PROJECT

Wynooski Road Bridge over the Highway 99 West Bypass

by Eric E. Bonn, OBEC Consulting Engineers

After 29 years in the making, the first phase of the Newberg-Dundee Bypass is almost complete. Currently, Oregon Route 99 West serves as both the main street for the cities of Newberg and Dundee, Ore., as well as a major transportation route between the Portland, Ore., metropolis and the Pacific Coast. Long backups and delays are common. This bypass facility, when complete, will be an 11-mile-long, four-lane, limited-access expressway on a fully new alignment south of both Newberg and Dundee. The first phase consists of 4 miles of 2-lane roadway and includes the grade-separated Wynooski Road Bridge over Highway 99, a significant arterial into the south end of Newberg.

The crossing location is pinched between a major industrial facility to the south and the 60-ft-deep Hess Creek drainage to the north. The existing Wynooski Road alignment also ran along the proposed bypass alignment for almost 300 yd. The resulting design moved the Wynooski Road Bridge to the top of the drainage slope, with a 603-ft-radius horizontal curve where the road goes over the bypass roadway. The bypass is in a cut section as it drops down to cross Hess Creek; therefore, a minor vertical curve was needed on the Wynooski Road Bridge to provide adequate vertical clearance underneath. The entering and exiting grades are 3.8% and -5.0%, respectively, and the resulting finish grade at the abutment is a minimum of 8 ft above the existing ground.

Post-tensioned concrete box girders and steel plate girders were considered for the Wynooski Road Bridge. The concrete structure was selected for multiple reasons:

- The cast-in-place (CIP) superstructure could be formed to follow the vertically and horizontally curved alignment, including the 4% superelevation.
- Prestressed concrete has a long and successful history in Oregon, exhibiting exceptional durability with minimal maintenance required.
- Concrete is also consistent with the other structures on the bypass, which all use precast, prestressed concrete girders.

Aerial view of bridge formwork showing horizontal curve of structure. Photo: Oregon Department of Transportation.

The bridge needed to cross over both the current phase of the bypass plus the future 4-lane build-out. Plus, the approaches to the crossing could not be supported on tall, wall-supported fills due to settlement and slope-stability concerns. Therefore, one end of the bridge was lengthened until it nearly met the existing ground at the west end. The resulting structure is 685 ft long and consists of four spans with lengths of 120, 210, 210, and 145 ft. The continuous box

The completed bridge with aesthetic treatment on the exterior face of the barrier rail. Photo: OBEC Consulting Engineers.

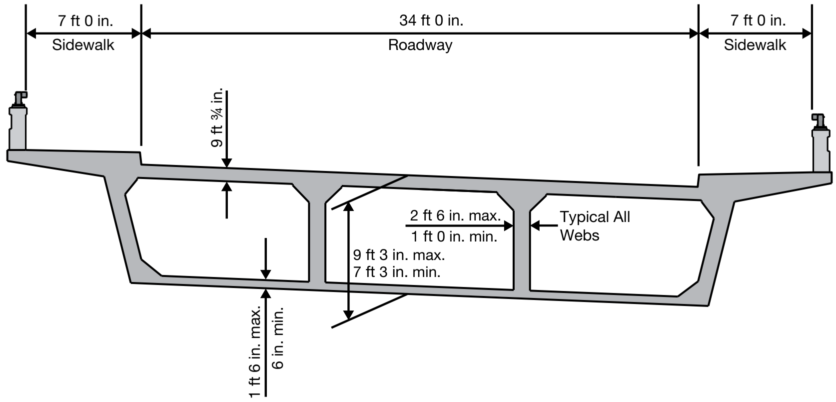
profile

WYNOOSKI ROAD BRIDGE OVER THE HIGHWAY 99 WEST BYPASS / NEWBERG, OREGON

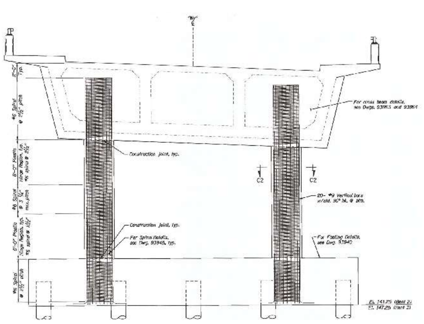
BRIDGE DESIGN ENGINEER: OBEC Consulting Engineers, Eugene, Ore.

PRIME CONTRACTOR: Wildish Construction Co., Eugene, Ore.

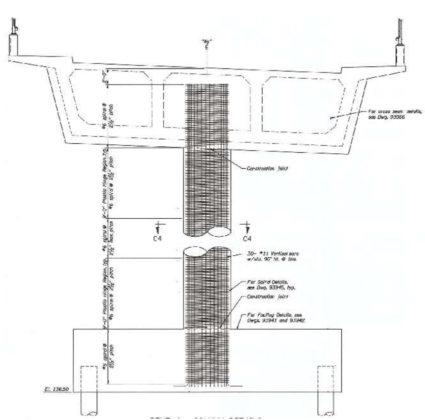
POST-TENSIONING CONTRACTOR: Schwager Davis Inc., San Jose, Calif.



Typical section of cast-in-place box girder. Figure: OBEC Consulting Engineers.



Bent 2 elevation. Figure: OBEC Consulting Engineers.



Bent 4 elevation. Figure: OBEC Consulting Engineers.

girder has a minimum depth of 7 ft 3 in., with 9-ft 3-in.-deep parabolic haunches at all interior bents. The span-to-depth ratio is approximately 29, resulting in a very slender appearance. The haunches extend for a distance of one-fifth of the span length on either side of the crossbeams to simplify the generally complicated forming geometry over most of the bridge's length. The depth of the haunches was minimized to provide the necessary vertical clearance beneath the bypass without raising the roadway alignment, which would have required additional bridge lengthening.

Wynooski Road Bridge's cross section includes a 34-ft roadway and two 7-ft-wide sidewalks. Including the rails, the total bridge width is approximately 50.4 ft. A three-cell box girder with a web spacing of 12 ft 6 in. was selected to coordinate with the column configurations, provide room for the necessary number of post-tensioning ducts, and limit the top slab overhangs to one-half of the web spacing per Oregon Department of Transportation (ODOT) requirements. The exterior webs are sloped 1:4 (horizontal to vertical). The raised sidewalks are integral to the box girder and act as the top flange in the overhangs. The thickness of the top slab above the cells is a constant 9.75 in. The webs and bottom slab have minimum thicknesses of 12 in. and 6 in., respectively, and thicken at the bents. The crossbeams of the interior bents are integral with the box girder.

Bents 2 and 3 each have two 4-ft-diameter columns. Bent 4 is located in the future median of the bypass and, with the alignments of Wynooski Road and the bypass intersecting at a 60-degree angle, a single 6-ft-diameter column was selected, thus allowing the crossbeam to remain perpendicular to the box.

The bridge is supported on driven steel-pipe piles. Concrete drilled shafts were considered, but they could not develop the necessary capacity in the site's soft, deep foundation soils. One of the geotechnical borings was advanced to a depth of 300 ft and encountered only clay soils. Therefore, large pile caps at the interior bents were needed to fit the required number of piles and space them as necessary to resist overturning forces. At bents 2 and 3, the pile caps are 22 ft by 44 ft and support both columns; the bent 4 pile cap is 34 ft square. During design, the 8-ft thickness of bent 4 caused concern that excessive heat of hydration might develop during the concrete curing. To address this issue, the bent was divided into two 4-ft-thick layers with a horizontal construction joint.

Two different concrete mixtures were used in the superstructure. The bottom slab and webs used 5-ksi concrete. The top slab and sidewalks used 5-ksi high-performance concrete (HPC) to increase wear resistance and reduce permeability. The HPC included 66% portland cement, 30% fly ash, and 4% silica fume for the cementitious material, as well as 5 lb/yd^3 of 1½-in.- to 2-in.-long polypropylene macrofibers. The water-cementitious materials ratio was limited to 0.40. All other bridge elements used 4-ksi concrete.

In addition to the HPC, other durability measures included limiting tensile service stresses in the box girder to one-half of the stress allowed by the American Association of State Highway and Transportation Officials' *AASHTO LRFD Bridge Design Specifications*, increasing the concrete cover over the top mat of top slab reinforcement to 2½ in., and eliminating all joints by using a continuous superstructure and semi-integral abutments. When using HPC in decks, ODOT does not require the use of epoxy-coated reinforcement in most regions of the state.

OREGON DEPARTMENT OF TRANSPORTATION, OWNER

BRIDGE DESCRIPTION: 685-ft curved cast-in-place continuous post-tensioned 7 ft 3 in.- to 9 ft 3 in.-deep concrete box girder with spans of 120, 210, 210, and 145 ft and a deck width of approximately 50.4 ft. The bridge was built with integral piers and semi-integral abutments to eliminate all joints on the structure.

BRIDGE CONSTRUCTION COST: $5.3 million (approximately $155/ft^2)

Placing concrete for bent 2 footing. Note the scale of the large footing supporting both columns. Photo: OBEC Consulting Engineers.

The bridge was designed according to AASHTO LRFD specifications, AASHTO's *Guide Specifications for LRFD Seismic Bridge Design*, and ODOT's *Bridge Design and Drafting Manual.*

The total post-tensioning required was four hundred 0.6-in.-diameter strands tensioned to 75% of ultimate strength for a total force of 17,577 kip. Each web contained four ducts. The number of strands per web varied across the cross section in relation to the lengths of the individual webs as they spanned the curved alignment, with the maximum number of strands being 108 and 92 for webs on the outside and inside of the curve, respectively. Previous experience shows this also helps counteract some twisting of the box due to dead load torsion. The post-tensioning and grouting occurred without issue, except that a limited amount of concrete needed to be removed at one of the abutments to allow the expected shortening to take place without engaging the pile cap.

Placing concrete in the bottom slab of a box girder near a pier. Post-tensioning ducts can be seen in the webs. Photo: OBEC Consulting Engineers.

ODOT required a two-tiered approach to seismic design: the bridge is to behave elastically during a 500-year event and not collapse under a 1000-year event. The peak spectral accelerations at the site are 0.58*g* and 0.72*g* for the 500- and 1000-year events, respectively, where *g* is the acceleration of gravity. Most of the design was controlled by the 500-year event criteria. A Seismic Design Category (SDC) of D was determined for this site.

Because the bridge needed to get back down to grade, the column heights at bents 2 and 3 were much shorter than those at bent 4, which is located in the excavation for the bypass. The AASHTO guide specifications require individual bent stiffnesses to be relatively similar throughout the length of a bridge that is being designed for SDC D. Using two smaller-diameter columns at bents 2 and 3 provided most of the needed flexibility, with the remaining required flexibility achieved by placing the pile caps an additional 6 to 8 ft deeper to increase the column lengths.

Lengthening the columns had the additional benefit of reducing the overstrength plastic forces transmitted into the crossbeams and pile caps, which were required to be designed as capacity-protected members, meaning they are to behave elastically while the columns are allowed to develop plastic hinges during a seismic event.

One of the design challenges on this bridge was detailing the reinforcement in the crossbeams. The AASHTO guide specifications have prescriptive requirements regarding the quantity of reinforcement encasing the intersections of the columns and crossbeams, which can result in significant congestion and interference between the seismic, column, crossbeam, and box-girder reinforcement plus the post-tensioning ducts. Using a three-cell box allowed placement of the column reinforcement between the webs, and extending the ends of the crossbeams 1 ft past the outside face of the box minimized the conflicts as much as possible. Inspection access hatches were provided in every cell at both ends of each span. Access holes were not placed through the crossbeams, to eliminate that additional design and detailing complication.

Placing concrete in web of the box girder. Photo: OBEC Consulting Engineers.

The Wynooski Road Bridge over the Highway 99 Bypass is a great example of how a post-tensioned CIP box girder can be applied to fit a geographically and foundationally challenging site with multiple restrictive design criteria, including horizontally and vertically curved alignments, high-seismic demands, and prescriptive detailing requirements. The flexibility of this structure type allowed for a cost-effective and attractive structure to advance the development of the long-awaited Newberg-Dundee Bypass.

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Top slab formwork being constructed. Detailing the reinforcement to avoid interferences and congestion was challenging. Photo: OBEC Consulting Engineers.