Appendix C - INNOVATIVE TECHNOLOGIES

The Alaska Department of Transportation and Public Facilities is a recognized leader in remote, cold climate, and seismic bridge engineering. Our current $2.6 million research portfolio includes partnerships with North Carolina State University, Texas A&M Transportation Institute, and the University of Alaska, with project topics ranging from material properties to examination of shear capacity of longitudinal keyways in decked bulb-tee girders.[1]

This emphasis on investigation stems from the fact that bridge design in Alaska's environment must consider multiple concurrent severe hazards and limitations. This combination of challenges makes extremes the "Alaska normal." Out of necessity, Accelerated Bridge Construction (ABC) has been standard practice in Alaska for decades. The challenges of design and construction in Alaska are presented below followed by summaries of the innovations applied to this project to address these challenges.

Alaska Challenges

Geography. Alaska DOT&PF manages an inventory of approximately 1,000 bridges, spread over 570,641 square miles; to put this in perspective, total land area of the next three largest states combined (California, Montana, and Texas) is only 562,557 square miles.[2] Many bridges are in communities only reachable by air or water; even those on the main NHS road system might be several hundred miles from the nearest gas station or other commercial services.

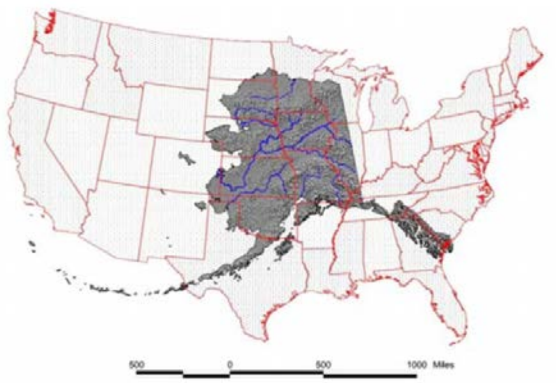

Figure 1 Alaska Superimposed over Contiguous U.S.

Extreme Seismicity. Alaska has the highest seismicity in the nation: epicenters of 9 of the 10 largest earthquakes in the North America since 1900 are in Alaska.[3]

Non-Redundancy. Most of Alaska's highways – and therefore, communities – do not have detour routes, because there is generally only one road in or out. When a bridge is out of service, traveling hours out of the way is the best case scenario; the worst case involves chartering a plane or helicopter or simply waiting until water has frozen thick enough for an ice road.

Short Construction Season. Excluding the most extreme areas, the Alaskan construction season is approximately May through September. Cold weather construction – generally considered to

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[1] See Alaska DOT&PF Current Bridge Research Projects 2018. Unpublished Report, Prepared by DOT&PF Research, Development & Technology Transfer Section.

[2] Land area from U.S. Census Bureau, "State Area Measurements and Internal Point Coordinates", Accessed November 15, 2018.

[3] Research Query: Largest North America Earthquakes since 1900. USGS Earthquake Catalog. Accessed November 13, 2018.

be after October or before April – increases the costs of work to such an extent that contractors avoid it when possible. This is one of the prime reasons that Alaska is at the forefront of research and implementation of Accelerated Bridge Construction innovations.

Environmental Constraints. Alaska produces the highest volume of fish and seafood of any state in the United States.[4] Subsequently, protection of streams is critical to the economy, but permitted "fish windows" – time periods during which in-stream work is allowed – also constrain the amount of time contractors can accomplish in-stream work.

Climate. According to the National Oceanic and Atmospheric Administration, Alaska's record low temperature (-80° F) occurred less than 150 miles from its record high temperature (100° F),[5] and as a result, DOT&PF bridge design practice calls for standard temperature ranges of up to 160° F.[6] Material properties can change over a temperature range of this magnitude, which is particularly relevant to seismic design.

For example, frozen soils behave differently from unfrozen soils, changing the location of the plastic hinge in pile foundations. Permanently frozen soils often underlie unfrozen or seasonally frozen soils, and each soil scenario alters seismic demand and response.

Limited Industrial Capacity. Alaska has no steel manufacturing, a small skilled labor pool, and limited options for construction equipment and materials.

DOT&PF design and construction staff regularly addresses all of these factors, and the innovations described below represent some of the resulting adaptations. Both the ABC and Every Day Counts initiatives have identified Prefabricated Bridge Elements (PBEs) as key tools for reducing construction time. Alaska DOT&PF has been using PBEs for decades and likely leads the nation in use of precast, prestressed concrete decked bulb-tee girders with installations at more than 300 locations.

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[4] *Fisheries of the United States 2016*. NOAA National Marine Fisheries Service. August 30, 2017 (p-12).
[5] State Climate Extremes Committee. NOAA National Centers for Environmental Information. Accessed November 16, 2018.
[6] *Alaska Bridges and Structures Manual*. DOT&PF Bridge Section. Chapter 19: Expansion Joints and Bearings. September 2017 (p 19-1, Table 19-1).

Appendix C - INNOVATIVE TECHNOLOGIES

Innovative Technology: Precast Prestressed Concrete Decked Bulb-Tee Girders (DBTs)

Summary of Benefits
• Expedited project delivery – saves 50% to 75% of deck construction time compared to a conventional Cast-In-Place concrete bridge decks • Expedited project delivery – design, fabrication and construction standards are mature in Alaska • Added bridge capacity – superior overload capacity (operating load rating) due to zero tension design standard • Improved bridge durability – high quality plant-cast concrete eliminates inadequate reinforcing cover, the leading cause of premature deck deterioration in the state

This innovation will be applied to the following structures in this project: Herring Cove Bridge (NBI No. 253), Hoadley Creek Bridge (NBI No. 725).

Description

Precast, prestressed concrete decked bulb-tee girders leverage traditional technology into a single innovation addressing multiple construction challenges. A standard precast concrete bulb-tee girder is fabricated with the final deck installed. Edge girders are cast with curb hardware.

Decked bulb-tee girders are connected by a combination of cast-in-place concrete diaphragms, welded steel connection "tabs" embedded in the edges of the top flanges, and grouted keyway longitudinal joints. "Alaska-style" DBT decks can be used as a riding surface as soon as the grout cures, or a waterproofing membrane with asphalt overlay can be added.

DOT&PF design policy further extends the advantages of DBTs. Girders are designed for zero tension under all loads which results in very high operating load ratings in flexure. To optimize these capacities, enough additional reinforcing is provided so the shear operating rating is roughly equal to the flexure rating resulting in efficient girders with optimal overload capacity.

Capacity to Implement

Alaska DOT&PF first used prototype DBTs in the late 1970s, and since then, they have become the most commonly used bridge superstructure in the state. DBTs are almost always the lowest cost bridge type in Alaska when geometric limitations can be met. Maximum DBT span lengths are typically limited 120 to 140 feet due to shipping and handling concerns.

Figure 2 "Alaska-Style" Prestressed Girder Installation

Example Financial and Time Savings

DBT bridges can be two to three times faster to construct than structures with conventional cast-in-place concrete decks. A comparison of typical deck construction sequences is detailed below.

Construction Time Comparison			
Conventional CIP Deck		**Decked Bulb-Tee Girders**	
Construct soffit forms	2 weeks	Place girders with integral deck	0.5 weeks
Place reinforcing steel	2 weeks	Weld & grout keyways	0.5 weeks
Place & cure concrete	1 week	Form & cast diaphragms & curbs	1 week
Strip forms	1 week	Install waterproofing membrane & asphalt overlay	0.5 weeks
Total	**6 weeks**	**Total**	**2.5 weeks**