Paper Title: Design and Construction of Southeast Anthony Henday Drive, Edmonton

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Author's Name: Chris Gauer, P. Eng., AVS

Author's Title: Transportation Manager, Alberta

Anthony Henday Drive (AHD) in the City of Edmonton is an outer ring road currently under construction 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, Access Roads Edmonton Ltd. (AREL), headed by ABN-AMRO Bank, PCL Construction Management Inc. and TSMI, was awarded the $493 million DBFO Contract for the southeast portion of Edmonton's Anthony Henday Ring Road in 2005. Marshall Macklin Monaghan (MMM) leads a design team for the assignment that includes MMM Alberta subsidiary Bel-MK Engineering Ltd., Stantec Consulting Ltd., Golder Associates Ltd. and Applied Research Associates.

Construction of Anthony Henday Drive SE started in the January 2005 and the road will open in October 2007. The southeast section of the AHD includes:

- 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 challenges associated with the construction of this major new transportation corridor within a compressed design and construction schedule, and the successes associated with the first highway Public-Private Partnership in the Province of Alberta.

The Project

Anthony Henday Drive (AHD) in the City of Edmonton is an outer ring road currently under construction 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.

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As of the summer of 2006, the design effort is essentially complete on the project and the construction activity is in the second of three construction seasons. This second construction season is "make or break" season of construction activity to ensure that work is completed by the assigned date. There is no tolerance for cost overruns or schedule delays, as the project must open on time and on budget by October 26, 2007. From this perspective, we can look back at the first year of activity initiating the work, developing the design build team environment, expediting the fast track design and ensuring that the contractors get working as quickly as possible.

Organization

The design-build-finance-operate (DBFO) team is led by the financial entity, which is the proponent for the 33 year life of the project and has the DBFO contract with the Province of Alberta. This lead group is Access Roads Edmonton Ltd. (AREL), headed by ABN-AMRO Bank. PCL Construction Management Inc. (PCLCMI) is 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 responsible for the 30 year operation and maintenance of the highway. The construction subcontractors to PCLCMI for the project are 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.

Marshall Macklin Monaghan (MMM) leads the engineering and design team for the assignment. The team includes MMM Alberta subsidiary Bel-MK Engineering Ltd., 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, supported by the geotechnical subconsultants. MMM and

Stantec also are involved in the construction oversight of the work in order to oversee the contractor Quality Management Systems and ensure that the work is constructed as designed. The other engineering responsibility is preparation of the record drawings for the project.

Procurement

Anthony Henday Drive is the first Public Private Partnership (P3) Highway Project in Alberta. The procurement phase of the project involved:

- An Expression of Interest Fall 2003
- The Shortlist of Prospective Proponents March 2004
- Responding to the Request for Proposals between May and November 2004
- Selection of Preferred Proponent December 2005
- Award and Signing of DBFO Contract January 25, 2005

Scope

The project to date is the largest single contract awarded by Alberta Infrastructure and Transportation. The $493 Million project cost is based on 2005 Net Present Value of the design, construction, operation and maintenance costs. The province will pay AREL a series of monthly payments starting from the Traffic Availability Date (when the highway opens to traffic).

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The main systems interchange at the southerly entry to Edmonton, the Calgary Trail Interchange, was partially built by the Province and is partly constructed by the AREL Team. The project involves a significant diversity of bridge types. Only three of the grade separation structures are similar in span and bridge type. All three local interchange structures are different in layout geometry and bridge span. The two systems interchanges generally involve a unique configuration of bridges on curvilinear alignments, except for the two sets of twinned CNR railway crossing/highway ramp structures. The most significant bridge is the Third Level interchange ramp structure from westbound AHD to southbound Highway 2. Many structures are constructed over live traffic.

The sideroad Interchanges are in a Parclo configuration. A key issue near the Systems Interchanges involved the weaving distances between the local and the systems interchange ramps. The highway will be fully illuminated. Of particular note is the fact that the Design Build Team was responsible for all utility relocation costs on the project.

Design Challenges

In the capacity as the lead engineering team member, MMM was called on to address a variety of challenges in order to meet the particular needs of this Design Build project. These challenges involved delivery of the design according to the contractor's needs, providing the best possible design in the fastest possible timeframe, standardizing/coordinating the design effort among a diverse project team, managing effective communications between the engineering and construction teams, overseeing the activity for quality workmanship, and working with the Design Build team to secure the required approvals.

Critical Path

At the outset of the work on a Design Build project, the design activity is ALWAYS on the critical path. The key challenge for the engineering team is for the design to get ahead of construction at the soonest possible date. In order to do this, resource allocation of the engineering teams at the outset of the project is crucial. One must understand that decisions early on in the project affect the overall delivery timelines of construction. Because of this, there is a simple need to design first what the contractor will build first. However, as the work progresses, unforeseen circumstances will arise. Because of this, the design and the construction schedule needs to be fluid to fit available design resources, the contractor priorities and unexpected field circumstances. One very important consideration is to integrate the third party (owner) review and oversight into the design delivery schedule.

Design Delivery

Once the design schedule is developed, the schedule requirements need to be clearly communicated and managed between the designer and the contractor teams. Delivery of work on time requires that every design team commit to the delivery dates. Timeframes must be reasonable and achievable, and the designers must meter their progress to meet the delivery date targets. There is always a designer predisposition to "polish the apple"; meaning that there are always ways to improve, recheck or optimize the design. However, early in the project it is generally more important to get work going, rather than refine the design to the nth degree.

In order to ensure management of the project schedule, mandatory and ongoing communication of design slippages is necessary. This requires an independent weekly monitoring of the design schedule. This individual reports back to the design management team and provides information to the construction team. In a project of this nature, delays or design changes at the outset of the work will back up subsequent design delivery. Therefore, this situation must be avoided so that the design delivery does not affect the contractor's schedule.

If the third party oversight design reviews precipitate subsequent design revisions, this additional work will have a cascading effect and possibly delay subsequent design packages. This is because the designers are sidetracked in modifying previous design work, rather than advancing the design associated with the upcoming design deliverables. Also, field demands and unforeseen circumstances can also serve to sidetrack the design effort. Therefore, it is important to set up a design process that minimizes the design changes, provides support to the field, yet minimizes the field distractions to the design delivery schedule keeping the designer's "eye on the ball" for the upcoming deliverables.

One truism is that a designer always expects to meet their assigned deadline. However in reality, scheduled delivery dates are missed for a myriad of reasons. These excuses must be eliminated and the management/coordination systems must enable the designer to focus on meeting the delivery targets while other teams manage the revision process and coordinate the field oversight engineering support.

Optimization

Any design can be improved through further work and study. Design at the initial bid stage is developed to about a 30% level of detail. Once the real work on the project is started, it was important to deliver the final design on the critical path

design elements as quickly as possible. One significant advantage of the Design Build process is the opportunity to collaborate on design with the contractor. This collaboration can and will result in a better and more constructible design, that is likely less costly to construct. However, the pace of the delivery of the design work can make this collaboration difficult. The designer is busy just moving the design forward and it is often difficult to take the time to provide interim design concepts to the contractor to enable the collaborative process.

Also in Design Build, the opportunity exists to share design experiences between different engineering teams. Typically on a project of this scope and magnitude, there are multiple design teams working on the various aspects of the project. The value in collaboration between the different design teams involves the consideration of different methods and integration of varying points of view to enhance the design due to input from multiple sources.

In order to improve the collaborative nature of the design, there needs to be a formal process to make this occur. Collaboration is not a natural outcome of the working relationships on a Design Build project, due to the pressures of work and the tight timelines for delivery. Beyond that, there also needs to be a design freeze deadline, as design cannot keep on changing which would delay final delivery of the work. Early in the project, the focus must be on design delivery. Optimization of the design can follow, if there is time.

Another situation to consider in the design process is whether work qualifies as value engineering or the design changes are just the natural refinement of the design. This is particularly important when the project has clauses with respect of incentives relating to value engineering initiatives.

Standardization

Standardization of common design elements can reduce the overall project cost by repetition of construction methods. This allows reuse of materials on site and permits the construction workers to repeat tasks, at a higher level of efficiency the second and third time around. The challenge from a design point of view is that different designers will take totally different design approaches to addressing the same problem. In order for standardization to occur, strong central coordination of the work is required, by an individual dedicated to this task. This individual would enforce project design discipline and nurture standardization of the work.

It is important to remember that the contractor needs to be part of the standardization process. The designers need to design what the contractors prefer to construct. Again, this is only achieved by direct collaboration and development of strong working relationships between designer and the

contractor. As discussed, it is difficult to standardize designs at the outset of the project as designers are busy working on and delivering the initial designs on a tight timetable.

Design Team Communications

Everyone recognizes communication is a key element in the Design Build process. However, most individuals do not appreciate how difficult it is to maintain effective and clear communication between all parties of the Design Build team. In the haste to do the work, individuals often fire and forget emails to their associates on the project. This is not necessarily the best means of communication. Full and clear communication requires outlining an action, acknowledgement of receipt and follow up to ensure full understanding and timely action. One danger of email communication is copying everyone on email correspondence. This often is counterproductive, as key messages can get lost in the clutter of irrelevant communications.

Because of the complexity of work and the large working teams, major Design Build projects require communication protocols to ensure that individuals know who to talk to about what, while respecting commercial relationships. This requires weekly designer-contractor meetings to ensure effective and ongoing communication of all relevant project activities, with properly documented meeting minutes

Quality Management

For engineering design, the quality of work normally is a product of the time taken to do the work, the experience of the individuals involved and the effectiveness of the quality control process. The Design Build schedule severely stresses the design delivery timelines, so the other two factors become even more important in delivering a quality product. The design activity requires knowledgeable, experienced individuals to quickly deliver the design and to thoroughly check the work.

One piece of advice is not designing to the limit of the code or minimum situation. In Design Build it is advisable to allow some latitude in the design by exceeding the required standards, because there is little time to “polish the apple” and refine the design. Therefore, a conservative design approach on the early design deliverables is acceptable. As previously discussed, design refinements and optimization can be undertaken only when there is time.

To ensure the best quality product and to improve commonality of the work by different design teams, independent oversight of design, review of standards and checking code compliance is a good practice. A standardized, and possibly centralized, review process is recommended to achieve effective quality results.

Oversight

On major P3 projects, the Owner will undertake their own review of the design and construction practices, or they will hire their own independent agent. Depending on the process set up for oversight, the owner's reviews can be at a high level (conceptual in nature) or can be quite detailed (calculation checks and detailed drawing reviews).

High level reviews imply that the designer takes responsibility for their work. Therefore, these reviews generally rely on the Engineer's professional stamp on the drawings to ensure compliance with all codes, standards, specifications and technical requirements. Detailed reviews by the Owner will take much more time and will likely require subsequent resubmissions and design refinements when the reviewer disagrees with the designer's approach. Also, because of such reviews, the Owner participates in the design process and when they dictate their preferences, they may also share in the responsibility for the design. In general, no two designers approach a problem in the same fashion. This leads to differences in interpretation in the design development and application of the project standards.

In many cases, the oversight role uncovers professional differences of opinion on the proper course of action and interpretation of the specifications. Also, the reviewer may have comments resulting from a lack of context or an incomplete view the underlying design rationale. The best way to address these situations is to meet with the reviewers often to expedite decision making and resolve the differences of opinion.

Construction Challenges

The Design Build project involves the engineering team in both the design and the construction of the work. Through the construction process, it is incumbent on the engineering team to oversee the contractor's work, to ensure that the design is executed as expected in the field. At the end of the project, the engineering team will need to provide record drawings documenting what was built by the contractor. This section discusses the challenges associated with this aspect of the work from an engineering perspective.

Commercial Relationships

Design Build execution of the work requires a firm understanding of the team's commercial relationships. There may be a myriad of relationships between the Owner, the Financing Agency, the Design Build Contractor, the Engineer, the Sub-Contractors and Operations/Maintenance organization. At all times, the project team members must understand that changes reducing cost for one Design Build team member may cost another partner time or money. This is why it is vitally crucial that all senior project team members understand the commercial relationships on the project.

Because of the interrelated financial, responsibility and schedule activities, it is paramount to ensure all parties are involved in decision making. Communications between parties without a commercial relationship are "off line" conversations. Formal communications must follow the commercial relationships and project communication protocols.

The fast track world of Design Build requires close co-operation between all parties, but understanding and respect of the commercial boundaries must always be maintained. Because of this, the design team needs an effective project management team who ensure that all design team members follow the correct protocol and respect the commercial relationships.

Designer - Contractor Communications

The strength in the Design Build process is in effective and ongoing designer - contractor communication. To achieve this, it is important to set out prescribed means of communication through knowledgeable/experienced key individuals. These individuals must be open to dialogue, discussion, compromise and action.

In all cases, it is imperative to follow the communication protocol. If the protocols do not work, they can be changed, but this is a team not an individual decision. Disagreements between various project team members will occur. The most important action is to face down the issues to resolve problems at the soonest possible opportunity. It does no good to leave differences unresolved. With effort and diligence, a solution will always be found.

The Design Build senior management team must always be open to enhancements, improvements and criticism. The project is dynamic, and the project path can and will be changed, where better solutions are evident or where unforeseen situations dictate a varied course of action. When changes are contemplated, it is important to clearly define limitations, costs and possible delays arising from the different course of action.

When many parties equally participate on a project task, it is important to designate a champion to lead the effort. Without an effective leader, the work will not progress as efficiently as needed, and disputes between various parties will not be managed. It is important to remember that there always needs to be give and take on the project, between the engineer and the contractor.

Quality Management

Many traditional designers and contractors have not worked in an ISO 9001 Quality Management System (QMS) environment. As such, they are not comfortable in the QA/QC role that they must undertake. In some cases, the traditional project delivery process has a fairly rigorous third party oversight of the construction work. In this case, the contractor may rely on this "third party" as a checker. However, the traditional process also permits interpretation of the project requirements in the field, just between the contractor and the contract administrator. This allows for quick decisions in the field between the contractor and the Engineer, but these decisions generally are not subject to the rigorous oversight associated with a QMS system and Owner oversight.

The Design Build process involves multiple layers of Quality Control and Quality Assurance by the fabricator, construction contractor, the design build contractor, the engineering team, the operations group and the owner. Therefore, there is far more oversight and transparency of quality management process is paramount. Typically, there is little latitude in acceptance standards in Design Build, because all work must meet the strict letter of the project requirements, or there is the appearance that the contractor is "given a break". In general, there is more flexibility of acceptance of minor deviations in the case of the traditional delivery model than on a Design Build project.

The key goal of Design Build is to do it right the first time and avoid rework. This requires a high level of rigor in the quality control process, over and above the typical project delivery process. Therefore, it is important to have effective quality control buy in by all project team members. Standards, specifications, processes and testing methodologies must be clearly thought out in the context of the project requirements. Once defined, the Quality Assurance procedures must be followed to ensure that the Quality Control process is effectively monitored. From this QMS documentation, the design engineering team's construction representatives monitor the work for conformance with the intent of the design.

Field Conditions and Design Changes

The design will always need to be fine tuned in the field as the person in the office is unlikely to foresee all field circumstances. Because of this, the design effort extends into the field in Design Build and the designer needs to be in the field along with the contractor.

Mechanisms need to be developed for quick resolution of field construction issues and problems. Minor changes to the design can be addressed by a field instruction but more significant changes require Owner review and acceptance, in addition to acceptance by the design engineer. As always, timeliness of responses to maintain the construction schedule is the key consideration. Because of this, placement of experienced designers in the contractor's office is the best way to manage this situation and deal with the field construction issues.

Risk Management

Design Build involves sharing of risk among parties. Designers are not comfortable with this situation. Where a course of action has risk, the risks and consequences need to be communicated, discussed and managed by the Design Build Team Members. In most cases, risk can be managed by avoidance, redesign or rescheduling work. However, this requires flexibility by the designer and the contractor to revise the plan of attack.

Commercial terms may require all Design Build team members to agree upon "work around" schedule changes. This is because a change beneficial to one project team member can be detrimental to another. It is evident that designers are not good at working with and communicating risk or living in a high risk environment. Therefore, a special effort is needed by the Design Build Team for training in the importance of recognizing risk and the consequences arising from the lack of management and communication of risk between the project team members.

Proprietary Systems

Design Build involves the marriage of two parties, the Designer and the Builder. However, in some cases, the line between design and construction can be blurred. This occurs in the area of proprietary design systems and products

where an engineered product is provided by a fabricator or supplier. When these situations occur, a clear definition of responsibility for the design is needed. Design Engineers cannot and will not take responsibility for proprietary systems or products. However, the engineer is responsible to ensure that any products specified on the project are “fit for use” in the proposed applications. However, for proprietary systems, the supplier provides the engineering design and as such, must be responsible for this work and stamp the drawings.

When proprietary systems are involved, it is important that an individual be defined by the organization as commercially responsible for the work. This individual becomes the systems integrator, ensuring all aspects of the proprietary design fit together along with the other external design inputs.

Design Revisions During Construction

Design Build often involves the design progressing in an incremental fashion. This means that there is increased risk, as the full consequences of the design may not be known until the entire design is completed. Because of this fast track process, design revisions during construction are unavoidable. With this process, the Contractors need to be advised and understand the possibility of late design changes and the impact of such changes on construction scheduling.

When work is progressing in this fashion, the designer needs to understand the limitations of their work and advise the contractor of risk associated with the incremental design. Where possible, it is best to direct construction work to areas where there is no, or a limited possibility for change due to design revisions.

Successes

It is evident from the above situations on the Anthony Henday Drive project that Design Build is a totally distinct environment for design engineers. The pace of work is accelerated; risk is real and requires management and decision making that must be decisive and correct. The following are a few successes associated with the delivery of the Anthony Henday Drive project.

Design Build Team Management

The PCL Design Build Management Team operated very successfully on this project. The working relationship between designers and the contractors is close, ongoing and effective and this relationship always allows for input and informed decision making. The management had no bias in favor of either the designers or the contractors. When problems did occur, they were addressed immediately and not allowed to get remain unresolved. Fault was not the issue, solving the dilemma was more important.

All key Senior Project staff, from the Design Build Team, the Design Team and the Contractor Team bought into this process. Things still went wrong, but there was ample willingness to get to the root cause of a problem and rectify any situation that occurred.

This occurred because the same Project Team worked on the project from the start of the bid stage, right through to the design and construction of the work. The relationships and processes developed early in the project bid stage helped to drive the work in the field to a successful result.

On the Anthony Henday Drive project, all involved will agree that the Design Build Team is cohesive and focused on problem solving and getting the project done.

Communications

Setting out communications protocol and maintaining proper communications channels following the commercial relationships was not an easy task. All project staff needed training in terms of commercial relationships and proper process and procedures as they applied to our Design Build process. With effort and repetition, the communications processes were ingrained in all project team members. The resulting climate produced a free, co-operative and productive design - construction team relationship.

These relationships led to better management of issues as they arose during the course of a project and permitted effective problem solving when things did go wrong. All team members learned that communication was not automatic, but took effort, repetition and verification to adequately, clearly and effectively communicate with others on the project.

The communications processes and protocols on the AHD project were found to be thorough and effective in getting all project team members working in the same direction.

Design Delivery

Engineers always believe that they will meet deadlines, even as the deadline fast approaches and they are having some difficulty in resolving the final design details. Often things proceed to a situation where the deadline is imminent, without the deliverables ready to go. Because of this, constant effort is needed to track, monitor and reinforce delivery dates. Communication is needed to anticipate problems and develop adaptive solutions where timelines cannot be met.

All design team members require constant schedule monitoring and deliverable tracking to keep the flow of work progressing as expected. Outside (third party) monitoring of the design process is a must. With an adaptive attitude and good communications process, unforeseen situations can be addressed by the design team and the schedule can be maintained, or adapted to suit.

Delivery of design packages on the project must provide drawings to the contractor in order for construction to proceed as required, without delaying the contractor's work

Problem Solving

Fast track projects, and construction in general, will always have problems to resolve in the design office and in the field. The key element to successful resolution of problems is to address and resolve issues in the quickest possible fashion. Time is money in Design Build and the work schedule is the driving force of the work. This requires effective and ongoing communication from the field to the designer, to understand the issues and develop solutions to the problems as they arise.

Effective design team-contractor communication is needed to make this work. Problems in the field must be identified, communicated to the designer and resolved in a timely fashion. The Owner and his review team must have the means to be a part of the solution and participate in the problem solving and decision making. This requires a good working relationship, trust and cooperation between all parties.

The project demonstrated a willing "problem solving" culture, where the designers solved construction problems and the contractors help out with design delivery difficulties.

Fast Break Start

When a design build project starts, the design is only partially complete, but the contractor needs to get started building the project as soon as possible. The primary goal is to start construction at the earliest possible date. This requires a running start to the design work immediately upon award. Because of this, design is delivered in an incremental fashion. In many cases, work in the field will begin before all final design issues are fully resolved. This challenges the communications strategies used on the project to identify and to mange the risks associated with the partially completed work. Because schedule is the driving force on the project, it is more important to get going, with a possibility of some small rework, rather than be frozen with paralysis and not moving forward in the field. On the Anthony Henday Drive project, construction started in February 2006, after a January 2006 project award. This meant that the initial design was out to construction very, very quickly.

Summary

A few of the lessons of Design Build include:

- Design Build work requires innovation in delivery within the framework of clearly defined processes and protocols;
- A key challenge is that the design engineers learn to contribute to help to manage risk, in cooperation with the Contractor construction activities;
- Effective communications are vitally important in all aspects of this work in order to be successful;
- Engineers working in Design Build cannot fear, they must act and clear informed and decisive king is needed; and
- Schedule drives the Design Build world.