ALASKA

Concrete bridges in extreme and remote environments

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Hyder Dock Trestle. All photos: Alaska Department of Transportation & Public Facilities.

Concrete bridges are a practical way to deal with Alaska's many design and construction challenges, including short construction seasons, remote locations, temperature extremes, seismic demands, and coastal environments. Currently, 44% of Alaska's state and local bridge inventory is concrete, but concrete accounts for approximately 80% of the new bridges built by the Alaska Department of Transportation & Public Facilities (DOT&PF). The state's oldest concrete bridges date back to the 1930s, but innovative girder shapes and enhanced materials allowed for the development of the Alaska DOT&PF's preferred superstructure type—the prestressed concrete decked bulb-tee girder.

Evolution of Concrete Bridges

Different configurations of precast, prestressed and post-tensioned concrete bridges were built during the 1970s and 1980s, including an impressive example of an early segmental, cast-in-place concrete box girder bridge—the award-winning Gastineau Channel Bridge. The Alaska DOT&PF designed the bridge in 1979 to replace the only link from Alaska's capital city, Juneau, to neighboring Douglas Island, where a significant portion of its population lives. This three-span bridge is 44 ft wide and has a total length of 1286 ft. The 620-ft-long center span is comprised of two 250-ft-long cantilevers from the piers and a 120-ft-long suspended span. Both vertical and longitudinal post-tensioning were used and contributed to the bridge's graceful shape.

Since the early 1970s, Alaska DOT&PF has been designing precast, prestressed concrete decked bulb-tee girder bridges using high-strength concrete (HSC). Decked bulb-tee girders are similar to concrete I-girders, but the upper flange is wide enough to also act as the bridge deck. Using this girder shape eliminates the need to cast and cure a conventional concrete bridge deck, greatly accelerating the superstructure construction time. In addition, by being precast, the entire superstructure has higher strengths and receives better quality control.

Initially, design concrete strengths were 5.5 ksi at transfer of prestress and 6.5 ksi at 28 days. It was presumed that improved durability would be one benefit of the increased concrete strength and no performance requirements such as chloride permeability, abrasion resistance, or freezing and thawing resistance were specified. Forty years and hundreds of bridges located in extreme environments have proven this assumption to be true. By the late 1990s, concrete strengths at transfer of 7.5 ksi and 28-day strengths of 8.0 ksi were specified. The need to consistently obtain the high release strength in a short period of time (typically around 18 hours) resulted in actual 28-day concrete strengths of 10 ksi or higher. As the specified concrete release strength has increased, there has been no change in the daily production cycle and no significant cost increase has occurred.

With the adoption of HSC, longer bulb-tee girders could also be designed. The Alaska-style decked bulb-tee girders come in standard depths of 42, 54, and 66 in. Typical girder spans range from 85 ft for a 42-in.-deep section to 145 ft for a 66-in.-deep section. Longer span lengths are technically feasible, but transportation from the precaster to the jobsite becomes an obstacle.

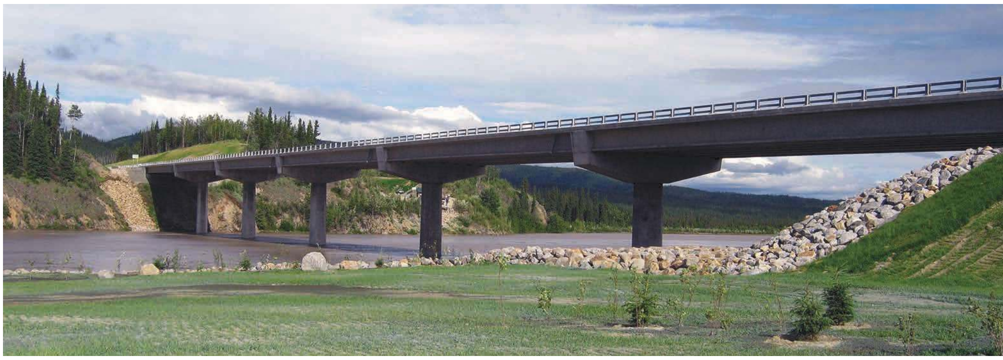
The typical top flange width of the decked bulb-tee girders varies from 6 to 8 ft with a maximum possible width of 8.5 ft. A typical two-lane bridge consists of five or six girders, depending on the girder length and required roadway geometry. The deck is an integral component of the flexural system and is designed to remain in compression under all service load combinations. Alaska DOT&PF policy limits tensile stress after losses to zero under the service limit state.

Shear keys and tabs, typically spaced at 4 ft along the longitudinal joints of the interior flanges, are used to connect adjacent girders. At the weld-tab locations within the shear keys, steel plates are welded to embedded inserts of adjacent flanges for a rigid connection. Next the shear keys and longitudinal joints are filled with high-strength grout to complete the shear transfer and for corrosion protection. Most decked bulb-tee girder bridges then receive a waterproofing membrane and asphalt riding surface, which has proven to be effective at keeping water from entering the joints and underside of the superstructure.

Durable to the Elements

The long-term durability and wear-resistance of bulb-tee decks has proven to be outstanding. There has been almost no girder-related maintenance required on the 273 bridges of this

The Gastineau Channel Bridge, as seen from a kayak at sunset.



Newly completed Tok Bridge near the city of Tanana.

Picking a bulb-tee girder for winter construction of the Hicks Creek Bridge.

style built since 1973. Although traffic volumes are low with respect to other states, Alaska has more severe environmental conditions. Studded tire and chain usage is high and may occur for up to 6 months per year. Deicing chemicals are frequently used in the corrosive maritime regions where snowfall is heavy and the number of freezing and thawing cycles is large. Most of Alaska's population is located in coastal areas, so corrosion-resistant bridges are important.

Geography is another factor that makes the durability of concrete structures so critical in Alaska. Although there are only approximately 1000 state and locally owned highway bridges in Alaska, these bridges are spread over a geographic land area of about 570,000 square miles. In other words, Alaska is roughly equal in size to one-fifth of the 48 contiguous United States—an area larger than Texas, California, and Montana combined. An added complication is that some bridge sites are accessible only by boat or plane. Limited access to such remote bridges off the road system and those several hundred miles from the nearest commercial services means that it's critical to select bridge types and features requiring little to no long-term maintenance.

Currently, there is only one prestressed concrete girder manufacturer in Alaska, whereas steel bridges are typically fabricated outside Alaska. By eliminating the need to ship girders from out of state, in-state precast concrete girders typically offer considerable savings. With the decked bulb-tee girder, bridge construction time is also significantly reduced. A typical highway overpass is often built in less than 3 months from mobilization of equipment to bridge railing installation. This is particularly important in Alaska where the construction season is short (sometimes less than 3 months) and cast-in-place concrete is not readily available outside the major population centers.

Decked bulb-tee girders aren't without some disadvantages. They are heavy and bulky to transport, require one or more cranes for placement, and the shape has limited use for curved roadway alignments. Experience has shown fewer problems occur when intermediate concrete diaphragms are used compared to steel bracing, but concrete diaphragms are heavier with more time and cost required for forming and placing.

More Active than California

Another significant consideration when designing bridges in Alaska is the state's high seismicity. Alaska is the most seismically active state in the United States and earthquakes in the state have released nearly 25% of all of the world's earthquake energy over the last century. This year marks the 50th anniversary of the 1964 Good Friday Earthquake, North America's largest recorded earthquake (moment magnitude 9.2). Besides the four minutes of shaking, the subsequent liquefaction, landslides, tsunami, and aftershocks contributed to the loss of life and extensive property damage. The Alaska Earthquake Information Center estimates that damages totaled $300-400 million in 1964 dollars.

In general, Alaskan highways do not have alternative routes. If a bridge in most parts of the state were to be damaged by an earthquake, transportation would be severely impacted. This makes the resilience and health of our bridges essential to life and commerce. Although seismic design for Alaskan bridges focuses primarily on the substructure system, decked bulb-tee girders have shown to be a reliable superstructure choice that act uniformly and perform adequately under seismic loading.

Overall, the Alaska DOT&PF has been highly satisfied with the performance of its concrete bridges. Low life-cycle costs, minimal maintenance, and excellent durability have proven advantageous for the state. The state plans to continue using concrete bridges wherever possible.

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