Innovation in Interchange Design – Golden Hill to West Portal

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Abstract

With a greater understanding of the importance of planning, designing, constructing and operating sustainable infrastructure, the highway design and construction industry must endeavor to develop new methods to reduce adverse environmental impacts and conserve natural resources. The Golden Hill to West Portal highway project in British Columbia is one such innovative example where infrastructure renewal can integrate with the surrounding environment and enhance mobility for vehicles, pedestrians, cyclists and wildlife.

This project, funded through a federal-provincial cost sharing agreement under the Building Canada Fund, is the third phase of the Kicking Horse Canyon Project. The curvilinear alignment provides a transition from the Town of Golden to the strategic east-west link, the TransCanada Highway. The project has been procured following the design-build model which engaged three consultant-contractor teams in a design competition.

This paper describes some of the challenges and opportunities unique to this innovative interchange and highway alignment. Construction on the 4 km long corridor will begin in 2010 and includes an interchange with Golden Donald Upper Road that incorporates a roundabout junction, ungulate guards on the access roads to the TransCanada Highway, cyclist and pedestrian paths linked to a trail system, and a dedicated wildlife crossing structure over the TransCanada Highway. There were many environmental challenges along the alignment such as the big horn sheep, which are listed as a protected species within the corridor. Other challenges involved the risk of avalanche or rock falls during construction and post construction, which was a major concern to CP Rail since their major pacific line is situated at the base of the mountainside. The project serves as an innovative example of design geometry that balances the needs of a variety of road users while adapting to the topographic and environmental constraints inherent along the corridor.

1.0 Introduction

With a greater understanding of the importance of planning, designing, constructing and operating sustainable infrastructure, the highway design and construction industry must endeavor to develop new methods to reduce adverse environmental impacts and conserve natural resources. The Golden Hill to West Portal highway project in British Columbia is one such innovative example where infrastructure renewal can integrate with the surrounding environment and enhance mobility for vehicles, pedestrians, cyclists and wildlife.

This paper describes some of the challenges and opportunities unique to this innovative interchange and highway alignment. The TransCanada Highway through the Kicking Horse Canyon is a section of road with many hazards and a high level of commercial and tourist traffic during the peak season. As such, many people will benefit from the improvements along with the local wildlife and the greater environment due to reduced vehicle emissions from a more consistently designed corridor.

Additional benefits of a corridor of this significance can be widespread. The Kicking Horse Canyon alignment is part of a main shipping route, linking Canada to the British Columbia ports and ultimately the Pacific Rim. The economic spinoffs from an improved corridor such as reduced times in goods movement and improved fuel efficiency of trucks will be passed on to consumers.

Improvements with respect to public safety will see the removal of substandard geometric conditions, implementation of a controlled access corridor, allowance for rock fall ditches, improved slope stability. wildlife control measures, and improved drainage systems.

2.0 Geometric Roadway Requirements

The BC Ministry of Transportation (BC MoT) and their owner's engineers, UMA/Focus Corporation/Izett Engineering invested considerable energy developing and refining the conceptual design. Through their efforts they developed a design that satisfied current design standards while providing an economical and operational configuration for a high standard controlled access highway.

Figure 1 illustrates the schematic layout for the project including the TransCanada Highway and the Golden Donald Upper Road Interchange.

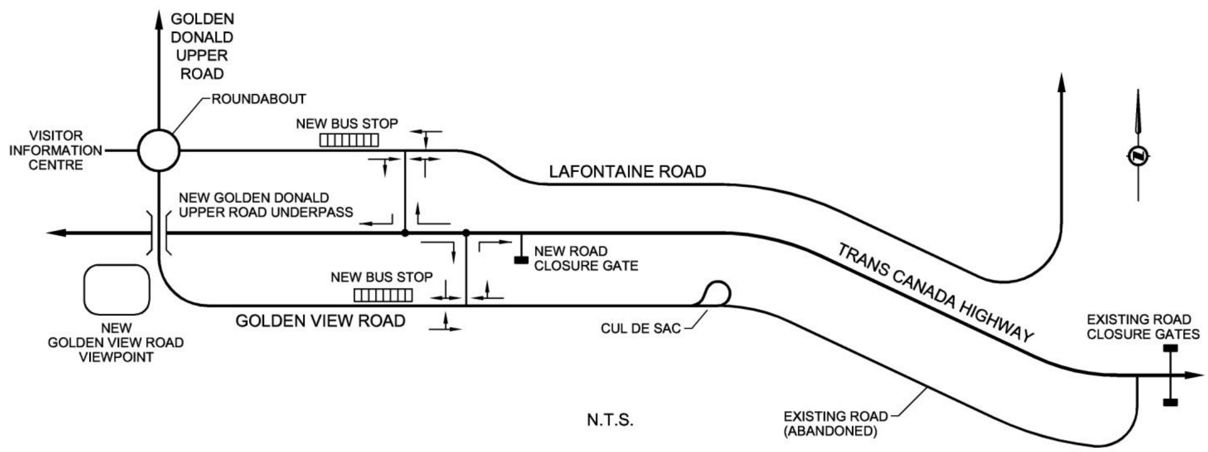

Figure 1: Schematic Layout of the Golden Hill to West Portal Project

The design teams did have flexibility in detailing the project, which was one of the significant benefits to the owner of procuring through a design-build approach; however certain elements were predetermined and could not be changed. These predetermined elements included[1]:

1. The interchange configuration at the TransCanada Highway and Golden Donald Upper Road/Golden View Road (where right-in/right-out access shall be provided between the eastbound lanes of the TransCanada Highway and Golden View Road, where right-in/right-out access shall be provided between the westbound lanes of the TransCanada Highway and Lafontaine Road and where Golden Donald Upper Road will cross over the TransCanada Highway in order to connect Golden View Road with Lafontaine Road);
2. The lengths of interchange entrance and exit lanes shall incorporate the upper ranges of Transportation Association of Canada (TAC) guidelines;
3. The bus stop locations on Golden View Road and Lafontaine Road; and
4. The new viewpoint shall be constructed off Golden View Road in the area of the Golden Donald Upper Road Underpass.

In addition, the BC MoT and owner's engineer team developed design criteria for the proponent teams to follow. A set of design criteria were developed for each of the urban and rural roadway sections. Tables 1 and 2 present the urban and rural design criteria respectively[1].

Table 1: Urban Design Criteria

ELEMENT	DESIGN CRITERIA
Classification	RAD 80
Posted Speed	60 km/h
Design Speed	80 km/h
Basic Lanes	4
Minimum Radius	250 m
Equivalent Min. K Factor - Sag - Crest	 32 Sag 36 Crest
Maximum Grade	6%
Maximum Superelevation	0.06 m/m
Stopping Sight Distance	140 m
Lane Width	3.7 m
Shoulder Width - Outside - Inside	 2.5 m outside 1.0 m inside (adjacent to CMB)
Clear Zone	8.5 m with 4:1 foreslope or CRB
Median Width	2.6 m with CMB
Design Vehicle	WB-20

Table 2: Rural Design Criteria

ELEMENT	DESIGN CRITERIA
Classification	RAD 100
Posted Speed	80 km/h
Design Speed	100 km/h
Basic Lanes	4
Minimum Radius	440 m
Equivalent Min. K Factor - Sag - Crest	 50 Sag 80 Crest
Maximum Grade	6%
Maximum Superelevation	0.06 m/m
Stopping Sight Distance	210 m

ELEMENT	DESIGN CRITERIA
Lane Width	3.7 m
Shoulder Width - Outside - Inside	 2.5 m outside 1.0 m inside (adjacent to CMB)
Clear Zone	9.0 m with 4:1 foreslope or CRB
Median Width	2.6 m with CMB
Design Vehicle	WB-20

In addition to the design criteria, there were several other constraints imposed on the geometric designers pertaining to areas of design consistency and successive curves. Most notably was the requirement that the radius of successive horizontal curves shall not be 50% less, nor 150% greater than the radius of the preceding curve and shall be not less than 440 m. In order to minimize earthwork volumes the horizontal alignment was very curvilinear, constrained by the length between curves in most cases required in order to successfully develop and resolve superelevation.

The project also included a significant length of local roadways. The owner's team also developed design criteria for these project elements as shown in Table 3[1].

Table 3: Two-way Local Road Design Criteria

ELEMENT	DESIGN CRITERIA
Classification	RLU
Posted Speed	50 km/h
Design Speed	50 km/h
Basic Lanes	2
Minimum Radius	80 m
Equivalent Min. K Factor - Sag - Crest	 12 Sag 7 Crest
Maximum Grade	8%
Maximum Superelevation	0.08 m/m
Stopping Sight Distance	65 m
Cross-Section	In accordance with Ministry RLU Typical Section of the Ministry's *Supplement to TAC Geometric Design Guide* Figure 440.A
Design Vehicle	WB-20

2.1 Vulnerable Road User Accommodation

The project also explicitly provides for vulnerable road users as there are several features incorporated into the design for pedestrian and cyclist accommodation. Proponents were required to design and construct a new viewpoint and provide linkages to a new separated pathway towards Golden and also across the TransCanada Highway (TCH) underpass structure.

Transit accommodation was also factored into the project. Bus stops and bus bays were strategically located on the urban roadways and passenger zones including wheelchair pads were incorporated into the project.

The west end of the project approximately coincides with an existing view point. This view point is connected by means of a 3 m paved pathway to the new Golden View Road Viewpoint on the south side of the TCH. Features such as labyrinth style controls were implemented on the pathway to incorporate the wildlife fencing and the pathway and provide further protection. Figure 2 illustrates a typical labyrinth gate configuration.

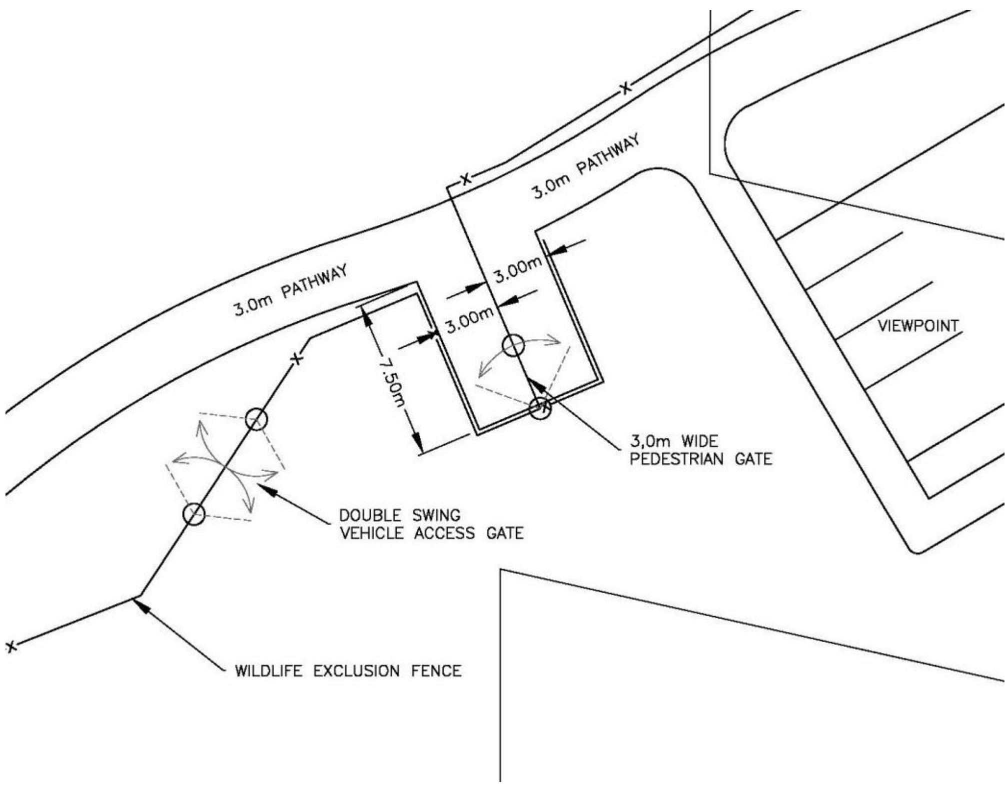

Figure 2: Labyrinth Gate for Wildlife Access Control

2.2 Golden Donald Upper Road Roundabout

Another innovative element for the project was the incorporation of a roundabout at the end of a 2 way semi-directional crossing of the TCH. Resolving sight distance triangles and providing adequate entry deflection were several of the challenges designers faced due to site constraints, however the intersection treatment is well suited to serving local traffic as well as those destined to the visitor information center on the west side of Golden Donald Upper Road. The existing intersection is not formalized and provides little positive guidance to drivers. Figure 3 below depicts the existing conditions at Golden Donald Upper Road area, while Figure 4 shows the detailed design.

Figure 3: Existing Conditions at Golden Donald Upper Road

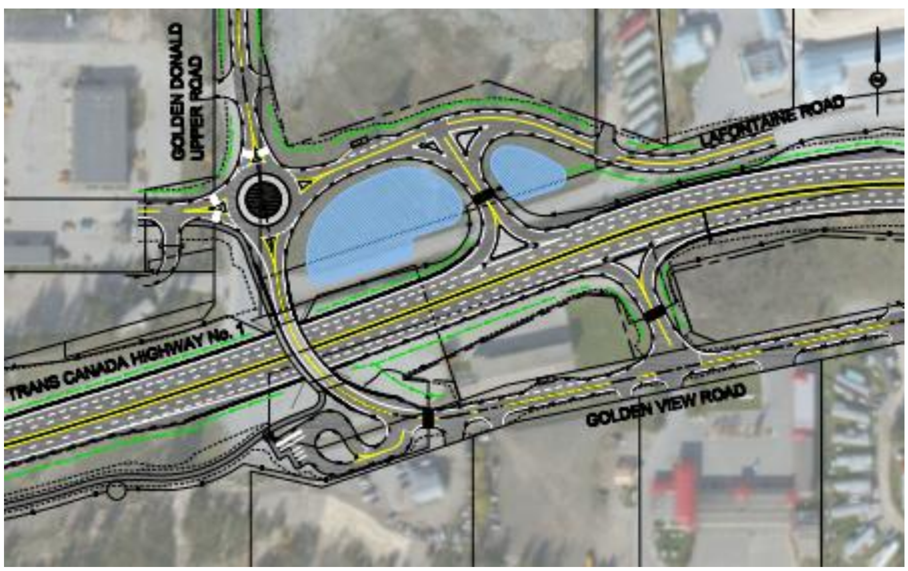

Figure 4: Roundabout Detailed Design

3.0 Structures

The project alignment is subject to some significant constraints relative to geometry and topography and as a result it was necessary to include underpass and retaining wall structures in the design. Typical to most interchanges, a grade separation of the highway and local roadway allow free flow operations on the corridor. An interesting feature of this project however is the inclusion of an animal overpass structure to safely accommodate migrant and resident big horn sheep that frequent the area.

Retaining walls were also required to accommodate the highway footprint within the established right-of-way. There were further constraints related to geological stability which also required structural designers to extend foundations below identified slip surfaces. More details regarding these constraints are provided in the subsequent section however 'micro-piles' were used where conventional foundation installations would not extend into the desired geotechnical zones.

3.1 Design Constraints

Geotechnical analysis completed during the planning study resulted in sloping restrictions on the embankment fills for the design alignment. The toe for all embankments could not infringe below established constraints identified as follows:

1. 20 m upslope from the crest of slopes identified as having moderate or high potential for terrain hazards;
2. a 1.5:1 slope beginning at the north ditch of the CP Rail alignment; or
3. a 1.5:1 slope beginning at the high water mark of the Kicking Horse River.

From the list of sloping guidelines, no. 2, 1.5:1 slope beginning at the north ditch of the CP Rail alignment, and no. 3, 1.5:1 slope beginning at the high water mark of the Kicking Horse River, posed constraints on the alignment when attempting to maintain 1.5:1 fill slopes and avoid large retaining walls.

A large gully near the Town of Golden limits made it impossible to avoid the sloping restrictions if an earth embankment was to be constructed. The options were to construct a bridge over the gully or an embankment fill with a retaining wall. Analysis proved that the retaining wall was the best economic solution however the footing of the wall could not be constructed such that it would lie within the 1.5:1 restriction zone extending from the CP Rail line. It was decided to construct the wall foundation on 'micro-piles' which would be driven into the in-situ soil below the 1.5:1 zone.

4.0 Drainage

Another significant challenge was the drainage planning and design for this stretch of the TCH improvements. We planned and designed all drainage infrastructure including, but not limited to, new infrastructure and improvements, relocations, protection and modifications to existing infrastructure, to ensure a complete and functional drainage system. The drainage design comprised major and minor systems to deal respectively with 100 year and 10 year storm events.

Runoff from all areas of the site was designed to be collected, retained, treated, and discharged in various ways. Drainage ditches were the primary means of runoff collection and conveyance for the project, though culverts and pipes were also a common design solution. Drainage ditches were also used in all rural areas. The drainage ditch side slopes met or exceeded the BC MoT guidelines based on local geotechnical requirements.

Retention was designed to occur at the dry pond locations proposed at the interchange. The treatment of runoff from the project was accomplished by taking advantage of the local soil conditions through bio-filtration. All opportunities to direct runoff to areas that can allow runoff to be infiltrated by the local soils was developed. It was also anticipated that the distance between the project and the Kicking Horse River will offer opportunity for the quality of runoff to be improved as it flows through the natural vegetative ground cover, prior to reaching the river.

Through the design process, impacts to the existing drainage systems within the Town of Golden as a result of this project were minimized. One of the main areas of focus was the interchange configuration at the TransCanada Highway and Golden Donald Upper Road. The existing drainage in this area is managed using road side ditches and drywells. In general, this condition is not anticipated to change, but dry ponds will be added to control the additional runoff created by the interchange configuration and road widening.

5.0 Utilities

Utility design was certainly a challenge in the mountainous terrain, but not an insurmountable task. Urban Systems covered the identification of all existing utilites, the interim servicing options, and the proposed design for all waterlines, sanitary sewer, and overhead power and telephone.

The overhead power and telephone lines were designed to continue to run along the south side of the TCH. Care was taken during relocations and construction staging considering the BC MoT Utility Policy Manual of encouraging utility relocations to go directly to ultimate positions with minimal interim movements to minimize costs. Regarding the sanitary sewer, in one area the new TCH grade will be approximately 7.5 m lower than the existing highway. This large cut required the sanitary line to be relocated. The design-build requirements called for a gravity system to be constructed that would tie the south Upper Golden Hill section along Golden View Road to the existing sanitary line at the bottom of Golden Hill, along the south side of the TCH. Urban Systems proposed an alternative connection of the sanitary line, connecting the Golden View Road line with the existing line on the Golden Donald Upper Road, reducing the amount of new pipe and manhole requirements while improving accessibility for Town of Golden maintenance.

Regarding the interim servicing options, some changes were required for the waterlines such as new connections for fire hydrants, new valves, and several temporary service outages to switch watermains. For the overhead power and telephone lines, the proposed overhead poles can be installed and the impact will be short term when the lines are moved over to the new poles and connected. And for the sanitary sewer, there will be no disruption to businesses; however, some sanitary sewer pumping will be required to maintain service during infrastructure upgrades.

In the end, a significant underlying project objective was to ensure that the new sewer and water systems provided equivalent or better flow capacity, pressures and fire protection than what exists in the current Town of Golden infrastructure.

6.0 Landscaping and Environmental Design

6.1 Environmental Design

As with all significant infrastructure developments in Canada, this project was subject to the *Canadian Environmental Assessment Act* and consequently went through a comprehensive analysis. The final report documented that if certain mitigation measures were followed, significant environmental issues were unlikely. One of these mitigation measures was the wildlife exclusion fencing system including wildlife exclusion fencing, ungulate guards, one-way gates, wildlife jump-outs, one double swing gate for vehicles, human access gates, a wildlife overhead crossing structure, and many small animal underpasses. In addition, a construction environmental management plan was developed to maintain strict control over the environmental impacts of the process.

6.2 Landscaping

The original aesthetics and landscape design associated with the Golden Hill to West Portal section of the TCH was simple and understated. Given the magnitude of the surroundings, including the Rocky Mountains and the Kicking Horse River, the blending of built structures with the natural landscape was a design goal.

The existing forest, especially north of the highway, provides habitat for deer, elk and big horn sheep. Wherever possible, existing vegetation was retained. The extent of protective fencing was indicated on the landscape plan. In areas outside of the embankment and cut slopes, where it was necessary to remove existing vegetation, 'close-cut clearing/no grubbing' practices will be implemented to retain roots, minimize soil disturbance and encourage re-vegetation.

The request for design-build proposals indicated that in addition to the basic landscaping that was intended to minimize surface erosion and promote attractive groundcover, there were areas of enhanced landscaping that warranted greater design detail. In the areas that promoted human interaction, such as the new Golden View Road Viewpoint and Golden Donald Upper Road roundabout, there was an opportunity to incorporate additional native, drought tolerant trees and shrubs. Pathways and additional hardscape elements accommodate pedestrian traffic and link existing and newly constructed elements.

Overall, the landscape design for this project was minimal, and was intended to complement, rather than compete with, the natural environment. Preservation and re-vegetation were key components; the most critical landscape elements already existed, and it was our goal to retain as much of the forest, and the wildlife it contains, as possible. Simple aesthetic additions, like native planting, naturalistic rock groupings, and thoughtful details created an overall design that is functional and respects its surroundings.

7.0 Conclusions

This paper described some of the challenges and opportunities unique to this innovative interchange and highway alignment. The TransCanada Highway through the Kicking Horse Canyon is a section of road with rather extreme hazards and a high level of commercial and tourist traffic during the peak season. As such, many people will benefit from the improvements along with the local wildlife and the greater environment due to reduced vehicle emissions from a more consistently designed corridor.

Urban Systems Ltd. has been able to finalize a successful detailed highway and interchange design with Emil Anderson Construction Ltd. on an accelerated schedule. This project is a great example of blending many public priorities: increased public safety, enhanced environmental protection, provision for vulnerable road users, improved connection for Canadian commerce, and a highly efficient use of public money through the private sector led design-build project delivery method.

8.0 Acknowledgements

The authors would like to acknowledge the contributions of Emil Anderson Construction as the design-builder for the project, AECOM (formerly UMA), Izett Engineering, and Focus Corporation. Special thanks also go to the BC Ministry of Transportation for permission to present this project to the TAC membership, and for their collaborative leadership over the last six months.

9.0 References

1. *Schedule A Project Scope, Golden Hill to West Portal Design-Build Agreement*, BC Ministry of Transportation, (2009).
2. *Geometric Design Guide for Canadian Roads,* Transportation Association of Canada, (1999), Ottawa, ON.
3. *BC Supplement to TAC Geometric Design Guide 2007 Edition*, BC Ministry of Transportation, (2007).
4. *Survey of Early Post-Natal Habitats of Bighorn Sheep and Mountain Goats on the Kicking Horse Canyon Project: April 2008 – July 2008*
5. *Hill to Portal – Photos for Procurement*