

DESIGN OF CAMPBELL ROAD OVERPASS IN KELOWNA

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ABSTRACT

Campbell Road interchange is located on Highway 97 at Campbell Road, which is at the western end of the William R. Bennett (WRB) Bridge in Kelowna. The new interchange will improve traffic flow and safety for the residents in the area and provide better access on and off the new WRB Bridge. Westbank First Nation managed the project from the pre-design phase until completion. This is the first time a First Nations in British Columbia has undertaken the delivery of a large design-build project on a major highway. The project includes a 5-lane overpass for Highway 97 traffic and a dumbbell-roundabout layout for the local traffic. Design and construction of the overpass allowed the project to be completed in phases while nearly eliminating construction impacts to the 50,000 vehicles per day traveling through this site.

The new overpass structure includes a 22 m span of precast concrete box girders and the associated MSE walls. Each precast box girder has a dimension of 1600 mm wide by 850 mm deep. A 150 mm thick cast-in-place concrete topping was placed on top of the precast girders. The precast girder was designed with the elimination of shear keys. This made the girder erection faster and easier. The roadway geometry placed the bridge in a spiral curve and this made the bridge geometry complicated. Detailed calculation for the deck screed machine setting elevation was carried out to ensure the finished deck would have the right geometry. This paper presents the design of the overpass structure and the staged construction of the interchange. The overpass structure was completed in October 2007 and the traffic was shifted to the bridge the following month. The interchange was officially opened to traffic in May 2008. The project was completed on time and within budget.

1.0 Introduction

Campbell Road interchange is located on Highway 97 at Campbell Road, which is at the western end of the William R. Bennett (WRB) Bridge in Kelowna. The new WRB Bridge has 5 traffic lanes for Highway 97 traffic and sidewalks at both sides. Westbank First Nation, teamed with BC government, initiated the project to build a full movement interchange at Campbell Road. The new interchange will improve traffic flow and safety for the residents in the area. It will also provide better access on and off the new WRB Bridge. The new Campbell Road interchange was expected to be open before the WRB Bridge. Emil Anderson Construction (EAC) won the design/build contract to design and build the interchange. SNC Lavalin Inc. provided the civil and structural design for the design/build team.

This project presented two challenges; firstly, there are approximately 50,000 vehicles per day traveling through the project site on Highway 97, and secondly, the project schedule was extremely tight. The interchange needed to be constructed with minimal impact on the traffic, and the overpass structure had to be built very quickly and efficiently. The project was fast tracked; the contract was awarded in March 2007 and the deadline for the overpass being opened to traffic was November 2007. In order for these deadlines to be met it was essential that the design and build team members worked in close collaboration.

This paper presents the preliminary and detailed design of the interchange and the overpass structure. Construction aspects for the project will also be discussed, focusing on the construction staging which was utilized in order to minimize traffic disruption to this high volume highway. Other works associated with this project, such as the MSE walls will also be mentioned.

2.0 Preliminary Design

This project will replace the existing at-grade intersection at Campbell Road with a full movement interchange. Figure 1 shows an aerial view of the at-grade intersection before the overpass structure is built. Highway 97 will run on top of the bridge structure with 3 westbound lanes and 2 eastbound lanes, and Campbell Road will be the underpassing roadway. The Campbell Road Overpass structure will have a single span of 22.4 m. The bridge deck width needs to be 27.3 m to allow a total of (5)-3.6 m wide traffic lanes, and 2.5 m wide shoulders at each side. The bridge structure will provide a minimum clearance of 5.3 m over the roadway below.

A simple supported precast girder with semi-integral abutment, sitting on top of MSE walls was the chosen structural system for the overpass. The plan, elevation and section view of the overpass structure can be seen in Figure 3 and 4. Precast I girders and precast box girders are the two options that were considered in the preliminary design phase. Advantages and disadvantages of each girder type are outlined below.

Precast I girders presents a simple and elegant solution. Eight type 4 standard MoT precast I girders would be required for this overpass. I girders are generally more efficient than precast box girders. They are also lighter and more aesthetically pleasing. The biggest advantage for using I girders is that a constant deck thickness can be achieved by varying the haunch height over the girders. However, constructing a cast in place deck on top of I girders requires formwork to support the wet concrete. There will be additional costs to set up and remove the forms.

Precast box girders have many advantages compared to the precast I girders, for example, they eliminate the need for on site form set-up and removal, except at the overhangs. They are generally shallower than I girders, which allows the bridge profile to be lowered. For this overpass twenty-two type 5 standard MoT precast box girders with a depth of 900 mm were considered. The disadvantage of box girders is that they will be difficult to erect with shear keys between the boxes on the complicated road geometry and the deck will require a varied thickness in both the longitudinal and transverse direction to accommodate the road slope. This option can provide a pleasing structure with proper detailing of the deck overhang and bridge parapet rail. After careful consideration the design build team selected the precast box girder as the preferred option.

3.0 Detailed Design

The new bridge superstructure consists of precast box girders composite with the cast-in-place reinforced concrete deck. Standard MoT type 5 precast box girders were initially considered for the overpass structure. The type 5 box girder is 1200 mm wide and 900 mm deep. Twenty-two type 5 box girders are required for the full deck width. Shear keys with projecting reinforcement are required between standard box girders for the live load distribution.

The overpass structure is located in a spiral curve. The bridge deck has a 5% longitudinal grade and a varying transverse slope of up to 5.2%. This complicated geometry would make girder erection very difficult if shear keys with projecting reinforcement were used. Having a fast girder erection was also important for the construction schedule. A study was undertaken to investigate the possibility of eliminating shear keys. In order to understand the girder behavior under the live load a finite element analysis (FEA) was carried out. The live load moment and shear distribution were analyzed and compared to the numbers calculated in accordance with the bridge design code S6-06. It was found that the 150 mm thick topping concrete can effectively distribute the live load effects. The live load moment distribution factor was found to be 0.32; slightly smaller than the code suggested value of 0.37. Nevertheless, the box girder design used the code simplified method value of 0.37.

After the feasibility of eliminating shear keys is confirmed the design team started looking at the possibility of increasing the box width in order to reduce the number of precast girders that would need to be erected. This is beneficial for the project construction schedule. Almost at the same time, the design team realized that the station beam for the Canada Line project used a 1600 mm wide single cell and 850 mm deep precast box girder. But these beams were initially designed for pedestrian loading. The same precast box girder was checked for the CL-625 highway truck loading and it was determined that the beam dimension was adequate. Preliminary stress analysis also confirmed that reasonable numbers of prestressing strands were possible. The decision was quickly made to adopt the 1600 mm wide single cell and 850 mm deep precast box girder without shear keys (Figure 5). The detailed stress analysis made sure that these girders were designed with adequate prestressing strands to ensure that no tensile stress occurs at the girder soffit at mid-span due to service loads.

The overpass substructure used cast-in-place reinforced concrete abutments resting on a concrete spread footing, on top of mechanically stabilized earth (MSE) retaining walls. The MSE wall was designed based on the consideration of internal and external stability analysis. RECO provided the MSE wall, precast wall panel and steel strap, and EAC did the MSE wall installation. A cast-in-place concrete coping was designed on top of the MSE wall. Due to the proximity of the wall to the Okanagan Lake, the potential of embankment fill sliding toward the lake was analyzed and the MSE wall was found to be safe (1).

A semi-integral abutment is designed to eliminate the expansion joints for the bridge. The effects of passive soil pressure on the precast girder design are considered. Special consideration was given to the girder end detail to ensure a smooth transition between the precast box girders and the MSE wall resulting in a pleasant appearance.

4.0 Construction and Staging

Construction of the overpass began in June 2007. After the site preparation the MSE wall construction commenced (Figure 6). The cast-in place concrete abutments were constructed in August 2007. The precast girder erection started in September and went fairly smoothly. The 12 precast girder were installed in about 10 days time. Figure 7 shows the girder erection underway. The elimination of shear keys helped reduce the time required for the girder erection. The cast-in place concrete deck was poured with a gomaco screed machine, as seen in Figure 8. Due to the complicated geometry the deck slab thickness varies both along the span and in the transverse direction. Detailed deck screed setting elevations were calculated and provided to the contractor on site. The constructed deck elevation is within construction tolerance. The deck was poured in two separate operations to accommodate the traffic staging. The second deck pour, on the south side of the overpass, took place while traffic was traveling across the north side of the overpass. The joint between the two pours is under the concrete median barrier along the bridge. Measures had to be taken to ensure the concrete wouldn't crack at the interface of the two deck pours.

The interchange was built in stages to accommodate the traffic flow. During stage one construction the north roundabout and Campbell Road Overpass were constructed. The north side of the deck was also poured to enable traffic to be shifted to the overpass in the second stage.

After the stage one construction was completed a temporary connection to the existing highway was built and the traffic was shifted onto the newly constructed overpass. At this stage the overpass had a width of 17.2 m and consisted of two temporary lanes in each direction. During this stage, the rest of Highway 97 was constructed south of the traffic.

For stage 3 construction all highway traffic was moved to the new alignment consisting of 3 lanes westbound and two lanes eastbound. The newly constructed WRB Bridge was also in use at this time. In stage 3 the south roundabout and Campbell Road were constructed, as well as the east bound on and off-ramps. This staging plan enabled construction to be completed quickly and with minimal disruption to the existing traffic.

5.0 Conclusion

The Campbell Road overpass was successfully designed and built in 8 months time and was opened to traffic in October 2007. Figure 9 shows a picture of the completed overpass structure. This project was the first of its kind to be delivered by a First Nations in British Columbia, and it was completed on time and within budget. The overpass and interchange construction went very smoothly and had minimal impacts on the high volumes of traffic traveling through the site. The interchange is functioning effectively; it provides safe and efficient access to the WRB Bridge for the local residents.

REFERENCES

1. SNC-Lavalin Inc., Campbell Road Overpass Geotechnical Report, June 2007.
2. SNC-Lavalin Inc., Detailed Design Drawings of Campbell Road Overpass, July 2007.

FIGURES



Figure 1. Aerial view of Campbell Road intersection before the overpass structure is built

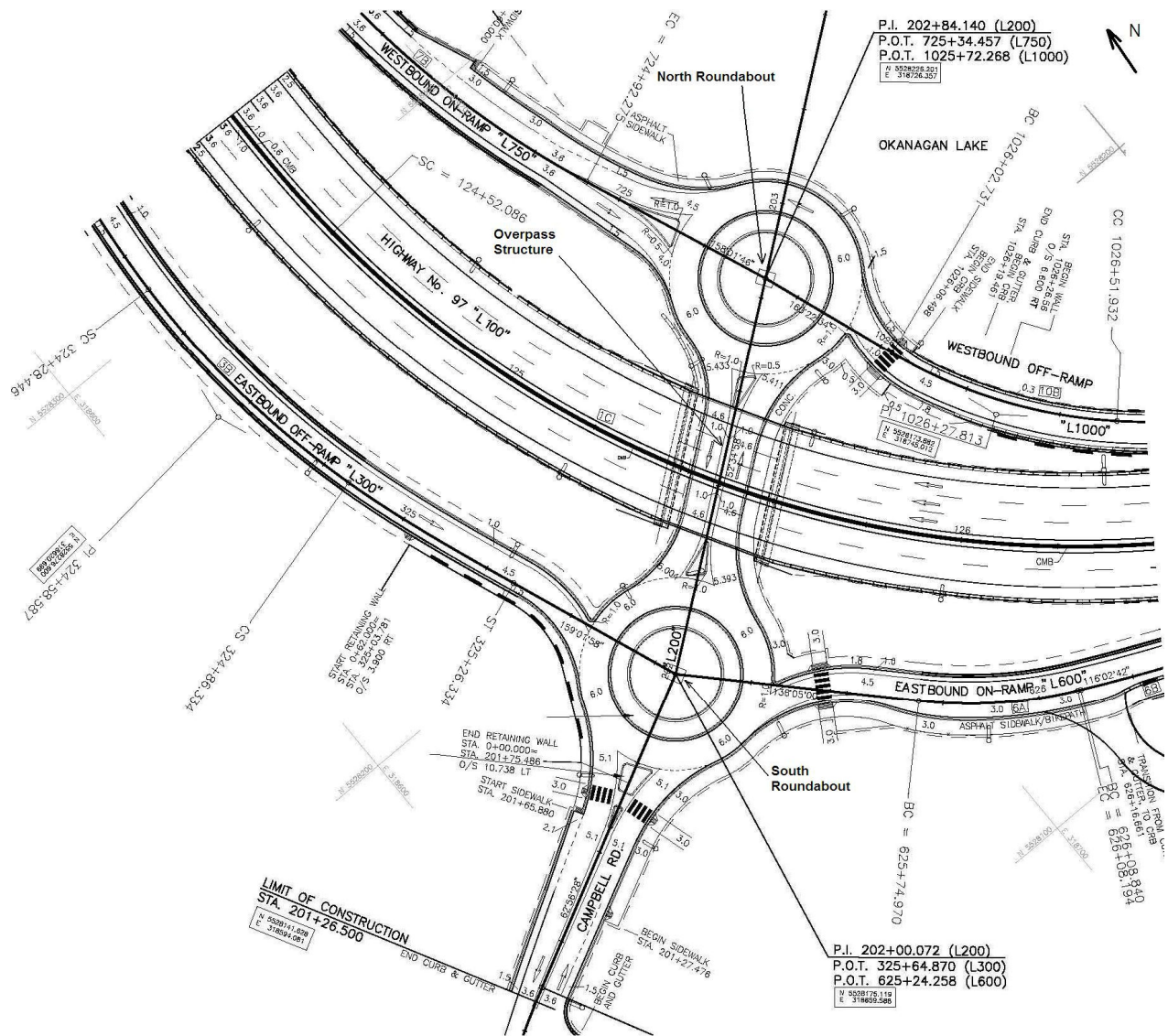
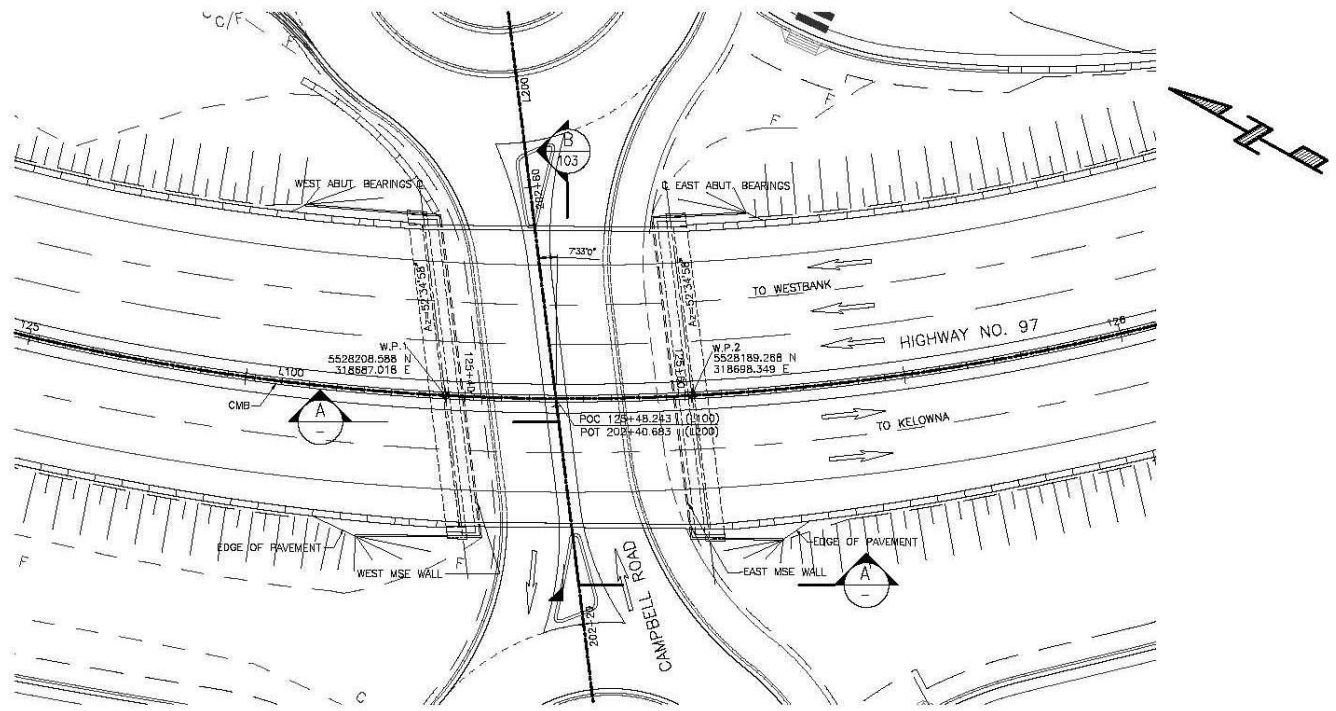
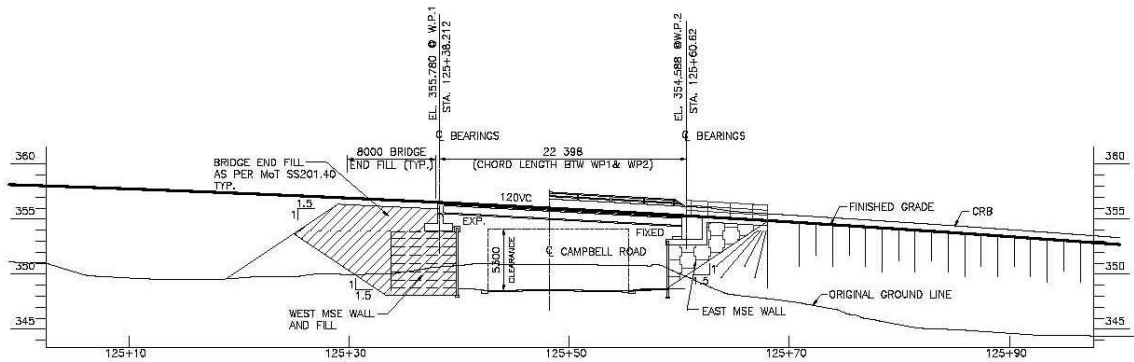


Figure 2. Campbell Road interchange – overall plan



PLAN

1:250



SECTION A

1:250

Figure 3. Campbell Road Overpass – plan and elevation

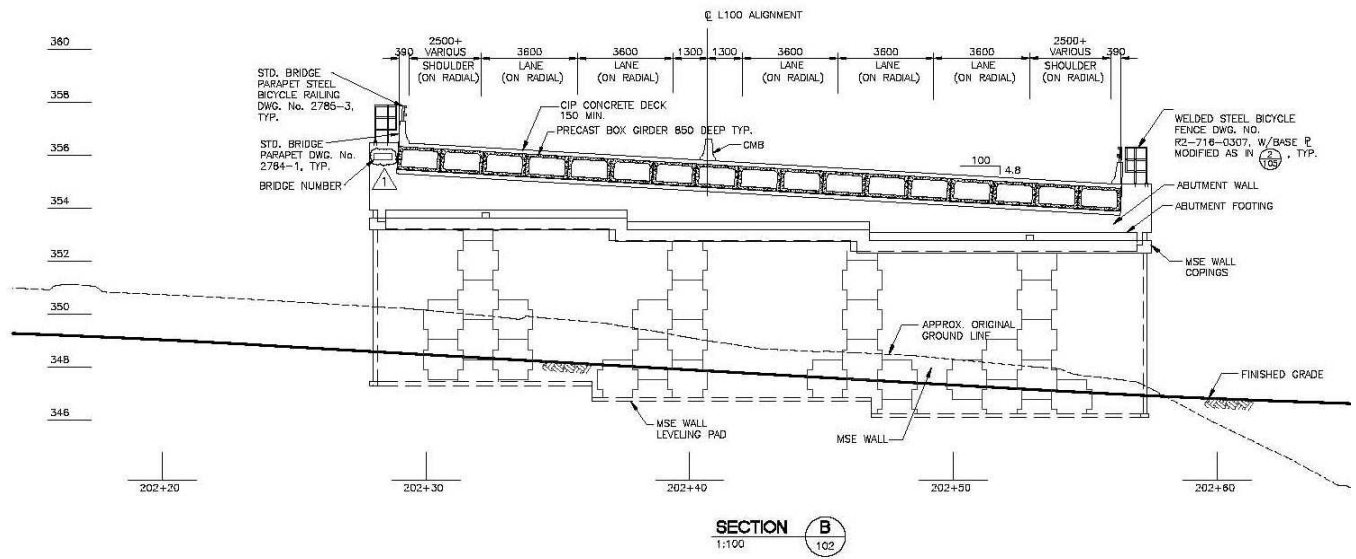


Figure 4. Campbell Road Overpass - Section

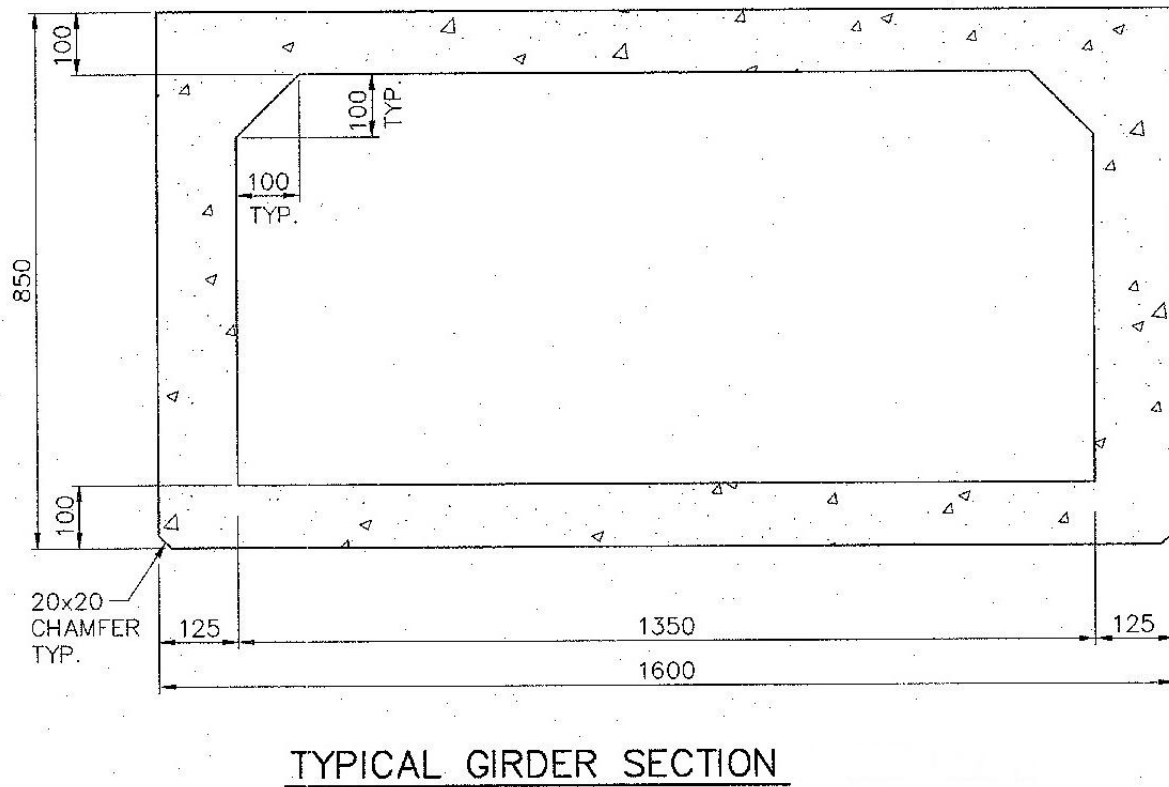


Figure 5. Precast Box Girder Section



Figure 6. Constructing the MSE walls



Figure 7. Erecting the precast box girders



Figure 8. Pouring the concrete deck with Gomaco machine



Figure 9. Campbell Road Overpass with South Roundabout