

Grass Lake Wildlife Overcrossing: Restoring Habitat Connectivity Through Innovative Bridge Engineering

by Habib Hotaki and Kerry Molz, California Department of Transportation

Collisions between vehicles and wildlife represent a persistent safety and ecological challenge across Western U.S. transportation corridors. Along U.S. Route 97 in Siskiyou County, Calif., elk movement routes intersect a major highway corridor, creating both a public safety hazard and a long-term barrier to ecological connectivity.

Between 2015 and 2020, vehicles killed more than 50 deer and 16 elk along this specific two-lane stretch near Grass Lake,¹ a collision rate typical of this region. U.S. 97 bisects seasonal movement paths for elk and mule deer across open grasslands, oak woodlands, and higher-elevation habitats.

To improve safety for both wildlife and the traveling public, the California Department of Transportation (Caltrans) devised an overcrossing that spans U.S. 97 about 26 miles from the Oregon border. Although several animal species benefit from the overcrossing, the land bridge was sized for elk because they are large animals and collisions with them cause major safety and financial issues for motorists. Mule deer, pronghorns, and elk are the primary users of the overcrossing, while black

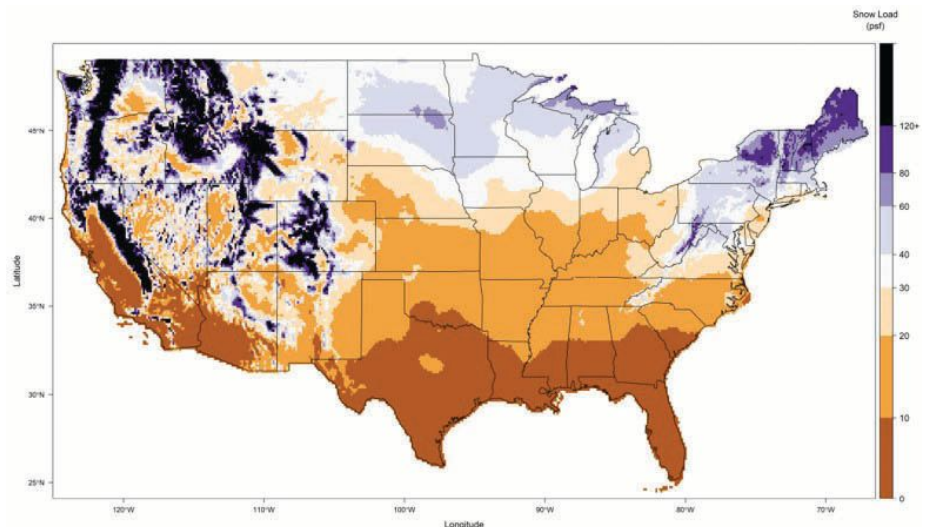
bear, wolf, bobcat, and other animals will also use the land bridge.

To further accommodate species-specific crossing behaviors, Caltrans has also built a precast concrete box culvert beneath the highway, 1.2 miles south of the overcrossing. The culvert is large enough for all local species, but it is meant for deer and smaller animals. Although the culvert complements the

wide land bridge, this article focuses only on the overcrossing.

The Grass Lake Wildlife Overcrossing was developed to restore habitat connectivity and improve roadway safety. The project has also advanced bridge engineering practice through a novel approach to snow-load design, an innovative prefabrication strategy, and the first use of glass-fiber-reinforced

A map showing proposed design ground snow-load requirements for the United States based on the results of the 2020 National Snow Load Study.⁴



profile

GRASS LAKE WILDLIFE OVERCROSSING /SISKIYOU COUNTY, CALIFORNIA

BRIDGE DESIGN ENGINEER: California Department of Transportation (Caltrans) Division of Engineering Services, Sacramento, Calif.

OTHER CONSULTANT: Caltrans District 2, Redding, Calif.

PRIME CONTRACTOR: McCuen Construction Inc., Loomis, Calif.

CONCRETE SUPPLIER: Sousa Ready Mix LLC, Mount Shasta, Calif.

polymer (GFRP) reinforcement in California state highway infrastructure.

Site Selection

In November 2019, Caltrans and subject matter experts from Montana State University, Western Transportation Institute, California Department of Fish and Wildlife, U.S. Forest Service, and California Deer Association conducted multidisciplinary field studies to evaluate potential wildlife crossing locations. The objective was to align structural feasibility with documented ecological corridors. Caltrans, in collaboration with the team of regional conservation partners, considered connectivity, engineering and construction challenges, and site constraints and selected a location east of Grass Lake, approximately 1.4 miles north of Deer Mountain Road.

The selected location corresponds to documented elk movement corridors described in the California Department of Fish and Wildlife's *Elk Conservation and Management Plan*.² U.S. 97 bisects these routes, along with those for deer, black bear, mountain lions, and wolves, creating a functional barrier. Without a grade-separated crossing, elk either attempt at-grade highway crossings, which may lead to vehicular collisions, or avoid traditional migration paths, contributing to habitat fragmentation and population loss.

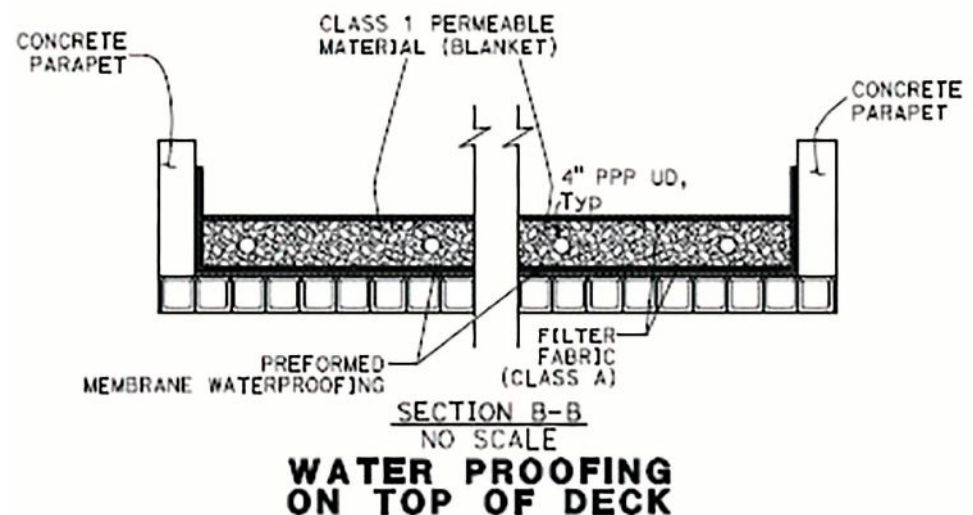
Site and Constructability Considerations

The remote location of the project significantly influenced decisions about the structural configuration. Because site access was limited and the delivery route for ready-mixed concrete was long, the design team chose to minimize cast-in-place concrete operations. Instead, the design team chose to

use 35 adjacent precast, prestressed concrete box girders to erect the 100-ft-long, 140-ft-wide superstructure. The box girders each contain thirty-five 0.6-in.-diameter strands and were designed with an initial concrete compressive strength of 7000 psi and a final concrete compressive strength of 8000 psi.

The box girders are topped with 8 in. of gravel for drainage and a maximum of 2.5 ft of noncompacted soil. Because there was no composite topping on the girders, cast-in-place concrete end diaphragms along the abutment seats were used to connect all girders together and to make the whole superstructure move together in case of any lateral movement. These diaphragm elements used GFRP bars tied together with mild steel bars, which extended from the box girders. No transverse post-tensioning was used.

A cross section of the structure shows the waterproofing membrane, drainage layer, and permeable blanket on top of the deck before the installation of 24 in. of lightweight, uncompacted soil and native vegetation. Figure: California Department of Transportation.



The precast concrete option shortened the construction duration, improved quality control, and limited environmental disturbance at the site and in the surrounding habitat. Projects that use cast-in-place concrete need falsework and temporary support for fresh concrete, and the erection schedule must include time to cure the concrete. By using precast concrete components, the project did not need falsework, eliminated on-site cure time, avoided long-term lane closures, reduced traffic disruptions, and improved safety for both motorists and construction workers.

Although the location of the site posed construction challenges, the geotechnical conditions at the site were advantageous. The seismic demand is relatively low (peak ground acceleration = 0.17g), and the foundation soils are competent. As a result, deep pile foundations were

CALIFORNIA DEPARTMENT OF TRANSPORTATION, OWNER

PRECASTERS: Girders: Con-Fab California LLC, Lathrop, Calif. —a PCI-certified producer; box culvert: Precast Unlimited Inc., Redding, Calif. —a PCI-certified producer

OTHER MATERIAL SUPPLIERS: Glass-fiber-reinforced polymer reinforcement: Camblin Steel Services, Roseville, Calif.

BRIDGE DESCRIPTION: 100-ft-long, 140-ft-wide single-span precast, prestressed concrete box-girder bridge on cast-in-place concrete abutments with spread footings

STRUCTURAL COMPONENTS: Thirty-five 4-ft wide by 4.5-ft tall precast, prestressed concrete box girders; cast-in-place concrete abutments

BRIDGE CONSTRUCTION COST: \$14 million (\$7 million for bridge items only)



The Grass Lake Wildlife Overcrossing is composed of precast, prestressed concrete box girders. The girders, which each contain thirty-five 0.6-in.-diameter strands, were designed to achieve an initial concrete compressive strength of 7000 psi and a final concrete compressive strength of 8000 psi. Photo: California Department of Transportation.

not necessary and shallow foundation systems could be used.

Unconventional Loading Conditions

Snow Loads

The design loads for conventional bridges in the American Association of State Highway and Transportation Officials' *AASHTO LRFD Bridge Design Specifications*³ are based on the assumption that snow loads are either negligible or offset by reduced traffic activity. (See Article C3.9 in the AASHTO LRFD specifications.)

Those assumptions are not valid for the Grass Lake Wildlife Overcrossing, which will not be plowed, will experience sustained snow accumulation, and will lack traffic-induced thermal or mechanical clearing effects. Also, unlike conventional highway bridges, the wildlife crossing will not be subject to fatigue from traffic loading, chemical deicing exposure, or deck wear. Consequently, the crossing will have significantly different deterioration mechanisms than those of a conventional bridge, and its expected design life is longer. Given these circumstances and the lack of wildlife crossing-specific design standards, the design team developed a probability-based snow-load philosophy to determine the loadings for this project.

At the Grass Lake site, the elevation is above 5100 ft, and snow accumulation is both routine and potentially severe. Seasonal snow accumulation in the region is typically moderate, but 4 to 5

ft of wet snow can fall during extreme storm events. For example, at Mount Shasta, which is just 16 miles away from the crossing, storms have delivered more than 15 ft of snow. Published estimates for ground snow loads at or near the site of the crossing vary widely, from 40 to 300 lb/ft².⁴ Project-specific snow load criteria were developed by the load committee of the Caltrans division of engineering services (DES).

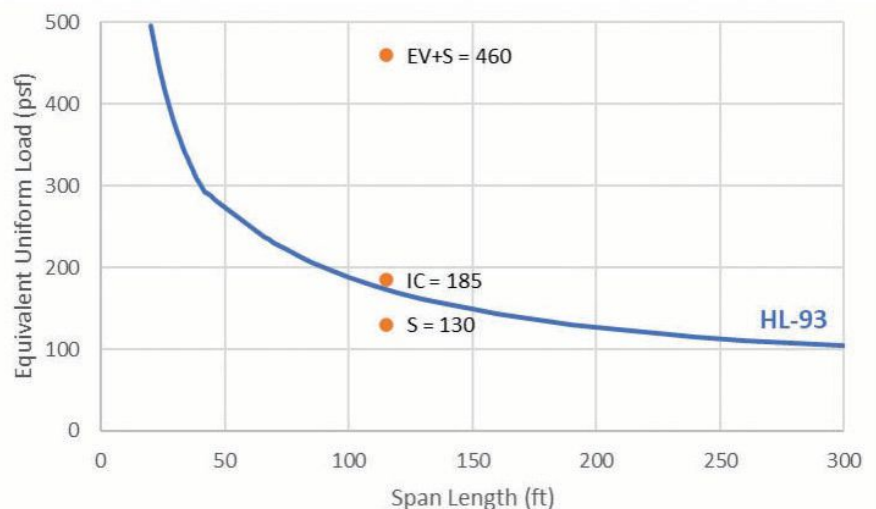
To determine load effects for the crossing, the design team compared equivalent midspan moments from the AASHTO HL-93 design vehicular loading with a uniform snow-load accumulation and determined that for a 100-ft span, the moment from snow loading would approach that of the vehicular live load. The AASHTO HL-93 load was only used to compare the traditional live load with snow load. H20-type design vehicles were used to design for the vehicular

load for this bridge and account for maintenance vehicles.

When the snow load S and the load from 3 ft of earth fill EV (330 lb/ft²) are combined, the total gravity load exceeds the HL-93 load pattern. The 3-ft of earth fill included 2 to 2.5 ft of noncompacted soil layer and the 8-in.-thick permeable (gravel) drainage layer. Thus, the governing load condition is $EV + S > HL-93$. This governing load condition is atypical in bridge engineering.

The design team adopted a dual-level snow-load framework for the overcrossing design in accordance with the project-specific snow load criteria developed by the DES loads committee. A 50-year snow event with a snow load of 125 lb/ft² was used for the Service Limit State/Strength Limit State, and a 500-year snow event with a snow load of 160 lb/ft² was used for the Extreme

Snow loads versus AASHTO HL-93 vehicular loads. Note: EV = vertical earth fill load; IC = ice load; S = snow load. Figure: Habib Hotaki.





Finished in 2025, the Grass Lake Wildlife Overcrossing provides safe passage for many animals across U.S. Route 97 in northern California. Photo: California Department of Transportation.

Event Limit State. The 50-year value aligns with the historical calibration of snow loads in the American Society of Civil Engineers' *Minimum Design Loads and Associated Criteria for Buildings and Other Structures* (ASCE 7).⁵ The 500-year event reflects the extended service-life expectations (100 to 150 years) for wildlife crossings, and guidance from the AASHTO LRFD specifications for extreme hazard evaluation beyond service life.

Wind Effects from Solid Fencing

To help guide animals, many wildlife crossings have see-through mesh or woven-wire barriers that provide ample visibility. The openness allows wind to pass through, prevents snow buildup, and creates a safe environment for animals. However, for the Grass Lake project, the design team chose an 8-ft solid steel wildlife fence to block oncoming vehicle headlights, muffle traffic noise, and help funnel the animals through the crossing. This solid wall introduced increased wind-load surface area, parapet overturning moments, and demand on diaphragm and edge beam systems. As a result, the parapet systems required enhanced stiffness and reinforcement to resist lateral wind-induced effects.

Approximately 6 miles of wildlife-exclusion fencing were installed to guide animals toward the overcrossing. The northern end of the fence line connects to Grass Lake, which serves as a natural barrier.

Creating an Inviting Overcrossing

Another aspect of the project that involved unconventional engineering was the bridge deck, which needed to be durable, be landscaped to resemble the site's natural environment, and invite wildlife use. To protect the top flanges of the precast, prestressed concrete box girders, workers installed a waterproof membrane and an 8-in.-thick gravel drainage layer over the girders. Crews then planted native low-growth and shallow-rooted shrubs in 24 in. of lightweight, uncompacted soil placed over the drainage layer. Heavier landscape items such as logs and boulders were placed at the deck approaches along with larger plants that guide the wildlife onto the bridge.

Innovative Prefabrication Strategy

For the Grass Lake project, GFRP bars were embedded in the precast concrete girders, which also had conventional steel reinforcing bars. The use of two

different types of reinforcement can lead to construction or durability issues. Therefore, extensive collaboration and coordination between the GFRP bar manufacturer and the precaster was required to accomplish the prefabrication work.

One constructability issue that was solved through collaboration involved embedding the GFRP bars together with steel reinforcing bars inside the precast concrete girders. Carbon steel should not come into contact with GFRP because contact causes a galvanic reaction. Although the steel bars had epoxy coating to prevent galvanization when in contact with GFRP bars, the small, uncoated metal bar ties had to be replaced with plastic zip ties. The bar chairs were also plastic rather than steel.

Glass-Fiber-Reinforced Polymer Reinforcement

GFRP reinforcement is a noncorrosive and lightweight alternative to traditional mild steel reinforcement. It has been used in bridge projects in coastal and snowbelt regions to prevent corrosion from marine environments or deicing chemicals. However, the Grass Lake Wildlife Overcrossing represents the first application of GFRP on a highway project in California.

On this project, GFRP reinforcement in transverse end diaphragms connects the precast concrete girder system and parapet elements along the exterior girders. The design team chose GFRP for its corrosion resistance, high strength-to-weight ratio, electromagnetic neutrality, and reduced maintenance. This application demonstrates increasing confidence by Caltrans in alternative solutions for structural longevity in challenging environments.

Conclusion

By integrating wildlife movement data, nontraditional load modeling, and advanced materials such as GFRP, the Grass Lake Wildlife Overcrossing project sets a precedent for future wildlife-crossing infrastructure in complex mountain environments. Motion-activated cameras show that animals such as mule deer began using the crossing before construction was complete. The structure is also expected to benefit other species, including mountain lions, black bears, and gray wolves.

These types of projects are critical to making roadways safer for both wildlife and motorists by reducing collisions. Many other wildlife crossings are being constructed or have been recently completed in California and elsewhere. For example, the Wallis Annenberg Wildlife Crossing in Agoura Hills, Calif., which spans U.S. Route 101 in Los Angeles County, is expected to open in December. (See the Project article on page 16 in this issue for more information on that project.)

References

1. California Department of Transportation (Caltrans). n.d. "Wildlife Crossing Project on U.S. 97 in Siskiyou County." Accessed July 30, 2026. <https://dot.ca.gov/caltrans-near-me/district-2/d2-projects/d2-wildlife-crossing>.
2. California Department of Fish and Wildlife. 2018. *Elk Conservation and Management Plan*. <https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=162912&inline>.
3. American Association of State Highway and Transportation Officials (AASHTO). 2017. *AASHTO LRFD Bridge Design Specifications*. 9th ed. Washington, DC: AASHTO.
4. Bean, B. L., M Maguire, Y. Sun, J. Wagstaff, S. Al-Rubaye, J. Wheeler, S. Jarman, and M. Rogers. 2021. *The 2020 National Snow Load Study*. Utah State University Mathematics and Statistics Faculty Publications paper 276. <https://doi.org/10.26077/200k-pr86>.
5. American Society of Civil Engineers (ASCE). 2016. *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*. ASCE 7-16. Reston, VA: ASCE. 

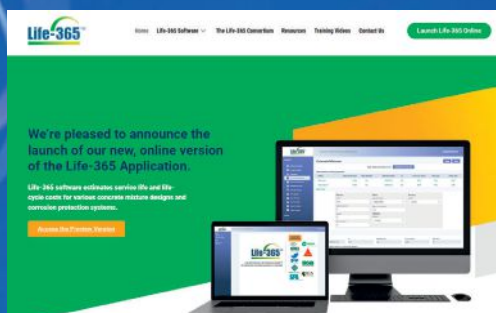
Habib Hotaki is a senior bridge engineer for the California Department of Transportation (Caltrans) Division of Engineering Services in Sacramento. Kerry Molz is the office chief for program/project management at Caltrans District 2 in Redding.

Life-365 Online Version (WebApp) Released



In 1999 a consortium was formed within American Concrete Institute's (ACI) Strategic Development Council (SDC) to fund development of a consensus model to estimate the service life and life-cycle costs of concrete mix designs. Shortly afterwards, the first version of Life-365 was released. During the last 20-years the software has gone through continuous updates, added features and a major User Interface redesign.

In November 2024, an online (WebApp) version of Life-365 was released. This version allows users to run this service life and life-cycle cost model in a web browser on a desk-top, laptop, tablet, or mobile phone. All features, functions, and ability to print reports remain fully intact.



The Silica Fume Association (SFA) was formed in 1998 to assist the producers of silica fume in promoting its usage in concrete. Silica fume, a by-product of silicon and silicon-based alloys production, is a highly reactive pozzolan and a key ingredient in high-performance concrete, dramatically increasing the service-life of concrete structures.

For more information about SFA visit www.silicafume.org.

Building a Durable Future
Into Our Nation's Infrastructure