Value Engineering and Innovation

in the Design and Construction

of the Southeast Anthony Henday Drive, Edmonton

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By

Christopher B Gauer, P. Eng., AVS

MMM GROUP

INTRODUCTION

Anthony Henday Drive (AHD) in the City of Edmonton is an outer ring road currently under development around the City's southern limits. Upon completion, it will have far reaching benefits to Edmonton residents and thousands of travelers who will use this route for leisure, business and goods movement.

A design-build-finance-operate (DBFO) team was formed named Access Roads Edmonton Ltd. (AREL). The team, led by ABN-AMRO Bank as the Developer with PCL Construction Management Inc. as the Design Build Contractor and TSMI as the Operator, was awarded the $493 million DBFO Contract for the southeast portion of Edmonton's Anthony Henday Ring Road in 2005. MMM Group (MMM) led the design team for the assignment that included Stantec Consulting Ltd., Golder Associates Ltd. and Applied Research Associates.

Construction of Anthony Henday Drive SE started in the January 2005 and the road was opened in October 2007. The southeast section of the AHD includes the following infrastructure:

- 11 kilometres total length from Highway 2 to Highway 14/216;
- Six lanes between Gateway Boulevard and 50th Street and four lanes between 50th Street and Highway 216/14 (with grading for two more future lanes);
- 20 separate bridge structures;
- 124 lane kilometres of road;
- Full freeway status (no traffic lights);
- Five interchanges offering access on or off the highway at Gateway Blvd/Calgary Trail (Highway 2), 91st Street, 50th Street, 17th Street and Highway 14/216;
- Four flyovers (bridges over/under the highway with no on or off ramps) at 34 Street, 66th Street, 34th Avenue and Parsons Road; and
- Two road/rail grade separations.

This paper will discuss the use of Value Engineering (VE) in the pursuit and design process; how the VE process affords enhanced safety through the safety oversight process; the application of enhanced geometric design standards in the P3 process; and the innovation arising from the VE and the P3 process.

PROJECT ORGANIZATION

The design-build-finance-operate (DBFO) team is led by the financial entity, which is the proponent for the 30 year life of the project in a Concession contract with the Province of Alberta. Access Roads Edmonton Ltd. (AREL) is headed by ABN-AMRO Bank. PCL Construction Management Inc. (PCLCMI) was the Design Build contractor responsible for delivery of all capital construction works for opening of the road by October 2007. TSMI, a division of Lafarge Canada Inc., is now responsible for the 30 year operation and maintenance of the highway. The construction subcontractors to PCLCMI for the project were PCL Maxam for bridge structures, Sureway Construction for grading/drainage and Lafarge Canada for granular, paving, illumination and signing. The Province of Alberta awarded the $493 million DBFO Contract for the southeast portion of Edmonton's Anthony Henday Ring Road in January 2005.

MMM Group (MMM) led the engineering and design team for the assignment. The team included Stantec Consulting Ltd., Golder Associates Ltd. (Foundation Engineering) and Applied Research Associates (Pavement Design). MMM was responsible for Project Management including scheduling, utility coordination and municipal/environmental approvals. MMM and Stantec shared the roadway and bridge design work. MMM and Stantec were involved in the construction work to oversee the contractor Quality Management Systems and verify that the work was constructed as designed. The other engineering responsibility is preparation of the record drawings for the project.

VALUE ENGINEERING

Value Engineering (VE) is an organized effort that analyzes the function of a process or product. The Value Engineering process reviews the basic function of the process or object with the intent of lowering cost and/or adding value. Any change promoted by Value Engineering must achieve the same or an enhanced level of performance.

The fundamental element of Value Engineering is the value equation. Value equals performance divided by cost. If cost goes down and performance is maintained then value is enhanced. If Performance goes up and cost is unchanged then value is increased. The intent of VE is to ADD VALUE by improving or maintaining performance and not just to cut cost

VE is needed, especially on Public Private Partnership (P3) projects due to the following:

- Project cost analysis and value considerations are not necessarily priorities in the planning of a project;
- Often, the design effort does not address life cycle cost;
- Scoping constraints, design standards and client direction often override any initiative in the planning process to optimize the design or to manage costs;
- Often there is little time in the planning process for creativity and innovation in design; and
- The risk associated with a P3 project delivery, schedule and operations may not be apparent in the project planning phase.

For these reasons, the best value solution is most often not achieved in design.

VE helps organizations improve the delivery of a project or product by reducing cost, improving performance, improving quality, saving time during construction, solving problems and using resources effectively.

VE helps the manager or designer to view a project from a new perspective. The VE process asks how a standard be changed and improved. VE provides an excellent opportunity to test innovative products or ideas as the proponent will be responsible for the durability of the innovative solution.

Value Engineering is a formal process undertaken in a workshop setting. A team of independent experts is selected to review a particular process or project. The team's expertise should mirror the fundamental elements of the work with the team composition made up of experienced, senior discipline specialists. The experts review the project during a three to five day workshop

VE is performed using a five step process. The steps are:

1. Information Phase
2. Creative Phase
3. Concept Development Phase
4. Evaluation Phase
5. Presentation

At the outset of the VE study, the designer provides information to the VE team regarding the project. The undertaking of the VE process requires knowledge of the project cost, scope, constraints and assumptions. Typically a cost model is developed for the project to identify value target areas. Pareto's Law says that 80% of the cost is in 20% of the work. This focuses the VE review on areas where there is the greatest chance of success.

The unique aspect of VE involves function analysis. Each aspect of the work is identified as a function described as an active verb and measurable noun. Functional analysis removes labels on the deliverables to stimulate creativity. Costs and functions are combined in a summary flow chart to assess the cost to deliver each element of the project.

The creative phase involves brainstorming ideas to address the problem differently. Ideas are sought addressing the value target areas. The focus is on positive responses to encourage idea generation. Even "wild" ideas can spawn a practical innovation solution. The creative ideas developed and the most promising ideas are identified. Each idea is developed and described.

In the evaluation phase, the advantages and disadvantages of the idea are summarized and the capital and life cycle costs are assessed. Performance measures are developed to evaluate the alternatives. The relative importance of the performance measures are ranked and weighted. Each idea is evaluated considering the performance (the value of the idea) and the cost to implement the alternative as compared to the Base Case.

Once the best ideas are identified, a presentation is made to the owner. Each idea is presented along with how value is enhanced, cost reduced or both. The analysis considers capital and life cycle costs. Fundamental elements such as safety, operations and maintenance are addressed

PROJECT GEOMETRIC DESIGN STANDARDS

The geometric design standards applied to the Southeast Anthony Henday Drive were defined in the Project Technical Requirements, Schedule 18 of the Concession contract. The standards applied to the highway geometrics were generous, generally exceeding the typical requirements of the TAC Geometric Design Guide and the Alberta Design standards. The Province defined these standards for the P3 process to ensure a high quality road layout, avoiding combination of minimums. Examples of the design standards included:

- A clear roadway design concept was mandated;
- Design Speeds were defined for each classification of roadway;
- Minimum and maximum profile “K” factors for the project were set 20% above the normal design standards;
- Maximum road gradients were prescribed;
- Minimum distances between vertical points of Intersections (VPIs) were set in the project requirements based on the road element standard and cross section;
- Minimum length of vertical curves (LVC) was defined in the project requirements;
- Structure clearances were defined;
- Weaving length minimums were defined between interchanges;
- Stopping Sight Distances was to be achieved exceeding TAC minimums for the design speed by 25%; and
- Cross section lanes widths, shoulder widths, median width and grading slopes were defined based on height of cut or fill.

No deviation from these project standards was permitted through the pursuit and delivery phases of the job. As such, the design innovations investigated and developed in the pursuit and delivery of the project were not allowed to modify the design standards. VE was restricted to the delivery of the project, the more complex elements of design and design solutions involving the trade off of opportunities and costs.

As a commentary on the Alberta P3 process, significant opportunities were missed due to strict enforcement of the project requirements. In many cases, the project requirements were not performance standards setting out the expected deliverables. The project requirements were more akin to specifications defining materials and processes already in use in the Province. Substitution of different materials, different approaches to design and innovation using ideas from other jurisdictions was discouraged when the alternatives did not strictly conform to the project prescriptive requirements.

VALUE ENGINEERING PROJECT APPLICATIONS

Formal Value Engineering was used in the project pursuit phase. During the start of the design pursuit, the engineering, construction and operations team met for a two day VE session. The VE session investigated:

- The geometric layout alternatives of interchanges to address traffic requirements while minimizing bridge span and width;
- Bridge girder optimization for both concrete and steel girder bridges;
- Standardization of structures;
- Traffic accommodation strategies;
- Structural staging and construction options;
- Material options for structural design and construction; and
- Operations and maintenance considerations.

The tight project performance requirements for both geometric and bridge design reduced the opportunity to innovate through Value Engineering. The project specifications restricted materials not currently in use within the Province. As such, many opportunities for innovation were missed. Notwithstanding the constraints, the project team did find many ways to implement VE principles during design but these innovations were generally limited to process and delivery of the project, although there were some significant design innovations.

During the project delivery, innovation and VE occurred on an “as necessary” basis based on design problems to be overcome as the work progressed. This really demonstrated that necessity is truly the mother of invention that triggers innovation. Design issues arose and each issue was addressed by a design and construction team that focused on the issue, developed alternatives, analyzed the cost of the alternatives and recommended the most cost effective solution meeting the Project Technical Requirements. This is the way that the majority of innovative ideas on the project were developed and implemented on the project.

SAFETY OVERSIGHT PROCESS

Safety on the Anthony Henday project was of the upmost concern and this project was the first major project in Alberta that required a formal Safety Audit sign off before opening to traffic. As a result of this requirement, the MMM Design Team worked with the PCL Design Build Team to develop a process that ensured all designs and construction work undertaken met the project safety standards. This process involved 30%, 60% and 100% design review by the Road Safety Audit (RSA) team, retained by Access Roads Edmonton. As safety issues arose during design, the design team submitted sketches and drawings to the RSA to discuss the issue and to identify the correct course of action from a safety point of view. Prior to opening of road detours and recently completed sections of road, the RSA team was invited to review the roadway in the field and suggest safety enhancements and improvements. These improvements were made prior to opening of the roadway to traffic. Prior to opening the completed highway to traffic, the RSA undertook advance pre-opening audits. Issues identified through the pre-opening audit process were immediately addressed and changed in the field.

The following safety design features were implemented prior to the highway opening as a result of the pre-opening audits.

- Safety oriented grading at pole and overhead sign footings (to direct errant vehicles away from the hazard);
- The use of TL-3 extruder crash attenuators at the approach end of the beam barrier systems;
- Installation of bicycle-friendly catchbasin grates on the arterial crossing roads;
- Installation of pipe runners on large diameter culverts (to allow errant vehicles to traverse over the culvert openings); and
- Enhanced conspicuity of gore locations.

The safety audit process introduced was very effective, involving the latest in highway safety considerations. All safety concerns were identified in advance of the highway opening. No issues were unattended to and the project completion date was met.

PROJECT DESIGN INNOVATIONS

Innovation in the design of the Anthony Henday Drive project included:

Highway Design

91 Street Interchange

The design and construction of the 91 Street interchange posed numerous challenges. 91 Street is a major roadway with a significant volume of traffic that is expected to grow exponentially over the next few years. The Functional Plans called for an interchange at 91 Street. However, there were significant planning and design constraints regarding this interchange. The proximity of 91 Street required provision for weaving of traffic to and from the Calgary Trail interchange. The interchange layout in the Functional Plan provided as the basis of the design build pursuit had minimal separation for weaving, due to the Diamond Interchange configuration. To compound the planning, design and construction was the existence of twin Alta Link Power lines crossing AHD on both sides of 91 Street, a power transformer station in the southeast quadrant of the interchange and major pipelines crossing 91 street (ATCO gas) to the south and AHD (Imperial) west of 91 Street.

Vertical clearance to the power lines was a significant concern as 91 Street needed to bridge AHD and the tower heights were based on the existing ground levels, not on future interchange requirements. Finally, the planning of the interchange needed to provide for a subcollector system for movements to and from the Calgary Trail interchange in the very long term, once the traffic volumes grow to the point where operational difficulties are expected.

The design needed to meet the above challenges and be developed in accordance with the project technical requirements. A Parclo AB interchange was the design solution. This revised configuration maximized the weaving of traffic to the Calgary Trail interchange by placing all ramps on the east side of Calgary Trail. Relocation of the oil and gas pipelines was avoided. Two Alta Link towers were relocated and one tower was raised. Synchro traffic analysis was used to model the interchange and intersection operations to demonstrate that the concept would perform at a desirable level of service.

As a result of this design a greater weave distance was provided which improves operation of this section of highway, enhances travel times and limits congestion. The design also minimized the amount of time power lines were shut down due to fewer tower relocations. Further, this change reduced the likelihood of any blackout or brownouts during the relocation work.

Costs were managed by finding the optimal balance between the bridge span and the cost of relocating the towers. Earlier planning concepts retained a tower in the gore between the subcollector and the Anthony Henday mainline, which increased the span of the 91 Street bridge. The revised layout reduced the structure span and the reduced bridge costs more than offset the cost of the tower relocation. The tower relocation work eliminated the risk of vertical clearance constraints between 91 Street, Anthony Henday mainline and the ramp profiles, with the expected sag in the towers. Finally, relocation of the tower from the gore between the mainline highway and the subcollector increased safety, as the originally planned tower location in the gore increased the likelihood of collisions.

Parsons Utility Cluster

East of Parsons Road is a utility corridor crossing AHD. The mainline profile is in a high fill as the roadway climbs to cross over Parsons Road causing concern that the weight of the fill would damage the existing utilities crossing below the highway. Of particular concern was an existing sanitary sewer, although buried quite deep, that required analysis of the soil pressures on the pipe.

As the design constraints did not allow a change in profile and the cost of relocation or replacement of the pipeline was significant, the design team looked at a means to reduce the loading on the pipe through use of lightweight fills. An innovative design was developed using bottom ash as a lightweight fill. The new design avoided the need to relocate the pipeline, minimized the risk of damage to the pipe and eliminated the need to shut down and re-route service in order to replace the pipe. The solution carried out was the most cost effective and value oriented design presented. It added value to the Design Build Contractor by cutting costs originally slated for the relocation.

Traffic Accommodation and Detours

Embarking on the design of Structure 1.6, the MMM Design Team was faced with a number of difficult design choices. As a result of previous work on the interchange, fills were almost fully placed at the interchange approaches. Also, the merge gore geometry at the NB-WB and NB-EB ramp diverge limited the opportunity to adjust the profile on the NB-EB ramp. Therefore, the preferred design scheme for this bridge was dependant on designing a cost effective structure that minimized the depth of the structure which could be constructed while maintaining traffic flow on NB Gateway Boulevard and the ramps from Ellerslie Road to NB Gateway. This posed a significant challenge in the design of a detour for accommodation of traffic.

The solution to this particular challenge involved the construction of a detour behind the structure, thereby reducing the span of the falsework for the new bridge construction to provide for the Ellerslie ramp traffic. The detour also provided for the opening of the westerly leg of AHD in the fall of 2006. This required planning for the interim and ultimate laning of the detour to allow for the connection to the westbound AHD as well as the NB Gateway Boulevard. In routing the detour to the west of the planned bridge site, the detour needed to match the profile of the NB-WB ramp, be located to allow for the construction of Structure 1.6 and then connect to the existing Gateway Boulevard while matching the existing ground to provide the required vertical clearance below Structure 1.5. Traffic from Ellerslie Road to NB Gateway required access and was routed below Structure 1.6 in a single lane with a reduced clear falsework span. The reduced span of the falsework for the ramp permitted the construction of the cast-in-place bridge at this location.

This engineering solution involved excellence in the coordination of the design elements between the designer, the design liaison team, the design build contractor, the bridge contractor and the project safety auditor, as each had a role to play in the development and resolution. The detour added value in the reduction of the cost of the structure by eliminating the traffic conflicts. Further benefits were reaped by society, including the safe and efficient design of the detour that provided for all traffic movements. In all, the detour operated effectively and safely thought the construction period which benefited all road users of Gateway Boulevard through the construction zone.

Pavement Field Issues

The baseline pavement designs for the project were developed using the 1993 AASHTO Guide for the Design of Pavement Structures, in general accordance with Alberta Infrastructure and Transportation practices. The design team used the next generation of AASHTO pavement design, referring to the Mechanistic-Empirical Pavement Design Guide, in order to model pavement performance and predict pavement deterioration. This technique allowed for an assessment of the whole life of the pavement through the concession period.

Pre-existing ground conditions west of 50th Street caused a number of construction difficulties that delayed platform formation. The section, some 2 km in length, exhibited extreme instability to construction traffic and could not be brought to the designed grade. The use of exaggerated drainage ditches beside the platform effectively lowered the pore water pressure for almost 1.7 km allowing the area to regain enough stability for equipment to operate. The remaining 300 m of subgrade was cut to near quick conditions and treated with a drainage layer. The drainage layer effectively cut-off pore water pressures from migrating into the overlying fills.

Barrier End Treatment

The SEAHD project required the use of barrier end treatments that meet the NCHRP Test Level 3 standard, which is a relatively new standard in Alberta. Initially, the application of various barrier and crash attenuator systems was researched by MMM from information available by the U.S. Federal Highway Administration (FHWA). The research included examining test results that were conducted by the FHWA, ensuring AHD project requirements were met and/or exceeded. This research addressed the suitability of the products to be used on the project. In addition, the design team liaised with the manufacturers of the chosen barrier system to provide technical input related to installation procedures.

Innovation was integral to this work as new barrier systems were introduced on this project. The value added included enhanced safety and performance of the barrier systems, reducing the cost of collision and the severity of injury to vehicle occupants involved in crashes. The liability risk with respect to highway safety is better managed by effective barrier systems that reduce the possibility of personal injury, resulting in reduced personal injury costs.

Bridges & Structures

Structure 1.1 – WB-SB Third Level Bridge

The seven-span 300 m long curved third level "fly-over" structure comprised of five kinked steel plate girders and a high mechanically stabilized earth (MSE) wall at the north abutment. A post-tensioned concrete structure was not selected since it required a high and complicated falsework supported on soils subject to settlement. Kinked girders were selected over curved to improve the construction schedule and to reduce steel waste. The cost of the structure was reduced further by eliminating a girder line during the detail design stage. This improved the construction schedule and eliminated nine bearings, therefore reducing a number of units requiring long-term maintenance.

The analysis and design was more difficult than normal due to the curved deck geometry combined with straight girder segments. The geometry introduced a large variety of member sizes, complicating girder fabrication and erection. As a result the final solution adopted was aesthetically pleasing with a reduced overall cost.

Structure 1.6A – NB-EB Skewed Bridge

Structure 1.6A is one of the most innovative structures on the project due to the unique arrangement of the girders with respect to the road alignment. The following were some of the challenges faced during the analysis, design, development of drawings and construction:

- Complexity of deck geometry: the deck webs are not only skew to the abutments but they were not aligned with the traffic lanes. In addition, exterior girders were flared to maintain the continuity of webs to follow the curvature of the outer edges of the structure. This arrangement was chosen to reduce the girder span length to achieve the required minimum clearance by designing a shallow structure of 2.15 m with a span of 74 m, resulting in a 34.4 span depth ratio.

- Due to the large skew angle of the deck, the difference of the reaction magnitude of equally spaced bearings was significant. Moreover, bearings were required to be designed as uplift bearings. Therefore, several analysis trials were performed to optimize the bearing design to maintain compression forces at to all bearings. The number and location of bearings was controlled by the loads transferred to the caissons and the bearing capacity of the caissons. The bearing movements were investigated and guided bearings were provided at abutments to control the lateral movement and to resist the earth pressure from the MSE walls at the structure level.

The complexity of geometry resulted in a non-traditional arrangement of post-tensioning tendons with different elongations and stresses. The detail for the tendon blockouts and the reinforcement around the end anchors was complicated due to the large skew angle between the center line of the tendons and the end of the bridge deck.

Structure 8.2/8.3 – EB/WB Highway 14 to AHD

The bridges originally proposed at this location comprised four individual structures carrying the EB/WB Hwy 14 connectors over the CNR and Hwy14 SBL. The configuration was driven by the need to lower the profile to reduce the fill quantity. The approach fills were retained by MSE walls at each abutment with a total wall area of 8,000m2 between the CNR and Hwy14 SBL spans in a MSE wall "island" configuration.

Schedule and resource concerns in completing the MSE walls led to a solution that eliminated the MSE "island". The two simple spans were changed to a 3-span continuous structure with the middle span replacing the MSE "island". This approach managed the risk of completing this work on schedule by reducing the labour, plant and material resources that would otherwise have been required.

With the proposed structure, the previous gradeline was unchanged. A haunched section reduced the girder depth over the CNR span respected the CNR vertical clearance requirements. The analysis, design, fabrication and erection were more difficult than normal as the variable depth sections, high skew, less than ideal span configuration and construction consideration needed to satisfy the project technical requirements.

Structures 9.1/9.2 – NB/SB Anthony Henday over CNR/AHD SBL

The bridges originally proposed at this location comprised four individual structures. Two single span overhead structures were proposed with a clear opening of 11.0 m at the railway and two 52.5 m single spans overpassed the Highway 14 ramp. MSE walls were required between structures to retain the fill, creating a long "tunnel" along both the CNR and Hwy 14 S-E Ramp. To allow for a more aesthetically pleasing and open structure, a pier was placed between the CNR and Hwy 216 SB instead of the fill material and twin 53 degree skewed two-span structures with spans of 37.0 m and 67.0 m investigated at the beginning of detail design.

With the new structure configuration, the previous gradeline was unchanged. A haunched section reduced the girder depth over the CNR span and provided for the CNR vertical clearance. Bearing design was challenged by the high skew and less than ideal span configuration. To avoid uplift at the bearings, massive concrete diaphragms were designed at the abutments. The analysis, design, fabrication and erection was unusually difficult as the variable depth sections, high skews and construction considerations needed to accommodate the project technical requirements.

The steel members were detailed for 'full dead-load fit', e.g: members detailed to fit in the field as though the webs are vertical after the full non-composite load of steel and concrete is applied. The girders were sufficiently flexible that this method only complicated the installation of the cross-frames slightly and resulted in girders webs that were plumb after construction. The final solution provided more open, aesthetically pleasing, structure and added value by reducing cost.

Structure 8.4

Structure 8.4 serves as the crossing of Mill Creek under the existing CNR railway tracks. A new crossing was required to facilitate the Bretona Interchange which connects Highway 14 and 216 with AHD while maintaining downstream flows in the naturalized Mill Creek channel diversion and the Bretona Constructed Wetland complex. Societal benefits include maintenance of downstream flows along Mill Creek, accommodation of fish passage between the existing Bretona Pond located upstream of the structure and development of the Bretona Constructed Wetland complex located downstream of the structure.

The structure consists of a 2.4 m diameter concrete jacking pipe with a length of 34.3 m. The culvert design and construction facilitated installation through a combination of horizontal jacking, augering and tunnelling. This type of installation method represented a significant advancement in technology for a structure of this size and loading in Alberta. The design and installation method facilitated fully loaded train traffic to be maintained throughout the duration of the construction which reduced construction schedule.

North Abutment of Structure 1.1

Structure 1.1 is the major connector bridge within the Highway 2 Interchange that includes a MSE abutment wall that is higher than 18 m. The use of the high MSE wall added value to the project because it allowed the construction of a shorter bridge structure, thereby reducing construction schedule and cost. At the same time, the high wall provided significant design and construction challenges. The satisfactory performance of this high MSE wall required technical excellence in design and construction because it is the highest MSE wall of its type founded on the highly plastic, weak Edmonton clays. To enhance reliability (safety) of the wall and approach embankment performance, the design required staged construction. The management of risk against potential ground instability was handled through the installation of vibrating wire piezometers to monitor the excess porewater pressure in the clay foundation soils during the placement of the embankment and MSE wall backfill. The results of the field monitoring during construction were used to confirm prediction of satisfactory performance of the ground and, in turn, control the schedule of fill placement in order to achieve a stable embankment and MSE wall.

Pile Load Testing

Full-scale pile load tests were performed to refine and confirm the geotechnical foundation design of the hundreds of concrete piles, some as long as 34 m, installed to support the piers and abutments of the bridge structures. The specialized load tests were carried out by a specialist contractor from Florida and utilizing Osterberg (O - Cell) technology. The tests were performed at locations along the highway alignment assessed to be representative of the challenging ground conditions. The findings of the load test results provided significant added value to the project by enhancing performance and improving the reliability (safety) of the foundations, while at the same time substantially reducing cost. This type of testing was the first of its kind in Edmonton, and the findings can be applied elsewhere in Alberta to provide more efficient pile foundation designs.

Bridge Geofoam Block Outs

Many of the bridge structures along the southeast leg of AHD incorporated MSE walls at the abutments to retain approach fills as a cost effective alternative to providing a longer bridge span with headslopes. The selected MSE wall system comprised a structural wire basket system with non-structural precast concrete facing panels. Concrete caissons supporting the abutment seats were located within the void between baskets and panels. To facilitate bridge expansion, the voids were extended to accommodate the additional caissons as part of the future substructure widening.

The provision for future widening created a full height void behind the precast panels that extended up to the finished ground surface. Design constraints did not allow for a large structural slab to cover these voids and to support fill material and maintenance vehicles. Instead, a unique design solution was developed that used expanded polystyrene (Geofoam) to fill the voids. The ‘towers’ of Geofoam were ground supported at the base and were tied to the MSE wall system at discrete points. The consultant, contractor and manufacturer worked closely together to present the Owner’s Engineer with this innovative use of Geofoam as a load bearing material. This type of application is unique at bridge structures and required that construction methods, material properties and the structural performance of the system be clearly understood. Particular consideration was given to the long-term creep and short-term elastic characteristics of the material. Expanded polystyrene was easy to handle on-site and standard sized blocks with staggered joints were arranged to accommodate each unique void size. This solution added value by reducing construction time and cost.

Environmental & Drainage

Environmental Approvals

Environmental approvals were obtained on an accelerated schedule to meet the construction timetable. In an innovative approach, the regulatory authorities were part of the environmental design process, participating in on-going meetings from prior to the start of construction to the end of the permitting process. Representatives from Environment Canada, Fisheries & Oceans Canada, Alberta Environment, Alberta Sustainable Resource Development and others were provided with design information as it became available and in return, committed to providing feedback and staged approvals on a timely basis. Temporary approvals were obtained as necessary (e.g. for wildlife diversion tactics; draining of wetlands, etc.) to meet the construction schedule.

The regulatory approvals process for construction was completed over a four month period from February to June 2005 while construction was on-going, as opposed to the traditional approval process which can take up to a year. The added value is apparent when construction proceeded while approvals were obtained.

Environmental Design

From the time of Contract Award, environmental considerations were incorporated into the design process. The various design packages that were approved for construction provided environmental guidance in mitigation of historical contamination issues, removal of old farmsteads, rail crossings; stripping, clearing and grubbing; and erosion control. This was in addition to the ISO 14001-based Environmental Management System (EMS) developed for the Contractor that identified environmentally significant aspects and incorporated the sub-contractor ECO Plans. Successful implementation of the EMS was tracked in bi-weekly meetings and communications between the design team, contractor and sub-contractors.

A valuable component of risk management was the incorporation of large-capacity forebays into the stormwater management facilities for capture and containment of any hazardous material spills. The key objective was to minimize potential environmental impacts and prevent downgradient migration of contaminants. The forebay areas above the normal water level were designed to provide multi-functional natural habitat and were counted towards the wetland compensation requirements by the regulators.

Bretona Stormwater Management Ponds

The Bretona Constructed Wetland Complex was a difficult and challenging stormwater management system design that achieved a sustainable and balanced solution in terms of function, habitat compensation, aesthetics and cost that will benefit society and the environment well into the future. The solution was developed through a truly multidisciplinary team approach with significant design build stakeholder and regulatory input. It presented and opportunity to employ an innovative combination of stormwater quantity and quality management techniques and design features.

Mill Creek Realignment

Integral to the design and function of the Bretona Wetland Complex and the Structure 8.4 crossing of the CNR and Mill Creek is the 1.3 km naturalized diversion of Mill Creek. The channel diversion facilitated construction of the Bretona Interchange connecting Highway 14 and 216 with AHD, including the CNR overpass Structures 8.2 and 8.3.

The design will provide a benefit to society by increasing the potential to support a more complex and varied fish and wildlife habitat, reduce the risk of downstream flooding and provide for a naturalized setting that is aesthetically pleasing and suitable for potential future development into parklands or to accommodate a future trail system.

Electrical Design

Illumination

Full illumination of the new highway and corresponding interchanges and flyovers was required. The type of illumination selected in the preliminary design stage considering the economical evaluation of alternatives was conventional lighting. Costs for this system were reduced by the use of 18.3 m median mounted poles allowing use of regular luminaire maintenance equipment, as opposed to more expensive devices on high mast poles. The resulting luminaire mounting height allowed a balance of light levels versus pole spacing by using two 600W High Pressure Sodium (HPS) luminaries per pole, in opposite arrangement. The design of the mainline illumination was done for the ultimate cross section of the highway. For the balance of the ramps and side roads within project limits, 13.1 m poles with single 250 W or 400 W HPS luminaries were used.

Underpass illumination design took into account the different type of structure designs. The obstructions presented by the girders were factored in the lighting calculation to optimize the illumination. A special challenge was presented by structure 1.6, where the design did not allow for the embedment of the electrical ducts. Drilling for the installation of underpass luminaries was not permitted. Electrical ducts were surface mounted inside the concrete girders and inserts were embedded in the structure at the required locations for the installation of underpass luminaries.

Special attention was required for the illumination of the side roads and ramps under the high voltage aerial lines within power corridors. Height restrictions for the lighting poles were imposed which led to the use of reduced height poles (4.1m /6.5m). The type and distribution of the luminaries selected for this application provided good lighting coverage across the road with uniformity, avoiding the use of floodlight luminaries and thus avoiding glare.

Wiring Scheme

The large number of lighting poles required challenged the team to reduce the number of power supply points and the length of cable to wire the lighting system. This was achieved by using a three phase wiring scheme with a four-conductor cable, where luminaries on consecutive poles were connected to consecutive phases of the same circuit in a repeating “daisy chain” scheme until the voltage drop limit was reached. This arrangement and the location of the power supply resulted in optimum loading of each distribution assembly, reducing the number of required supply cabinets, the number of circuits and ultimately the length of trenching and wiring.

Traffic Signals

Traffic signals were required at the 91 Street and 50 Street interchanges. Use of a single power supply for both intersections on each road was justified from a cost perspective but individual power supplies were specified for each signalized intersection. This increased reliability and safety was enhanced by limiting the probability that both intersections be without operational traffic signals in case of damage or failure of the a single power supply.

In the future, when 91 Street and 50 Street are widened, the use of joint use poles for traffic signals and illumination was considered. Since luminaries within the intersection have a rated voltage of 347 V and traffic signals are energized at 120 V, a double voltage power supply for the signalized intersections was provided allowing for future use of a single power source and separate voltages for the lighting and traffic signal circuits present in the same pole shaft,.

PROJECT PROCESS INNOVATIONS

A P3/Design Build project requires a heightened level of management and a radically different approach. On a P3 project, risks are shared by the designer and the contractor while the work is done at a vastly accelerated pace compared to a traditional delivery project. Beyond this, there is an expectation that the design and construction is undertaken at a reduced cost, with innovative approaches to the design and construction. Add to the mix the Owner, who must ensure a quality product generally better than that delivered through the traditional process, oversight by an Owner's Engineer and a Quality Management System to monitor progress, achieving the above noted goals is challenging.

Communications

Communication is paramount to handling the challenges on a project of this scope and magnitude. The design team is large, the scope of work is wide, things happen fast, and everything must get underway with a minimum of lead time. Electronic communication systems assist in the transfer of data and email allows for the instantaneous transmission of messages between individuals. However, many of these contemporary tools actually impair effective communication, which only comes from hard work, interpersonal interaction and controls guiding the conduct of the communication process throughout the project. Understanding this and the principals that govern effective communication the design team collaborated with the construction team to develop an effective communication plan between the designer, the design build contractor and the subcontractor representatives.

E-Builder was used on the project to record the project requests for information, submittals and documents. The software worked effectively to handle the "formal" communications part on the project, while interaction between the engineering management team, the designers, the design build team and the subcontractors ensured success. Regular meetings and conversations took place to address any concerns and discrepancies, resulting in new processes put it place to guarantee the project proceeded as planned, designs were optimized by designer/contractor interaction and construction problems were resolved.

As result of the procedures put in place, the constant evaluation of current communication methods and the effective utilization of technology, the overall communication systems set in place were very effective - risks were minimized and effectively managed by the processes implemented on the project.

Design Schedule and Incremental Design Delivery Process

The Anthony Henday P3 project required the design and construction to be undertaken over a period of three consecutive construction seasons - 33 months. The project capital cost was in the range of $300 million; therefore about $100 million of work had to be undertaken each year. To achieve this, the contractor needed to start construction by the spring of 2005, with the delivery of the design in a "just in time" basis. Because of this and the need to proceed as soon as possible, an incremental design process was developed by the design team.

The incremental design process involved delivery of the design in parts, as required for construction in the field. For bridges, this involved delivering the structure Design Development (DD) drawings at the identical time as the foundation design. The next sequential bridge deliverable involved the substructure design, followed by the superstructure design. In some cases, elements of the superstructure design were advanced to ensure delivery of girders, so the superstructure design was further split into girder design and bridge deck design.

The roadworks was also delivered in an incremental fashion, with the submittals starting with clearing and stripping designs, followed by rough grading designs including drainage, then final grading, paving and the finishing designs for illumination, traffic signals, pavement markings, safety barriers, signing and fencing.

The added value in this approach involved the accelerated design delivery schedule allowing the contractors to get building the work almost immediately. Traditional projects involve completing the full design for a project, often taking well over a year to deliver the design. In a fast track project such as this, that does not work. This incremental design approach ensured that the construction work started in February 2005, rather than having the contractors wait a full year before beginning construction, as would occur on a traditional job.

Construction Oversight Design Liaison Team

In order to manage the delivery of the design to the design build team, a Design Liaison Team (DLT) was formed with members from engineering design consultants, MMM Group and Stantec. This team was responsible for the management, scheduling and tracking of the project design information and drawing submittals; oversight of the design build team's quality management processes; coordination of all activities between the designers and the construction subcontractors; addressing and documentation of field changes and site instructions; and the preparation the record drawings of the work as completed by the contractors.

Forming the DLT was a required step to handle the project efficiently and effectively. The use of a DLT does not exist on the traditional delivery of a project, nor is one needed because of the nature of the work on a traditional delivery job. Therefore, it was imperative that all DLT roles and responsibilities were defined and all participants were trained on the project to fulfill their roles in a co-operative effort with the design build contractors to meet and resolve the project challenges.

The existence of the team added substantial value to the design build process by increasing communication between the designers and the contractors. The DLT brought a design perspective to the field, while the oversight was instrumental in ensuring a speedy resolution of design issues on site. DLT also acted to ensure that constructability issues were effectively communicated to the designers for resolution.

The work carried out by the DLT was instrumental in the management of risk, schedule, quality and communications. As the engineering eyes and ears on the project, the DLT were an integral part of the construction Quality Management System ensuring oversight of the work and assuring that the work undertaken, met and/or exceeded the project technical standards.

SPEAKER'S BIOGRAPHICAL NOTES

2008 TAC Annual Conference
September 21-24
Toronto Ontario

The information you provide on this form will be used by your session chair to introduce you before your presentation. Please outline your education, current position and responsibilities, and any special awards or recognition received.

Name: Christopher Gauer, P. Eng., AVS

Paper Title: Value Engineering and Innovation in the Design and Construction of the Southeast Section of Anthony Henday Drive, Edmonton

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Session: Implications of P3 Projects for Geometric Design

Biographical Notes:

Chris Gauer received his B.A.Sc. from the University of Toronto in 1978. He has worked in consulting engineering throughout Canada and internationally and is currently the Transportation Manager, Alberta for the MMM Group which has offices nationwide. Mr. Gauer is registered with the Association of Professional Engineers, Geologists and Geophysicists of Alberta (APEGGA) and the Professional Engineers Ontario (PEO) and is an Advance Value Specialist with SAVE International.

Chris was currently the Engineering Manager for the Anthony Henday Drive project responsible for all engineering on the project. Chris also has previous Design Build experience on the Fredericton to Moncton Highway in New Brunswick and Highway 407 in Toronto.

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