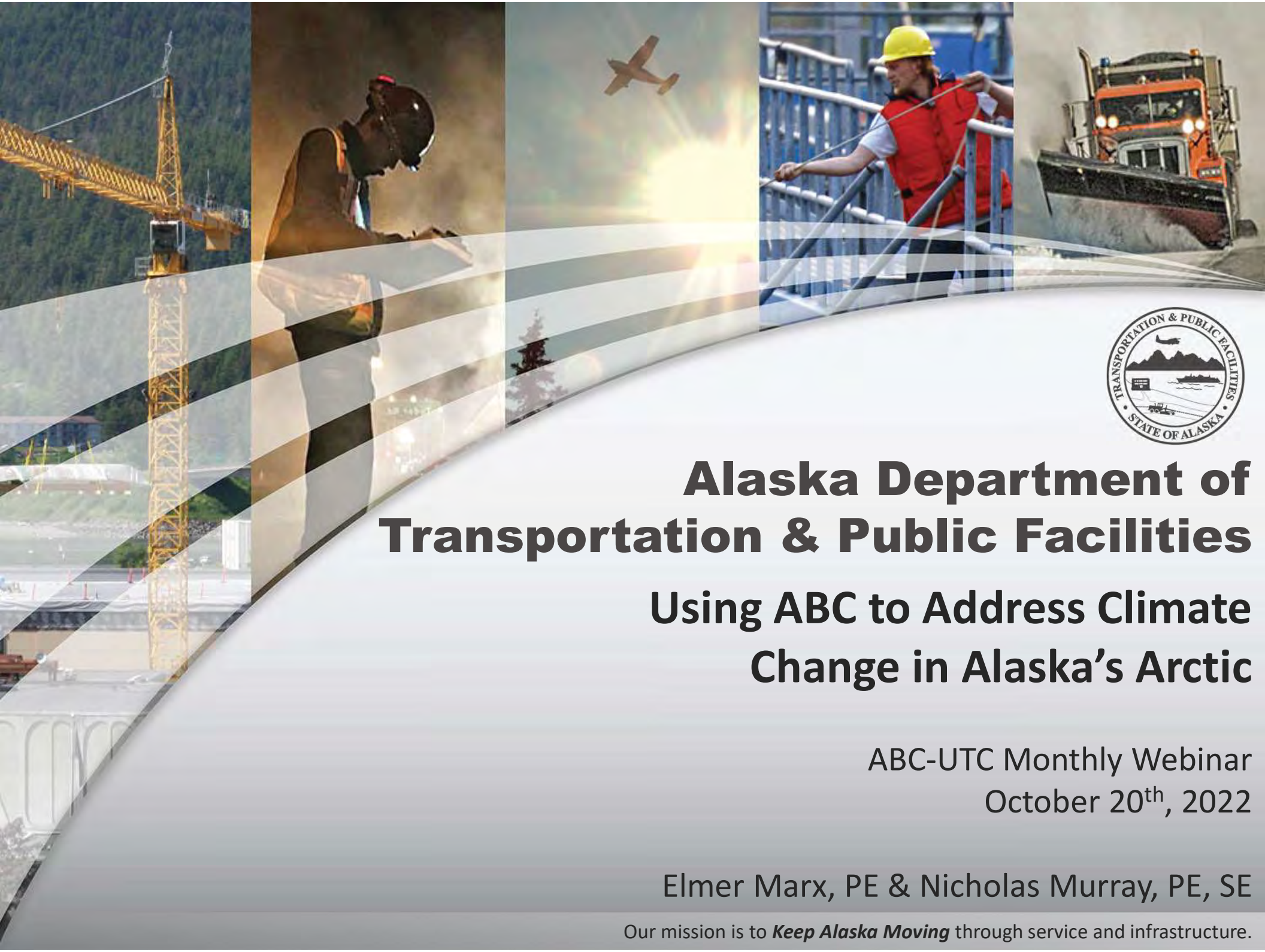


Alaska Department of Transportation & Public Facilities

Using ABC to Address Climate Change in Alaska's Arctic

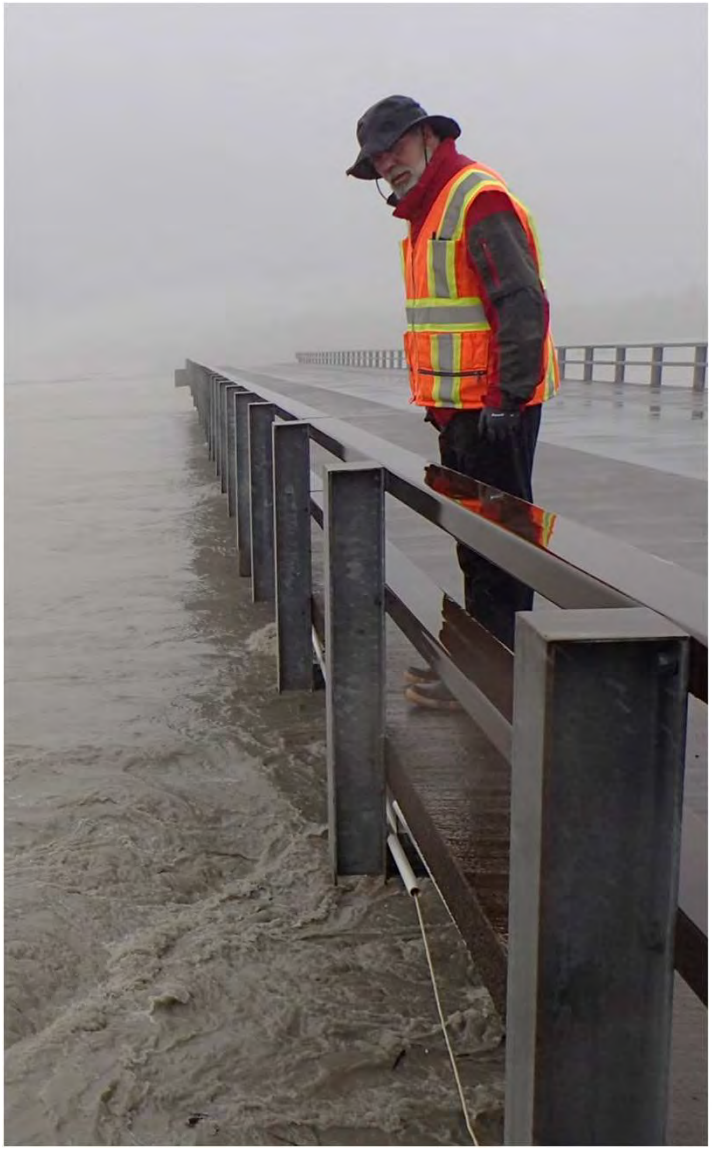
ABC-UTC Monthly Webinar
October 20th, 2022

Elmer Marx, PE & Nicholas Murray, PE, SE

Our mission is to ***Keep Alaska Moving*** through service and infrastructure.

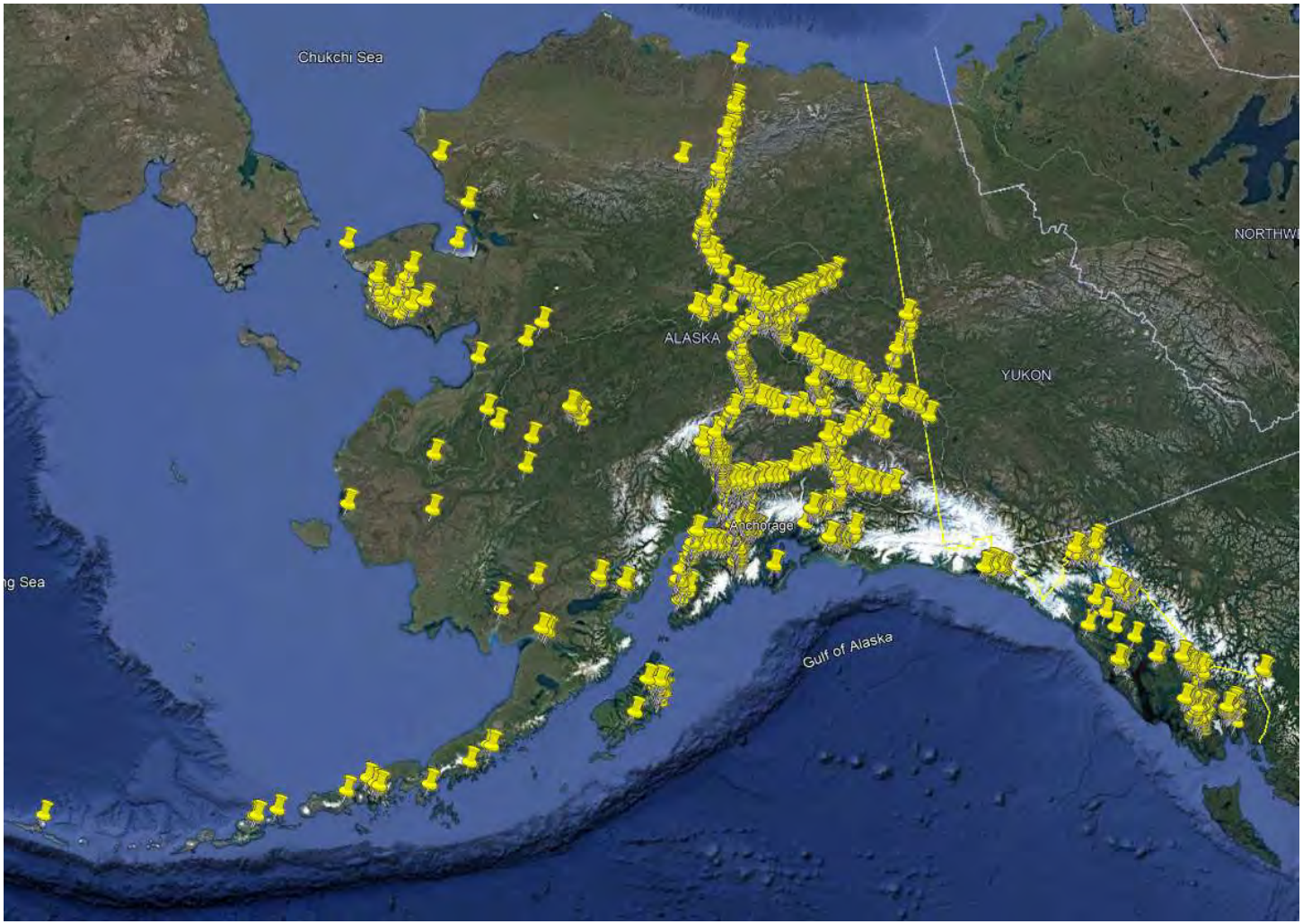
Congratulations to Rich Pratt on his Retirement!

- Alaska DOT&PF Chief Bridge Engineer 2000-2022
- Chair of AASHTO T-3 Seismic Design 2005-2022
  - *Guide Specifications for LRFD Seismic Bridge Design*
  - *Guidelines for Performance Based Seismic Design of Highway Bridges*

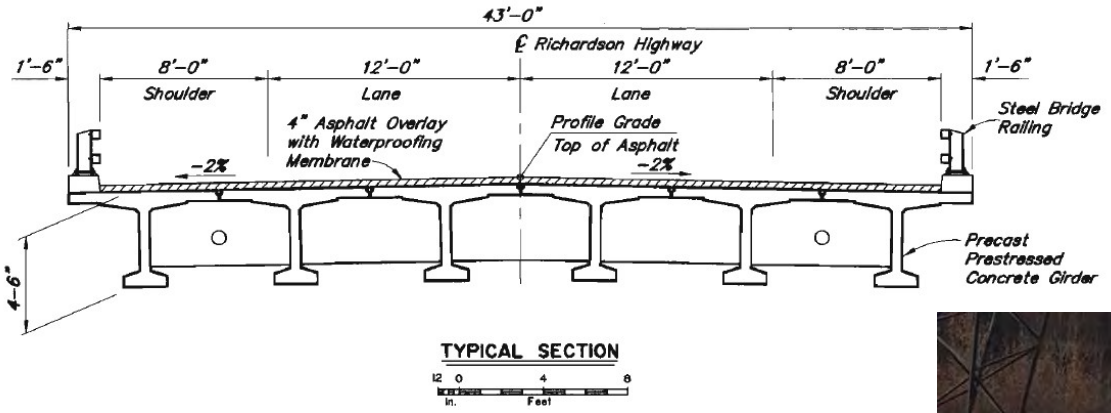


Alaska ABC

Alaska has been ‘accidently’ using ABC style construction for ~50 years due to short working season and remoteness of bridge locations



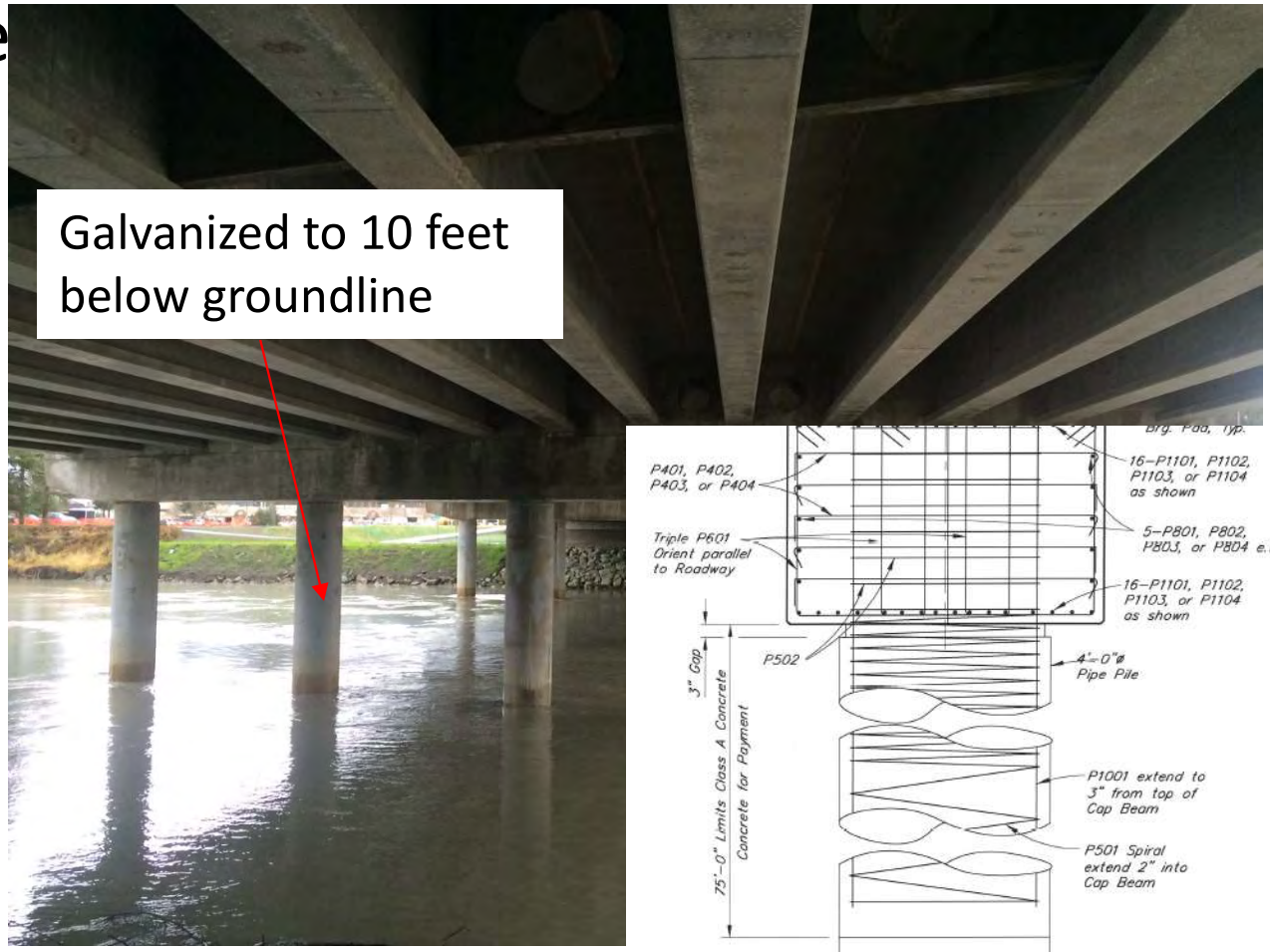
Preferred Details



- Preferred structure type is a ‘decked bulb-tee’ that requires no CIP deck or formwork. Asphalt is placed directly on precast girders
- Used successfully since mid 1970’s

Preferred Details

- Preferred substructure is concrete filled steel pipe pile extensions.
- Removes need for cofferdams (permitting issue)
- Acts as permanent formwork instead of separate concrete column
- High strength, high ductility system with large deformation capacity



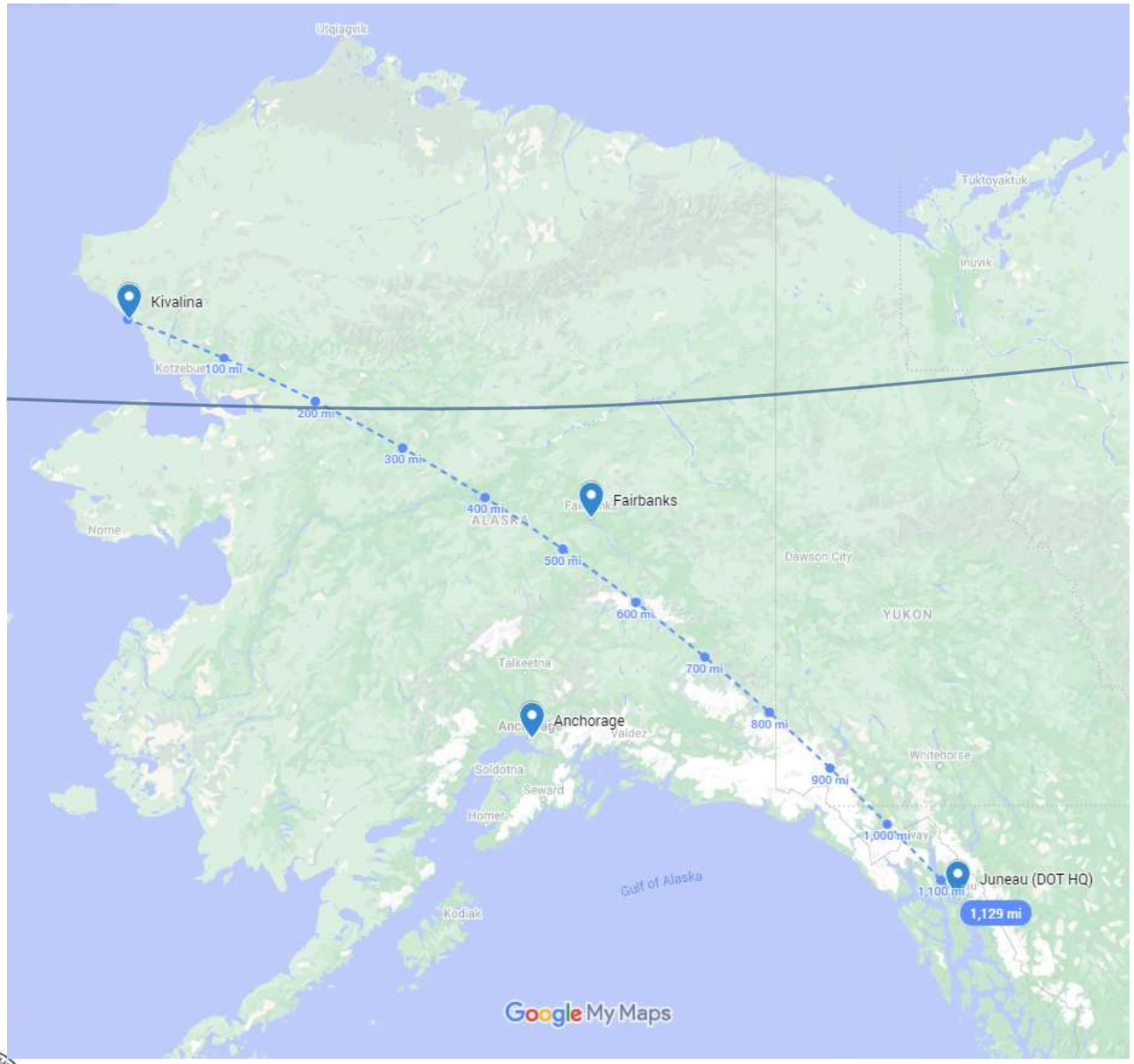
Proportion of Bridge Types

- ~41% of all bridges in the state are Decked-Bulb Tees
  - Since 1990 ~60% of new bridges are Decked-Bulb Tees

- ~3.5% of all bridges in the state are Steel Girder with precast deck panels (this bridge style)
  - Mostly in remote parts of the state not on the road system

Where is Alaska?

Project Location

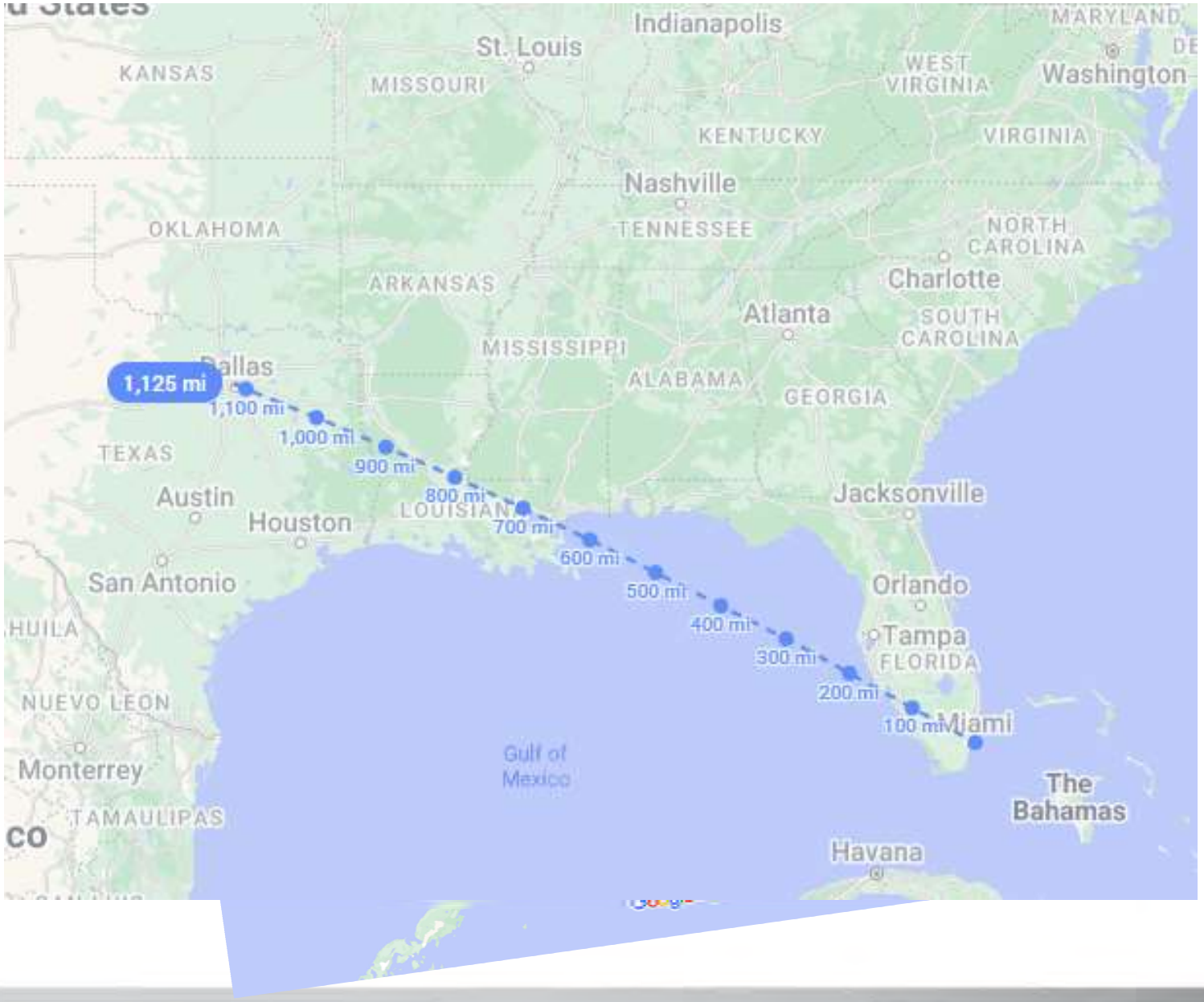


- Kivalina, Alaska
- Pop. 444[1]
- 80 Miles north of Arctic Circle
- Avg. high 30.5°F
- Avg. low 18.1°F
- Area inhabited for ~1,500 years by Iñupiat Alaska Natives[2]

[1]https://en.wikipedia.org/wiki/Kivalina,_Alaska

[2]http://colby-sawyer.edu/currents/articles/In-Research-Kivalina-Alaska.html

Project Location



Why is a bridge needed?

Project Location

Why is a bridge needed?

Why is a bridge needed?

https://www.kvlseaice.org/20212022-forecasts/may-23-current-conditions-and-forecast

Why is a bridge needed?

(video) https://alaskapublic.org/2020/10/16/kivalina-on-the-coast-how-an-arctic-community-is-responding-to-climate-change/

Project Scope

https://dot.alaska.gov/nreg/KivalinaEvacRd/files/kivevac-area-sites.pdf

- ~8 miles of new gravel road needed over permafrost and tundra to Kisimigiuqtuq Hill (K-Hill)
- 3,200ft causeway across lagoon with a ~190ft single span bridge

Delivery Method

- The Construction Manager/General Contractor (CM/GC) method was chosen to accelerate the schedule, reduce risk and create efficiencies in the design
  - Contractor is selected via RFP by owner (DOT) prior to 100% design
- Alaska DOT&PF performed most of the roadway design work and all of the bridge design work.
- Contractor was able to provide feedback on design constructability during the design stages.

Alaska's Experience with CM/GC

- Allows for positive collaboration between contractor and owner will still allowing for ingenuity and efficiency
  - Owner retains right to dictate design decisions
  - Provides more control to owner than design-build
- Facilitates design considerations for contractor's construction methods
  - For example, this bridge was checked for contractors unloaded off-road equipment
- Still allows project to go to bid if GMP (guaranteed maximum price) negotiations fail

Bridge Construction Partners

General Contractor — ASRC Construction

Bridge Subcontractor — STG Incorporated

Girder Fabricator — Fought & Company

https://www.foughtsteel.com/newsfeed/kivalina-bridge

Precast Panel Fabricator — Olympian Precast, Inc.

Barge Transport — Lynden

https://info.lynden.com/blog/kivalina-evacuation-road-and-bridge-project-in-western-alaska

Why ABC?

- High impact to traffic?

AGE AND SERVICE			
Year Built 27:	2020	Year Reconstructed 106:	
Type of Service on 42A:	1 Highway		
Type of Service under 42B:	5 Waterway		
Lanes on 28A:	2	Lanes under 28B: 0	Detour Length 19: 124 mi
ADT 29:	18	Truck ADT 109: 1%	Year of ADT 30: 2019

- Reduced construction time?

> After two years of construction, the Kivalina Access Road is now usable for the community. It's the first step in a process to potentially relocate the entire Northwest Alaska village from the threat of an eroding coast and rising sea levels.

https://alaskapublic.org/2020/11/30/kivalina-emergency-access-road-now-open-for-use/

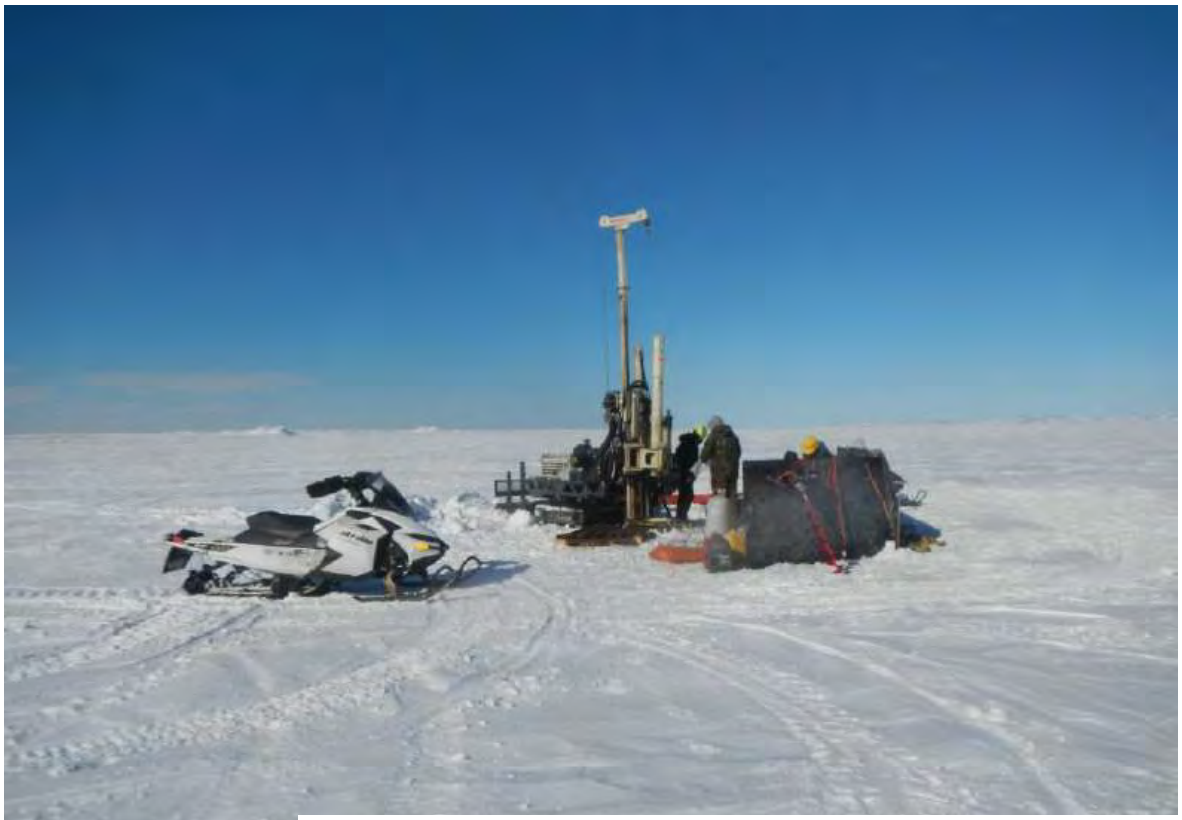
- Bridge construction time would have been ~ 3 months if completed in one continuous operation

Why ABC?

- Obviously very remote
  - Getting equipment, labor and materials to the site is exceedingly expensive, time consuming and logically challenging.
  - Complicated details that require specialized equipment or labor are avoided. (UHPC, post tensioning, deck screeds, etc.)
  - Cast-in-place concrete is expensive and quality control can be difficult so maximum precast elements.
  - Future maintenance will likely be very limited so avoid ‘maintenance-prone’ detail. (joints, drains, etc.)
  - Weather and daylight considerations can drive schedules

Foundation Drilling

- Frozen ground conditions present unique challenges for foundation drilling as well as pile installation.
- Up until mid 1980's many bridges in the Arctic were supported by short piles bearing on frozen ground.
- But as ground begins to thaw…

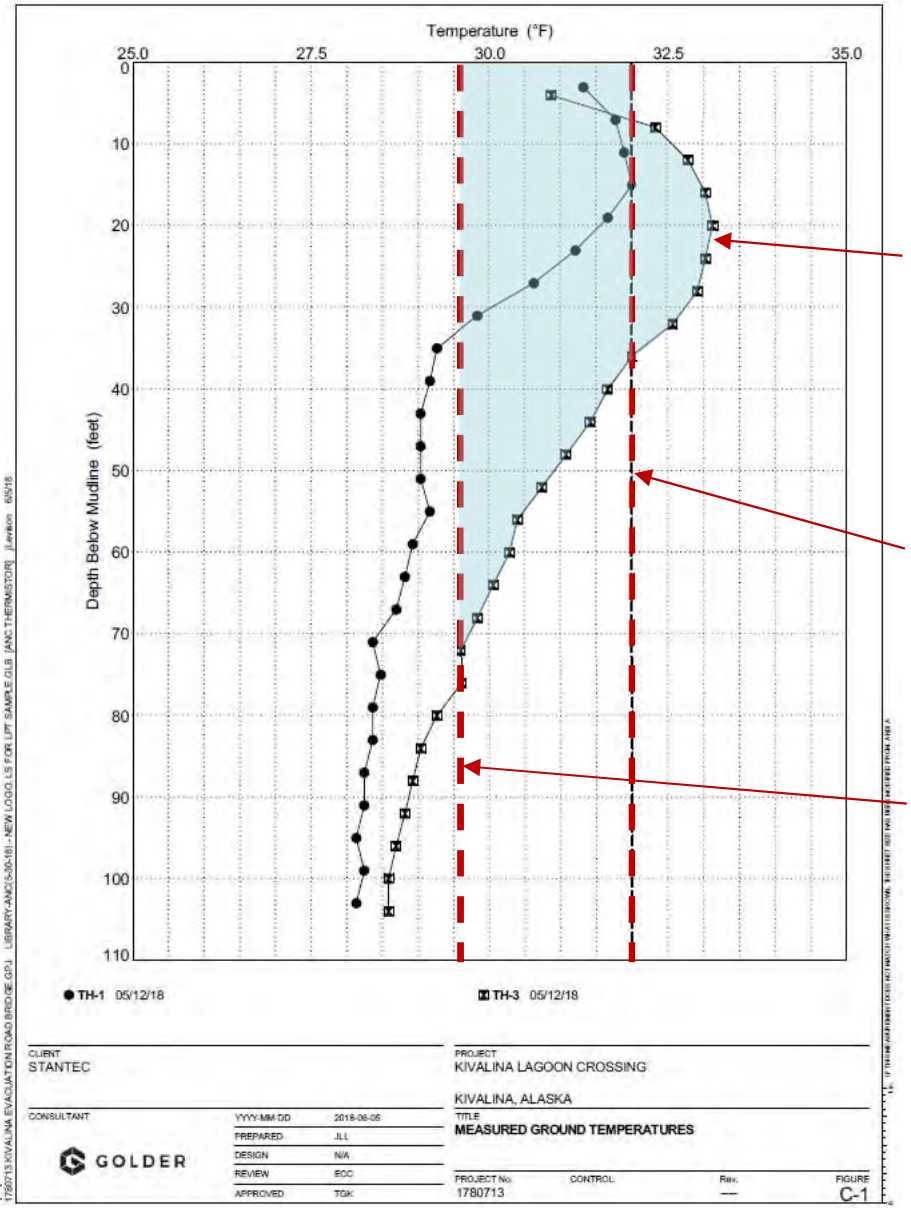


April 2018, Temperature ~12°F, Winds ~20 mph

Consequences of Thawing Ground

- As the arctic warms, previous strategies of supporting structures are becoming less reliable

Measured Ground Temperatures



Thawed region

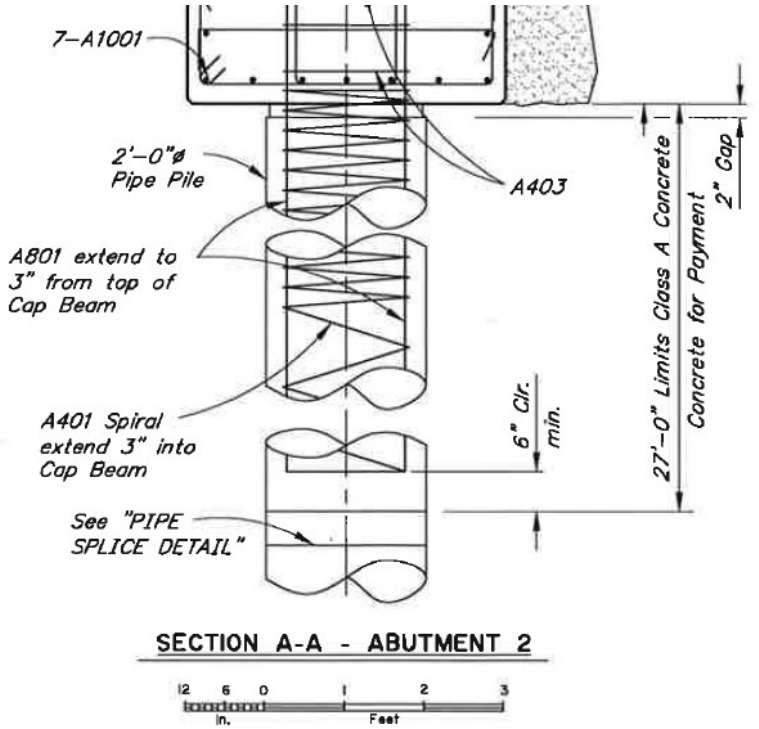
Freezing Point of freshwater

Freezing Point of saltwater

- SPT testing not particularly useful in frozen soils.
- Pile bearing capacity based on future thawed conditions
- But pile installation needs to occur during current frozen conditions

Foundations

- Close ended helically welded steel pipe piles
  - 2’-0”Ø x 1/2” x 80ft deep (A709 Gr50T3 or API 5L-PSL2)
  - Concrete filled with a gap in shell at the top to force the plastic hinge location during design seismic event.



Foundations

- Ironically working in winter does have its advantages

March 2020, Temperature ~4°F, Winds ~10 mph

Foundations

4.2 Axial Compressive Resistance

The subsurface conditions at both abutments generally consist of silty sands overlying sands and gravel at depth with mixed thermal states and salinity. Due to the uncertainty regarding the thermal states in each test hole and the continued degradation of the permafrost, the driven piles were designed based on the thawed soil properties. Without passive or active cooling for the pile foundations, the observed frozen ground may continue to degrade and may thaw entirely over the design life of the bridge. The axial compressive resistance may be significantly higher after pile installation, but the long-term strength will depend on the unfrozen soil strength properties. Note that pile verification methods such as the Pile Dynamic Analyzer (PDA) or wave equation driving criteria may not represent the true long-term strength due to influence from the permafrost during driving.

- Predrill to 75%-90% of final pile diameter and advance pile through loose cuttings.

6. Frozen Ground. Use alternate methods to drive through frozen ground. Obtain written approval from the Engineer before employing any alternative methods of pile advancement. If predrilling is used, the maximum predrilling diameter should be no greater than 90 percent of the pile diameter and predrilling should not be used within three feet of the estimated pile tip elevation.

Abutment Cap Beams

- Contract allowed precast pile cap beams

501-3.13 PRECAST CONCRETE MEMBERS.

1. Shop Drawings. *Add the following:* If precast concrete pile cap beams are approved, meet the requirements of NCHRP Report 681 (Development of a Precast Bent Cap System for Seismic Regions, 2011).

- Contractor chose to use CIP cap beams instead for field flexibility.
- Cold weather protection required when air temp <40°F. Max temp of 90°F

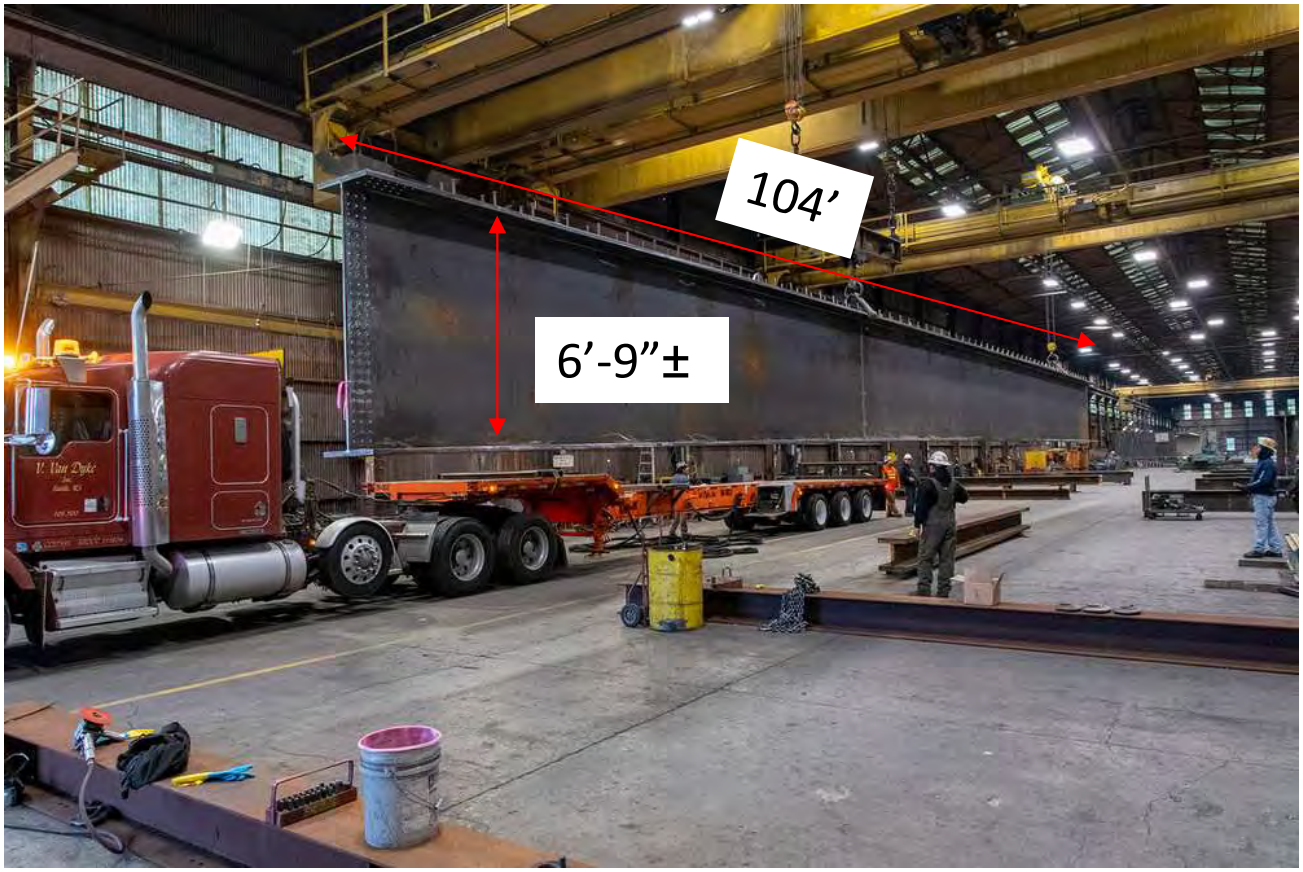
March 2020, Temperature ~4°F, Winds ~10 mph

Cast-in-Place Concrete

- Pre-measured supersack components mixed on site

Girder Fabrication

- 185’-6” Plate girder with field splices at ~ ¼ and ¾ points
- Shop installed shear connectors (minimize field welding)
- Spray metallized
- ~9” of total camber
- Fabricated in Tigard, OR



https://www.foughtsteel.com/newsfeed/fought-fabricates-future-evacuation-route-kivalina-alaska

Girder Transport

Girder Transport

https://info.lynden.com/blog/kivalina-evacuation-road-and-bridge-project-in-western-alaska

Girder Transport

- No port facilities in Kivalina so landing craft unloaded girders directly onto beach.

June 2020, Temperature ~45˚F, Winds ~10 mph

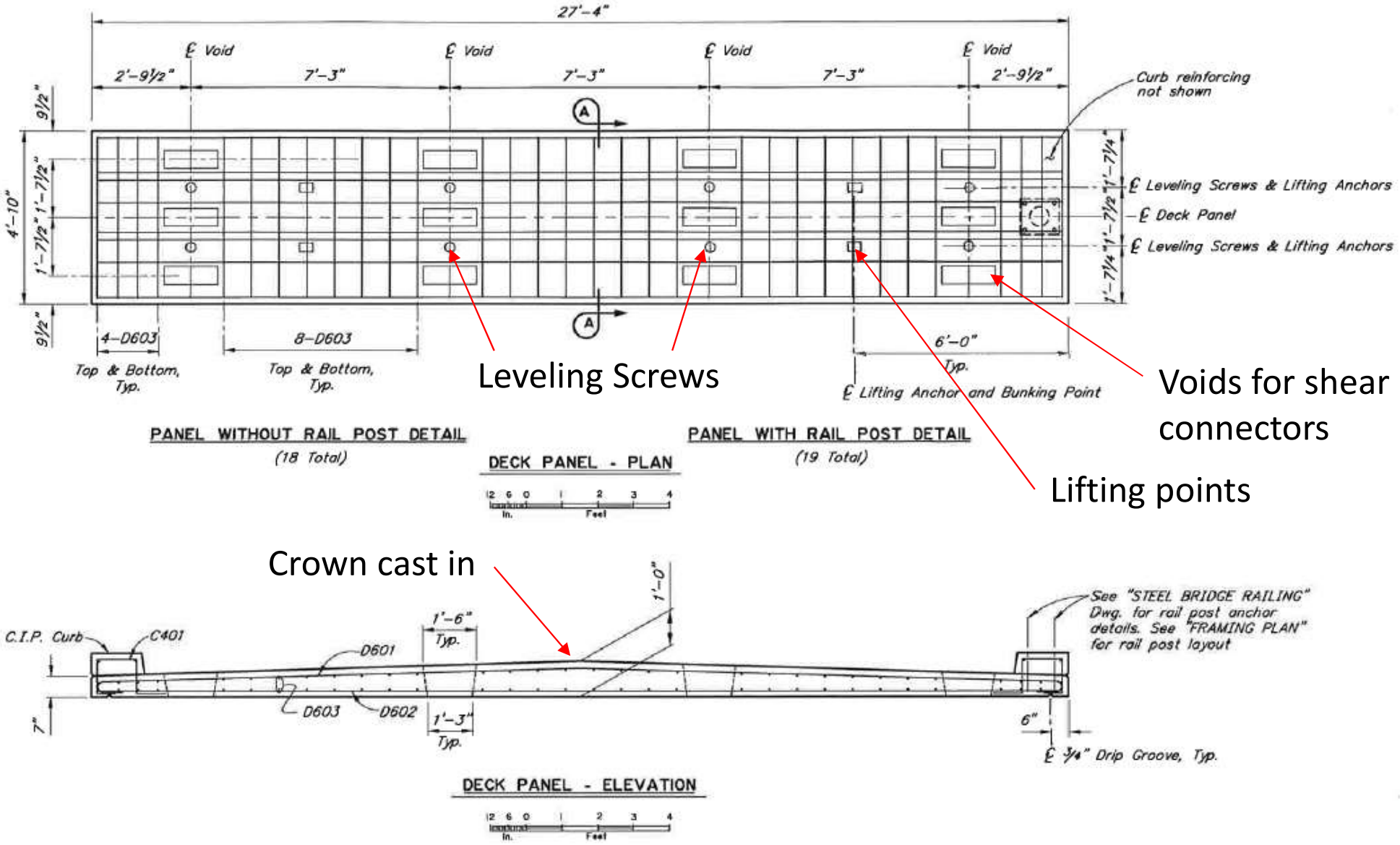
Girder Launching

- Crane assisted launch

Girder Launching

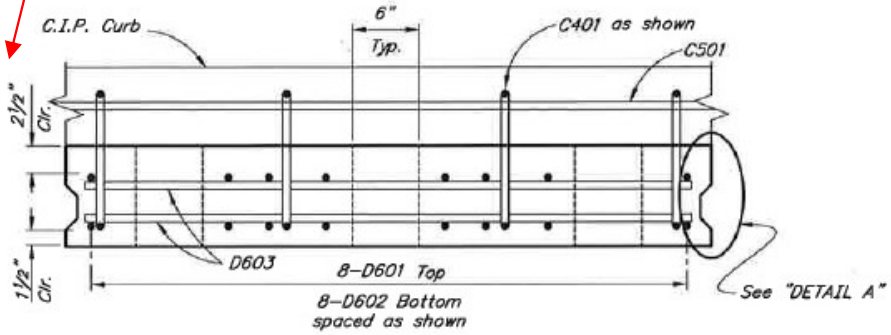
Girder Launching

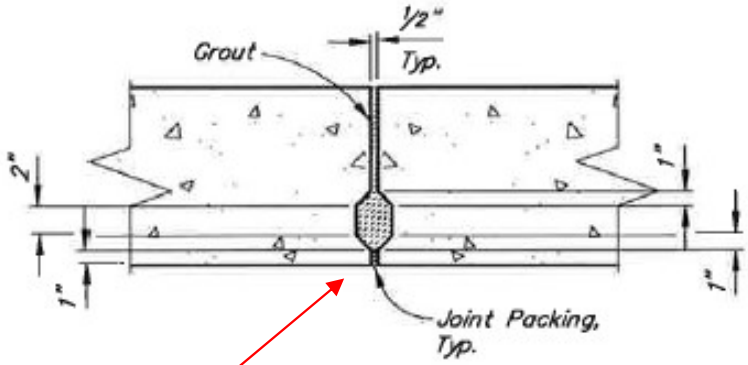
Deck Panels


27'-4"
℄ Void
2'-9½"
7'-3"
Curb reinforcing not shown
9½"
4'-10"
1'-7½"
1'-7½"
℄ Leveling Screws & Lifting Anchors
℄ Deck Panel
℄ Leveling Screws & Lifting Anchors
1'-7¼"
4-D603
Top & Bottom, Typ.
8-D603
6'-0" Typ.
℄ Lifting Anchor and Bunking Point
Leveling Screws
Voids for shear connectors
Lifting points
PANEL WITHOUT RAIL POST DETAIL
(18 Total)
PANEL WITH RAIL POST DETAIL
(19 Total)
DECK PANEL - PLAN
Crown cast in
C.I.P. Curb
C401
D601
D603
D602
1'-6" Typ.
1'-3" Typ.
1'-0"
7"
6"
See "STEEL BRIDGE RAILING" Dwg. for rail post anchor details. See "FRAMING PLAN" for rail post layout
℄ ¾" Drip Groove, Typ.
DECK PANEL - ELEVATION

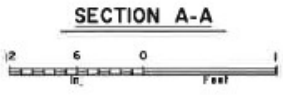
Deck Panel Details

Extra sacrificial clear cover since no wearing surface



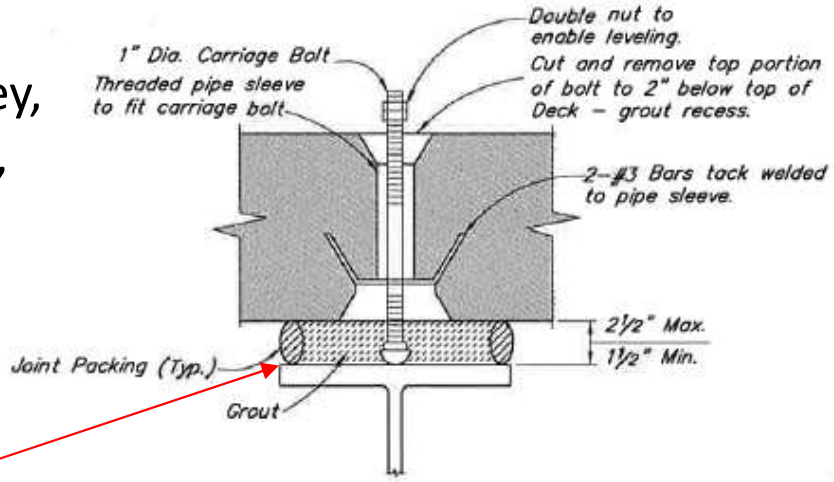


DETAIL A
No Scale



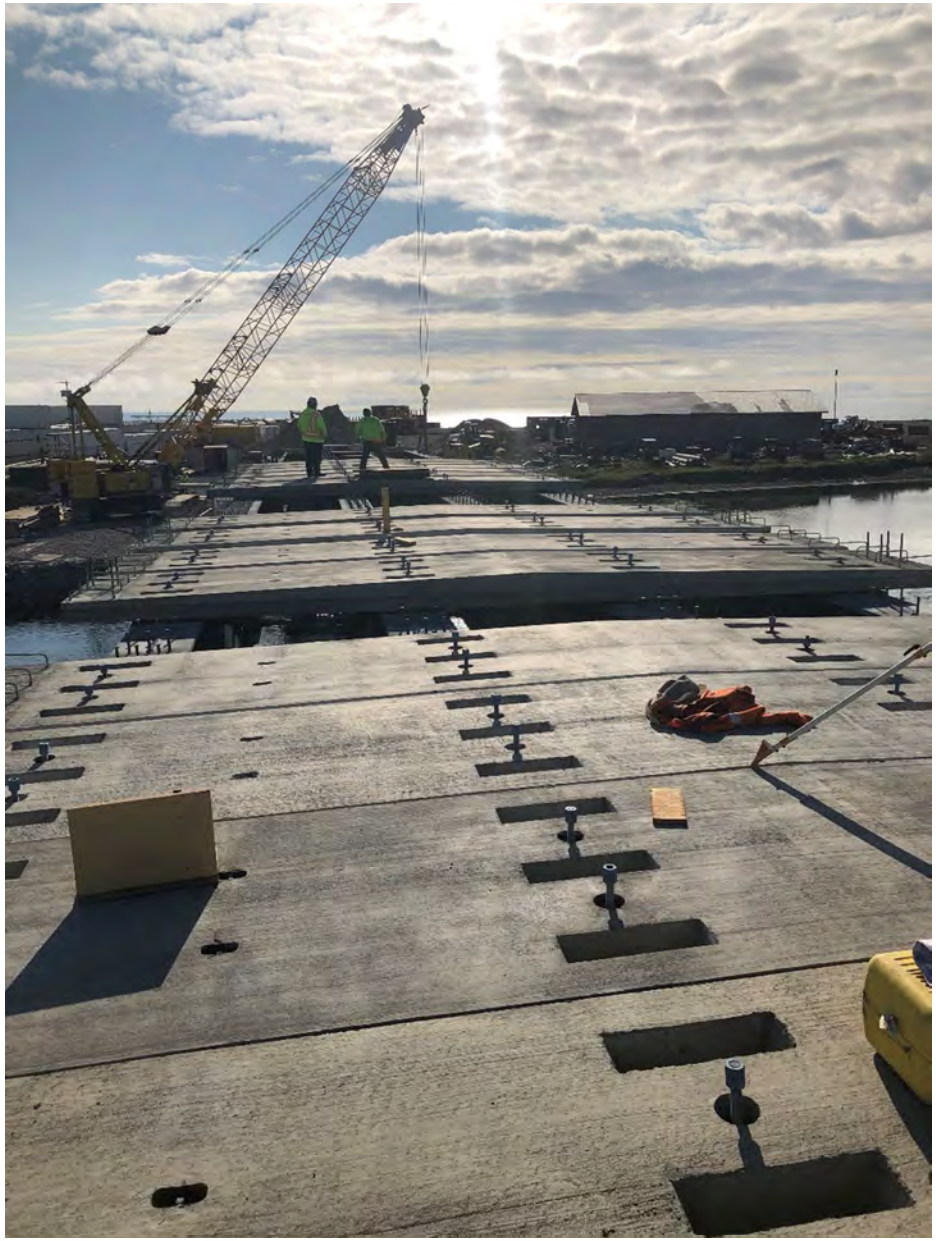
Simple grouted transverse shear key, no post tensioning, reinforcement or UHPC

Grouted haunch



LEVELING SCREW DETAIL
No Scale

Deck Panel Installation



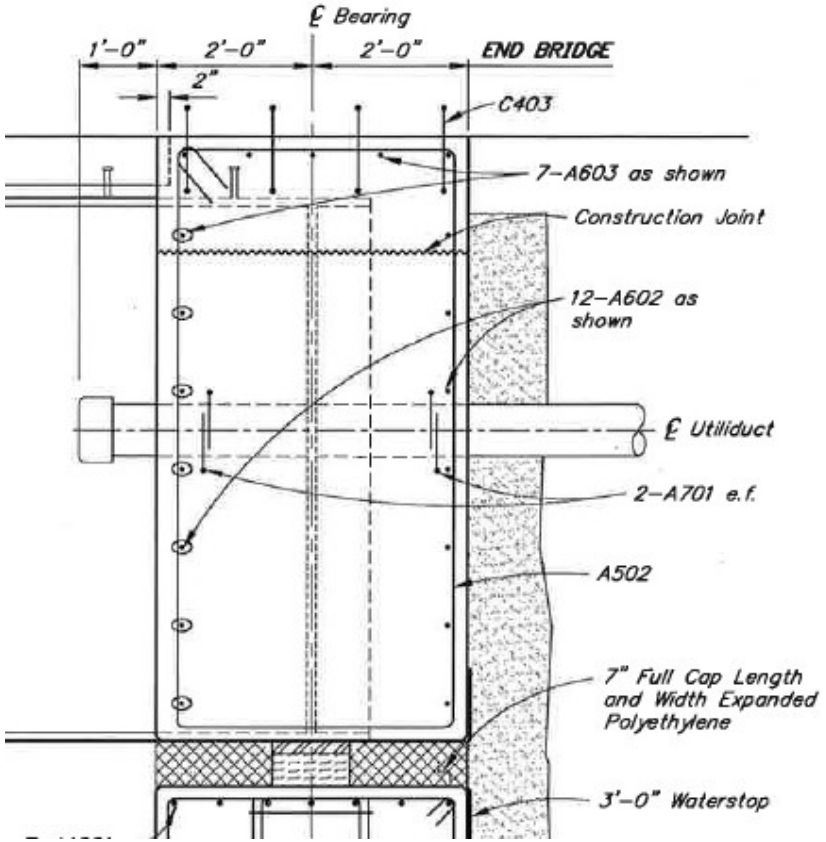
Grout Placement

Sept 2020, Temperature ~42˚F, Winds ~10 mph

Deck Panel Installation

- Benefits
  - Rapid installation, usually 1-2 days to set and level panels
  - Factory controlled production (made in WA)
  - While they are heavy, they are still readily shipped
  - Easily adjustable in the field for varying camber
  - No access from below required

End Diaphragms



- Jointless bridge, no exposed bearings, sole plates or cap beams. Uses reinforced elastomeric bearing pads

Completed End Diaphragms

Completed Bridge

Completed Bridge

Materials

DESIGN:	AASHTO LRFD Bridge Design Specifications, 2017 Edition, with latest interim specifications. Seismic design per AASHTO Guide Specifications for LRFD Seismic Bridge Design, 2011 with latest interim revisions.
LIVE LOAD:	HL-93
DEAD LOAD:	Includes 50 psf for all wearing surfaces.
SEISMIC PARAMETERS:	PGA = 0.12 Ss = 0.27 S1 = 0.08 Site Class = D Liquefaction Potential = Low AASHTO 7% probability of exceedance in 75 years.
REINFORCEMENT:	ASTM A706, Grade 60, Fy = 60,000 psi ASTM A970 Headed bars, Class HA. Space reinforcement evenly unless otherwise noted. Galvanized reinforcing bars may be substituted for epoxy-coated bars.
CONCRETE:	Class A Concrete unless otherwise noted, f'c = 4000 psi Class P Concrete for precast deck panels, f'c = 5,000 psi. Provide rubbed finish on all exposed vertical surfaces.
STRUCTURAL STEEL:	ASTM A709, Grade 50T3, Fy = 50,000 psi Galvanize structural steel in accordance with AASHTO M111 or SSPC CS23.00 unless shown otherwise. All steel is main members subject to tension.
HIGH STRENGTH BOLTS:	Galvanized ASTM F3125 Grade A325 or F1852, Fu = 120,000 psi. Exclude threads from shear plane. Do not use punched holes.
STRUCTURAL STEEL PILING:	API 5L X52 PSL2, Fy = 52,000 psi. or ASTM A709 Grade, 50T3, Fy = 50,000 psi. Close-ended pile tip reinforcing is required.
SHEAR STUD CONNECTORS:	ASTM A108, Fu = 60,000 psi

GROUT……Non-shrink, non-metallic, 9,000 psi (prepackaged)

Costs

- Since this was a CMGC project, there are no ‘bid prices’ but from similar projects:

	Urban Alaska	This Project
Class A Concrete	~$1,500/CY	~$6,000/CY
Reinforcing Steel	~$2.50/lb	~$10/lb
Structural Steel	~$3.50/lb	~$4/lb
Furnish 2’ dia. Pile	~$150/ft	~$175/ft
Drive 2’ dia. Pile	~$10,000/ea	~$30,000/ea
Precast Deck Panels	*Not typ. used*	~$20,000/ea
Class III Riprap	~$125/CY	~$250/CY
Worker Meals and Lodging	*Varies*	~$2.7mil
Mobilization	*Varies*	~$3.0mil

- Total bridge cost ~ $5.1M Total project cost ~ $43M

Lessons Learned

- CM/GC allows the owner to work *with* the contractor rather than against them
- Project staff are instrumental and show that high quality projects can be completed even in remote locations

- Assumptions about what is easiest for the contractor are not always correct
  - Precast cap beams vs CIP option

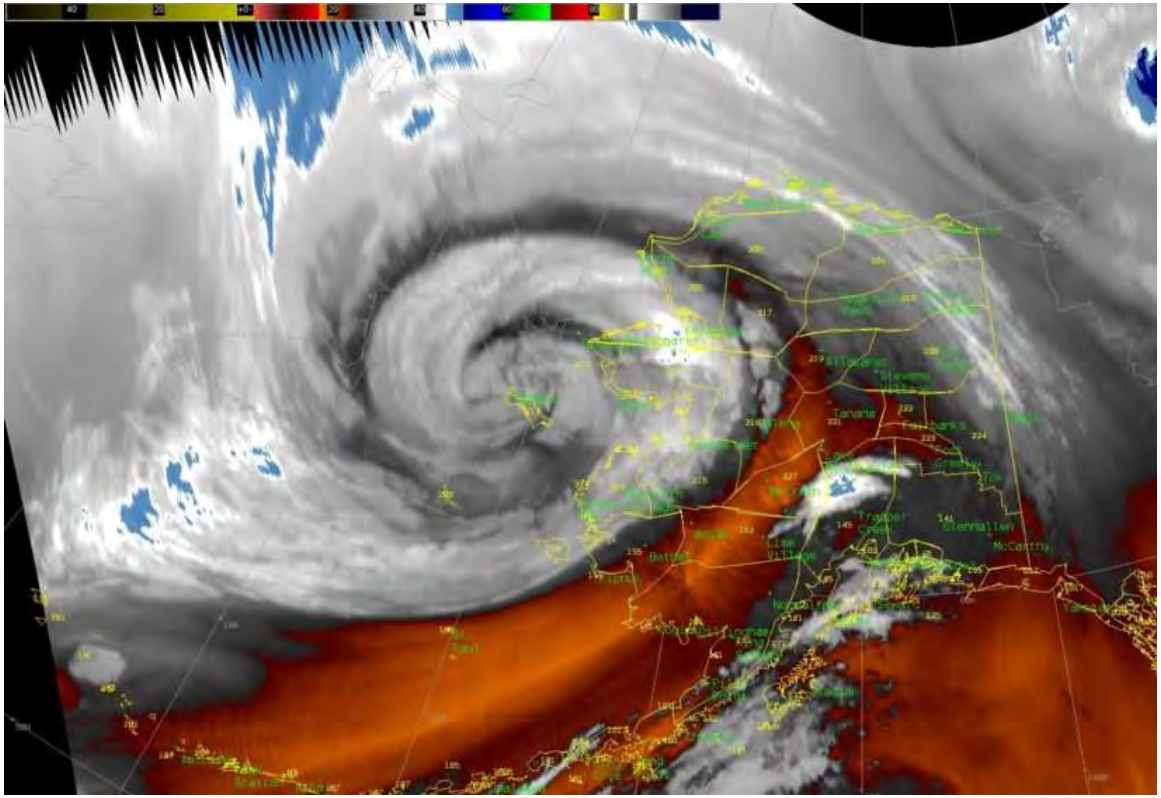
Typhoon Merbok– Sept 2022

Did climate change have a bearing on the storm?

There's a strong likelihood that Merbok was able to form where it did because of the warming ocean.

With warm ocean water, there's more evaporation going in the atmosphere. Because all the atmospheric ingredients came together, Merbok was able to bring that very warm moist air along with it. Had the ocean been a temperature more typical of 1960, there wouldn't have been as much moisture in the storm.

- No evacuations occurred in Kivalina, but residents were warned to be ready.



https://alaskabeacon.com/2022/09/19/typhoon-merbok-was-fueled-by-an-unusually-warm-pacific-ocean/

Nome – August 2022

Nome – September 2022

Thank you!

Questions?