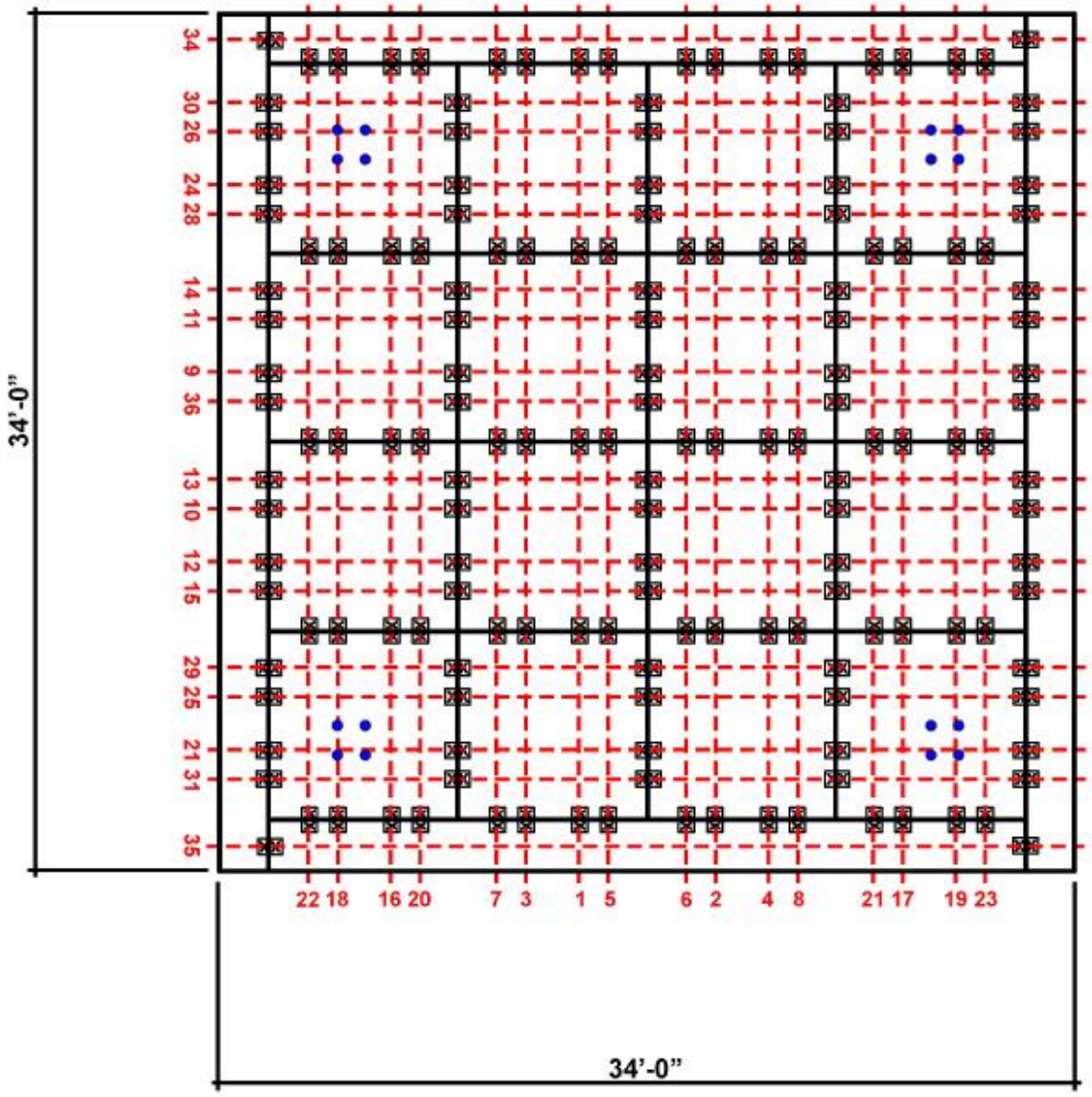
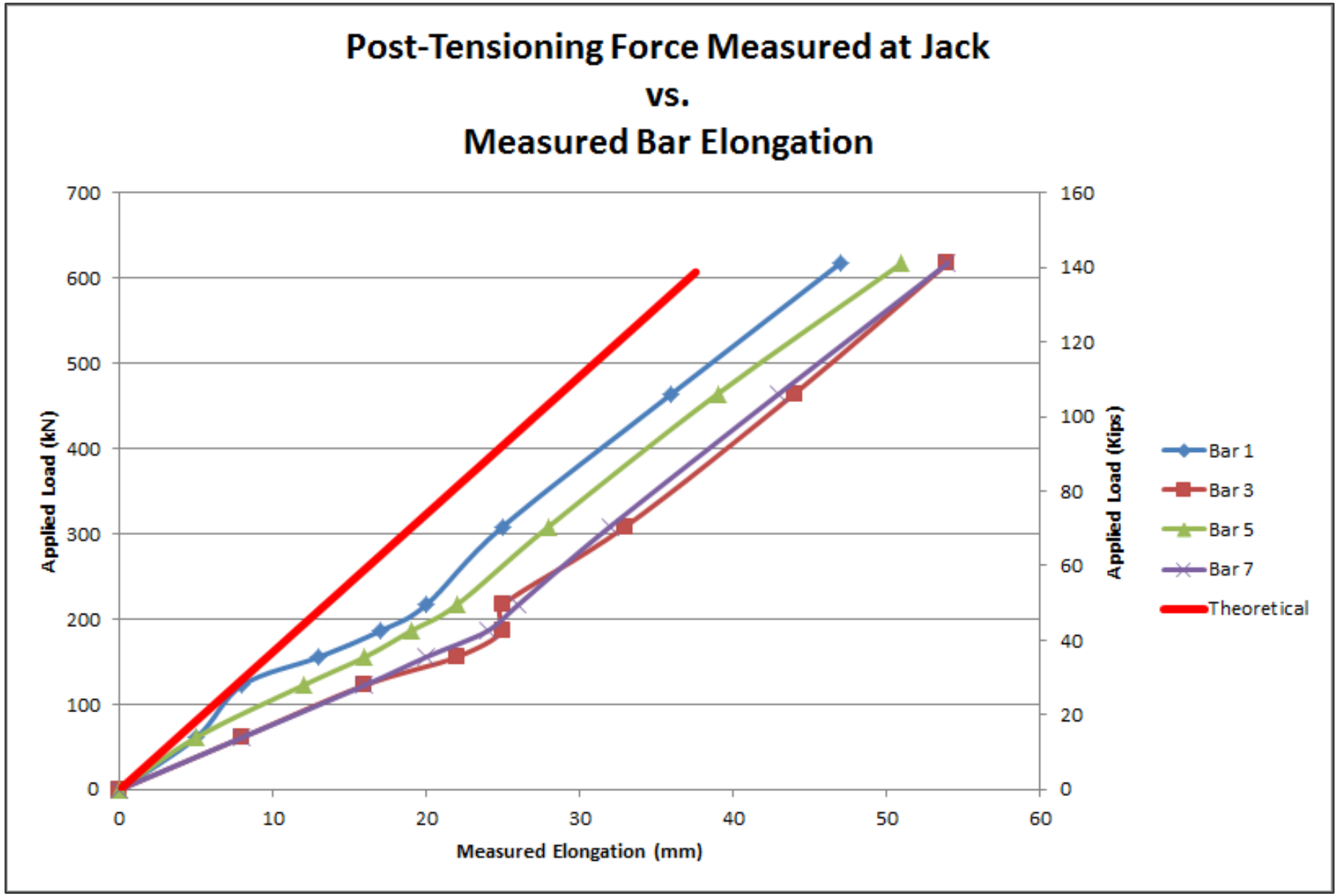


2011 – MAT FOUNDATION TENSIONING



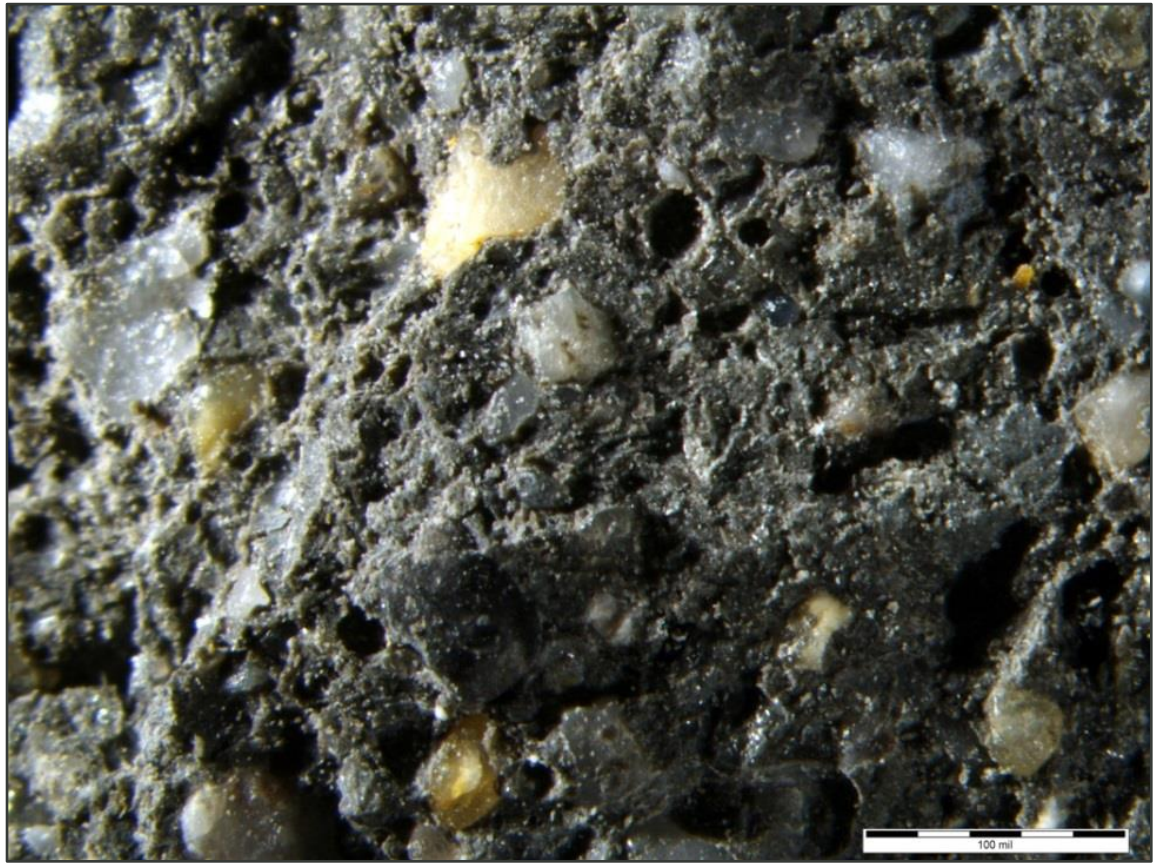
2011 – MAT FOUNDATION TENSIONING

- Reconciled the measured (apparent) PT bar elongation with actual elongation
- Verified PT bar forces by performing lift-off tests
- Grouted the hand holes, tendons, and anchorage zones
- Sealed mat surfaces with a methacrylate sealer

2011 – GROUT TESTING

2011– GROUT TESTING

2011– GROUT TESTING



2012 CONSTRUCTION SEASON

2012 CONSTRUCTION SEASON – SUPERSTRUCTURE AND ENVELOPE

2012 – ANCHOR ROD SURVEY

2012 – ELEVATED BUILDING FLOOR | MISALIGNED ANCHOR BOLTS

- Misaligned by up to 1 in.
- Enlarged hole in beam flange to fit over as-built anchors
- Field-welded plate washers

Modified 1-1/8 in. Diameter Anchor Rods Connection

2012 – ELEVATED BUILDING FLOOR ERECTION

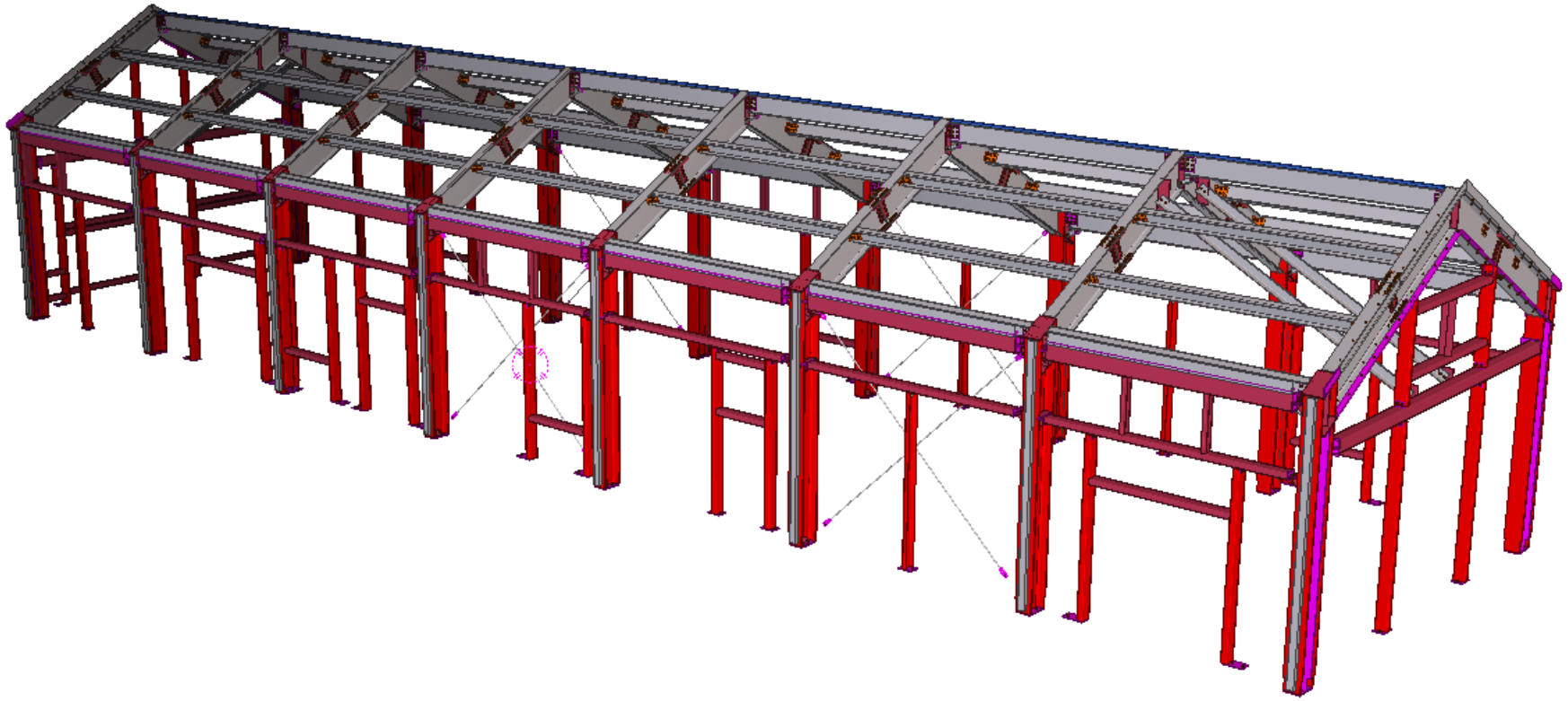
2012 – JOISTS AND SHEATHING INSTALLATION

2012 – ELEVATED SLAB PLACEMENT

2012 – GROUTED SLAB JOINTS

2012 – BUILDING FRAME ERECTION

- Switch from U.S. Steel shapes and materials to European shaped and materials
- Research European design standards and material specifications
- Redesigned and re-detailed the building while the fabricator produced shop drawings



2012 – BUILDING FRAME ERECTION

- Installing moment frames

2012 – EXTERIOR WALL CONSTRUCTION

2012 – ENVELOPE

- No approved submittals
- Temporary enclosure

2012 – ENVELOPE DEFICIENCIES

- Wrong panel type
- Wrong panel color
- Insufficient fasteners
- Poor wall panel installation
- Significant air loss

2012 – STRUCTURAL DEFICIENCIES

2012 – STRUCTURAL DEFICIENCIES

2013 CONSTRUCTION SEASON

2013 CONSTRUCTION SEASON – ENVELOPE INSTALLATION

- Still no approved envelope submittals
- SGH extensively researched envelope products for the contractor
- SGH engaged a fire testing lab to verify the fire-performance of European products

2013 – MORE DEFICIENCIES

- Contractor omitted steel from the building
- Steel was intended to support the bottom of the wall panels and the leading edge of the soffit panels

2013 – AS OF TODAY…

- Cladding installation begins
- Still no approved submittals
- Incomplete calculations
- Less than two months to go

SUMMARY

SGH Resources and Relationships

- Combined many SGH resources (SE/BT/EMI/Lab) to solve a series of unique challenges
- Engaged Unistress and DYWIDAG (DSI) – pseudo-Design-Build relationship

Client Service

- Responded to the challenges of scope increase and substantial time constraints
- Assisted our client when an unsophisticated contractor had difficulty with submittals and construction means and methods

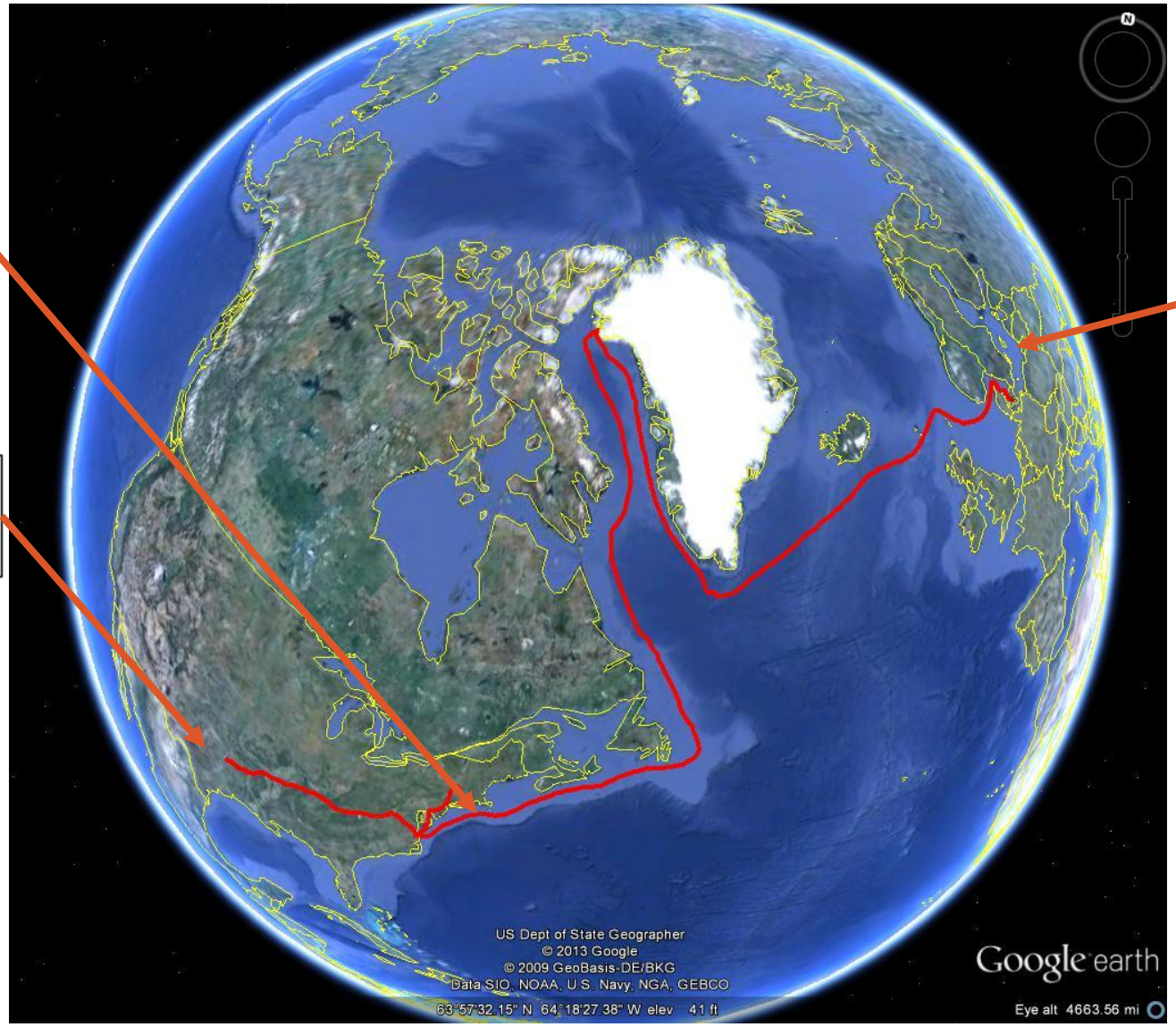
Technical Lessons (some)

- Specify and purchase extra components and accessories (precast elements, bolts, nuts, plate washers, post-tensioning components)
- Provide details that maximize adjustability for field-connected components – communicate this to the contractor!
- Many others…

A GLOBAL PROJECT...

Massachusetts:
Precast concrete (foundation and elevated slab)

Texas:
Elevated floor framing



Denmark:
Superstructure framing

QUESTIONS?