Leadership in Sustainable Infrastructure
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Vancouver, Canada
May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

RISK REDUCTION IN TRANSPORTATION PUBLIC-PRIVATE-PARTNERSHIP (P3) PROJECT DELIVERY THROUGH INTEGRATED QUALITY MANAGEMENT

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Abstract: P3 project model has gained wide acceptance for transportation infrastructure projects. In Canada, public sector has utilized the P3 model due to the ability to transfer the risk of asset life-cycle costs to the private sector. The essential feature of P3 model is that the project specifications are defined by the public sector entity in terms of the performance objectives over the life cycle of the asset. With this model, the risk due to design, construction, financing and operations is typically assumed by the private sector partner. Shortcomings in design and construction phases result in a greater risk transfer to the operations phase of the project. As the specifications in a P3 model are performance-based, the success of the project is highly dependent on demonstrating that the performance objectives have been met. The Quality Management System (QMS) established within the project determines the forms of the evidence to be produced during design, construction, and operational stages of the project to ensure that the project specifications have been met throughout the life-cycle of the asset. A well-designed QMS will ensure mitigation of hidden risk transfer between different project phases and project partners, and efficiency gains in cost and schedule. This paper provides a framework for an integrated quality management system that ensures risk reduction during design and construction phases in P3 projects. The implementation of this system and the efficiencies gained due to the process are demonstrated through the case study of North-East Anthony Henday Drive (NEAHD) Project in Edmonton, Canada.

1 INTRODUCTION

Project delivery through P3 model has gained wide acceptance in North America for transportation infrastructure projects, such as bridges, highways, light rail and airports. In Canada, government initiatives at both federal and provincial levels have encouraged P3 model due to the ability to transfer the risk of life-cycle costs of an asset to the private sector through this approach. Some of the recent examples of large infrastructure projects using P3 model are the Canada Line Project in Vancouver, North-East Anthony Henday Drive Project in Edmonton, Eglington Metrolinx LRT in Toronto, Chief Peguis Trail Extension in Winnipeg and Valley Line LRT Project in Edmonton.

The essential feature of P3 model is that the project specifications are defined by the public sector entity in terms of the performance objectives over the life cycle of the asset. This is in contrast to the prescriptive technical specifications set for other types of project delivery. Although P3 projects could include different types of procurement, the typical procurement model includes design, build, finance, and operation and maintenance (O&M). The ownership of the asset is held by the public sector while the private sector acts as the asset manager over a part of the asset life cycle. With this model, the risk due to design, construction, financing and O&M is assumed by the private sector partner. Shortcomings in design and construction phases impact schedule, durability, and project quality. Consequently, greater risk can be transferred to the O&M phase of the project. Figure 1 shows the project delivery structure adopted from Alberta Transportation. In this delivery structure, a shell company is created by the lenders as "special project vehicle" (SPV), which acts as the private contractor mediating between the government agency, private financing, and other subcontractors for design-build, and O&M.

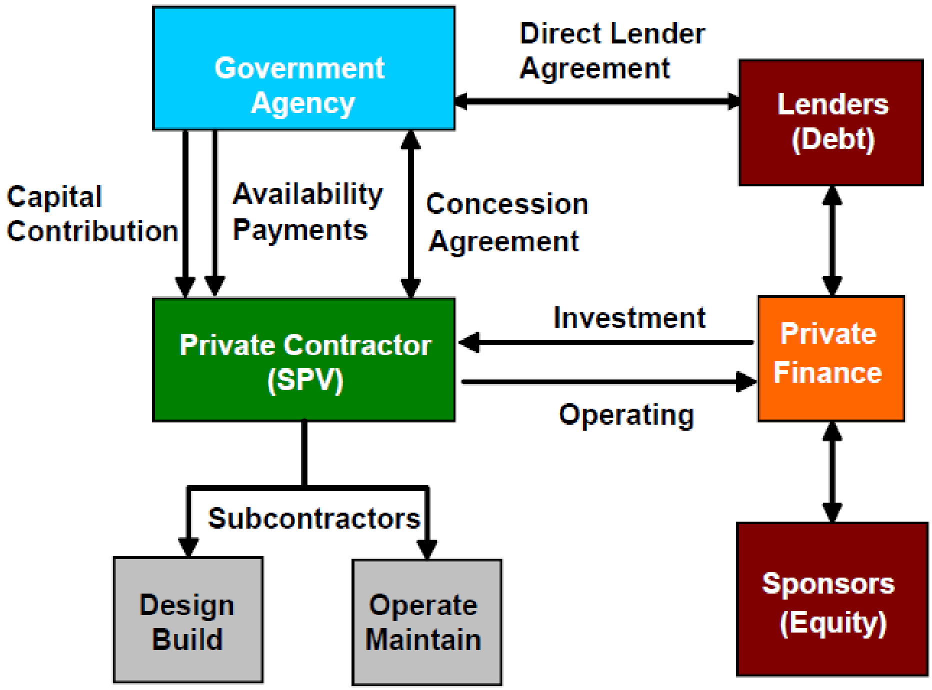

Figure 1: Project Delivery Structure in P3 Model (adopted from Alberta Transportation, 2016)

As the specifications in a P3 model are performance-based, the success of the project is highly dependent on demonstrating that the performance objectives have been met. The Quality Management System (QMS) established within the project determines the forms of the evidence to be produced during design, construction, and operational stages of the project to ensure that the project specifications have been met throughout the life-cycle of the asset. A well-designed QMS will ensure mitigation of hidden risk transfer between different project phases and project partners, and efficiency gains in cost and schedule.

This paper provides a framework for an integrated quality management system that ensures risk reduction during design and construction phases in P3 projects. An overview of the integrated QMS is presented in the next section. The implementation of this system and the efficiencies gained due to the process are demonstrated through the case study of North-East Anthony Henday Drive (NEAHD) project in Edmonton. A general description of the NEAHD project, relevant stakeholders, implementation approach of the integrated QMS, and the consequent benefits are presented in the subsequent sections.

2 INTEGRATED QUALITY MANAGEMENT SYSTEM

QMS developed according to ISO9001:2008 (ISO9001, 2008), defines a framework to ensure that policies and procedures are in place for management of project quality. While QMS is an overarching policy, it sets the guidelines to establish Quality Manuals (QM), Quality Management Plans (QMP), and Quality System Procedures (QSP). QM and QMP define the roles and responsibilities within the project team and set the quality objectives, which outline the acceptable level of quality with clearly defined outcomes. QSP contains the quality implementation details, e.g., Inspection and Test Plans (ITP), work methods for each construction element, non-conformance report procedures and quality check lists. Figure 2 shows the structure of a typical QMS, adopted from ISO9001:2008.

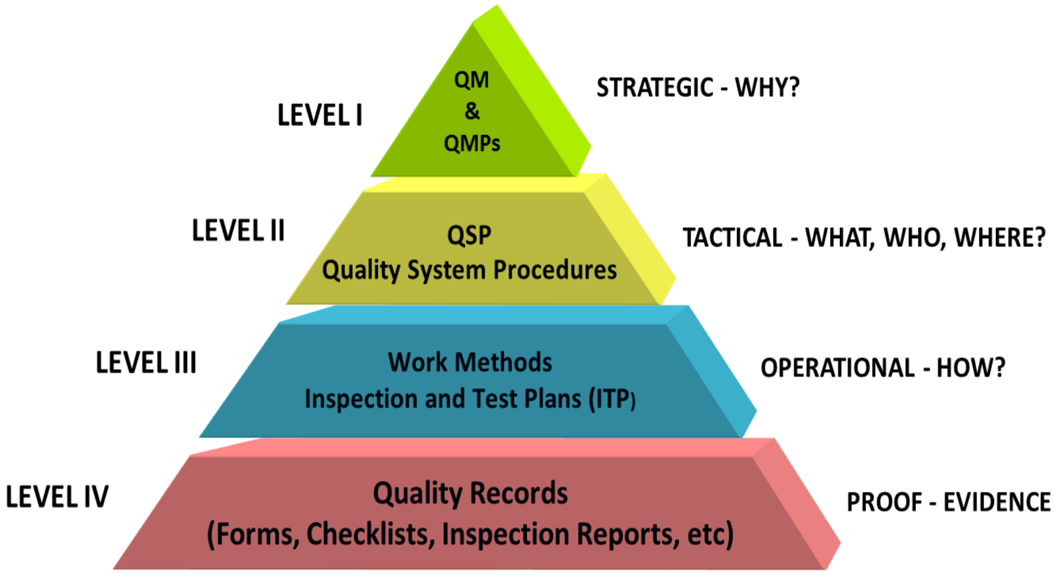

Figure 2: Hierarchy of Quality Management System

In P3 model, development and implementation of QMS can be distinct for private contractor representing SPV, and subcontractors for design-build and O&M. In this case, each entity may establish quality objectives internally, which may lead to discrepancies in the quality expectations between different subcontractors, consultants, financiers, and government agency.

In an integrated QMS, all the entities involved in the project delivery (as shown in Figure 1) agree to establish common quality objectives and QSPs. This enables transparency and coordination among all the parties involved, and prevents unnecessary conflicts and liabilities arising due to differing quality objectives. As all parties follow similar procedures to meet similar quality expectations, more effort is devoted to achieving the quality requirements of the project instead of conflict resolution due to misalignment in the quality objectives. It is noted here that the implementation and success of an integrated QMS is heavily dependent on the willingness to coordinate among all the parties involved, including the government agency that sets out the project performance requirements. Successful implementation of the integrated QMS, and the resultant benefits in the design and construction phase of NEAHD project are described in the following sections.

3 PROJECT DESCRIPTION

NEAHD project consisted of 27-kilometer highway construction with six- to eight-lane divided roadway, nine interchanges, and 47 bridge structures with the total cost of up to two billion dollars. It is the final component of a multi-year infrastructure development for a ring road Edmonton, as shown in Figure 3. The design and construction of the project was started in 2012 and the highway has been successfully open to the traffic on October 1, 2016. Figure 3 also shows the project boundaries related to NEAHD portion of the project.

The project delivery structure was as shown in Figure 1 where Alberta Transportation (AT) is the government agency which set the project requirements and represented the Provincial interests. Capital City Link General Partnership (CCLGP) was the primary contractor formed as SPV representing the private financiers to the project. Design-build was subcontracted to the joint venture among Flatiron Constructors Canada, Dragados Canada, Aecon Infrastructures, and Lafarge (FDAL). O&M was subcontracted to Volker Stevin Highways (VSH). Figure 4 shows the project delivery structure for NEAHD.

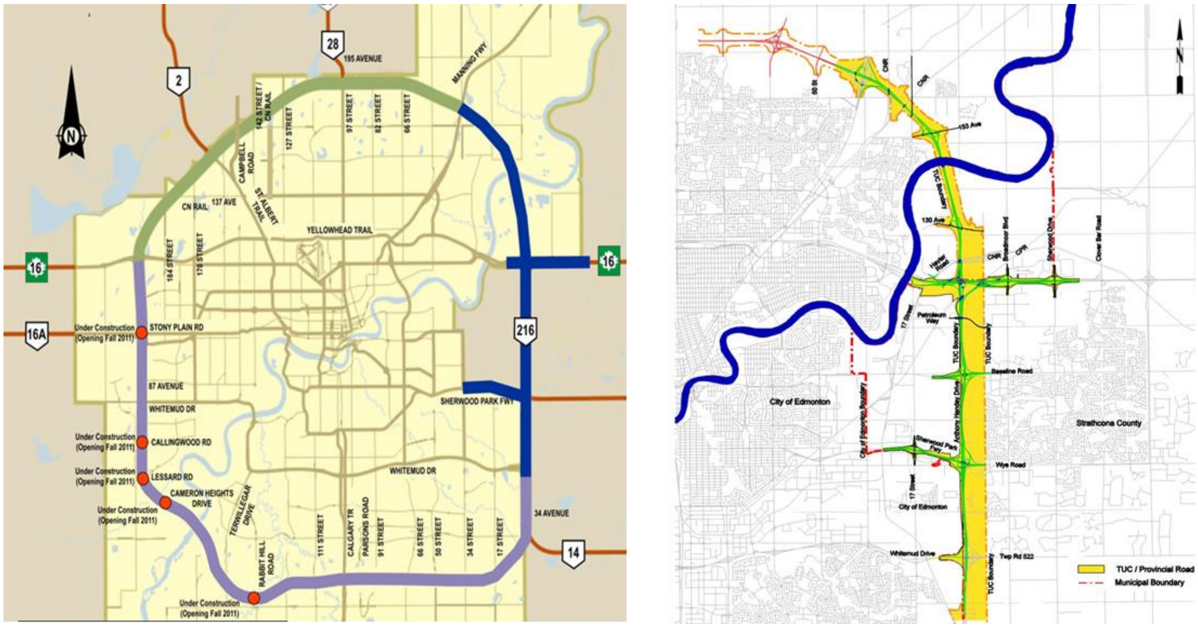

Figure 3: Anthony Henday Ring Road in Edmonton (left) and NEAHD Project Boundaries (right)

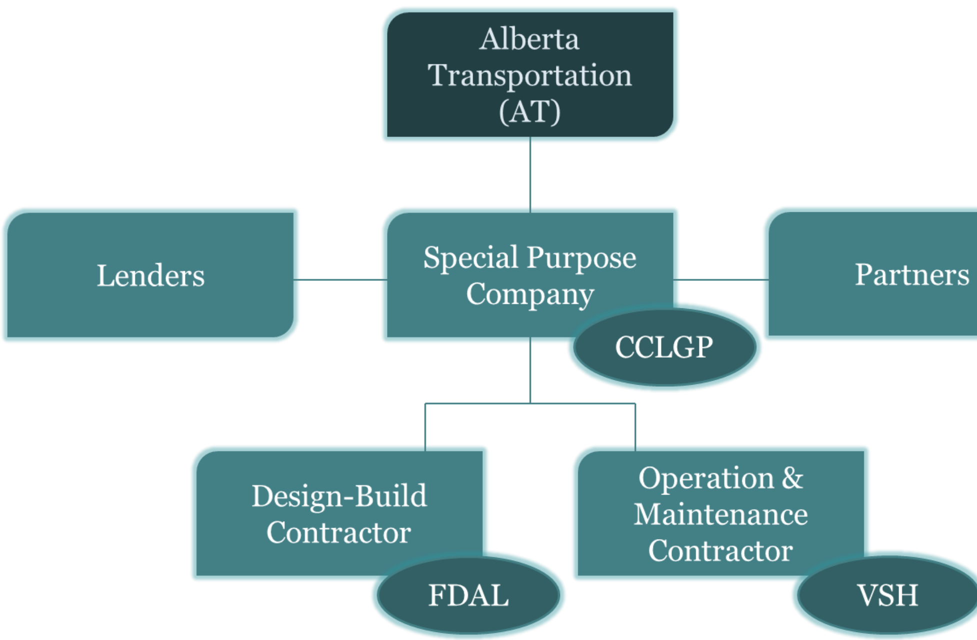

Figure 4: Project Delivery Structure for NEAHD Project

4 IMPLEMENTATION OF INTEGRATED QMS

Implementation of integrated QMS within the design and construction phase of the project was achieved by addressing the following components:

4.1 Quality Objectives

Quality objectives were established by design-build subcontractor, FDAL in alignment with the quality objectives set out by the primary contractor, CCLGP. Through integrated QMS program, both parties have agreed to review the performance measures set out for each quality objective. The performance review was agreed to be conducted with the completion of construction of each design segment or structural component. This enabled the development of a feedback loop to improve and align the quality objectives and the associated performance measures between the parties involved. Table 1 shows the quality objectives of the primary contractor and Table 2 shows the quality objectives and performance measures set out by the design-build subcontractor.

Table 1: Quality Objectives of CCLGP

Quality Objective	Performance Measure
Meet or exceed the requirements in the project agreement with AT	Provide for internal or external audits of all QMPs and all elements critical to quality once each year to determine compliance with the Agreement.
Ensure the project is completed on schedule	Monitor the schedule on a regular basis; develop a relationship with the AT, FDAL, VSH and their subcontractors so that contingencies are available in case of schedule delays
Ensure all personnel understand the relevant QMS clauses.	All employees are to be given an introduction to the QMS within one week of starting work
Monitor QMS at planned intervals	Perform internal audits and management review

Table 2: Quality Objectives of FDAL

Quality Objective	Performance Measure
Meet or exceed the requirements in the Agreement	Minimize non-conforming works
Minimize disruptions to traveling public	Meet the traffic requirements in the project specifications
Specify and control quality	Produce, review, revise and issue Quality System Procedure before each work activity commences
Ensure all personnel understand the QMS	All employees are to be given an introduction to the QMS within one week of starting work

4.2 On-site Communication

Construction and design personnel, represented by Field Engineer and Field Review Engineer, are tasked to communicate and coordinate with the quality control (QC) and quality assurance (QA) personnel of the design-build subcontractor, FDAL, based on the QMS. In the integrated QMS, the field quality monitors representing AT and CCLGP were also included in the communication and the coordination of the construction activities. The objective of this on-site communication system was to enable CCLGP and AT to be aware of the construction progress, quality records generated and any non-conformities in the construction work. Figure 5 shows the presence of the AT and CCLGP field quality monitors and quality verification (QV) within the construction workflow of FDAL (shown in filled blue boxes). Integration among all the parties is shown in the large blue rectangle with broken line border.

4.3 Records Management

Given the size and scope of the project, the number of records generated during the design and construction phase of the project were anticipated be in the order of thousands. In recognition of the size of records, an electronic records management process was established with shared access to improve the ease of communication, review and approval of the required documents. Within the electronic records management process, a framework of required documentation for the review and approval of each construction component by AT was established. This enabled all the parties to be aware of the anticipated records for each component and timely generation of required records by the responsible personnel in design, construction, contracts, quality, safety and environmental approvals. This also enabled early handover of the final documentation for critical construction components.

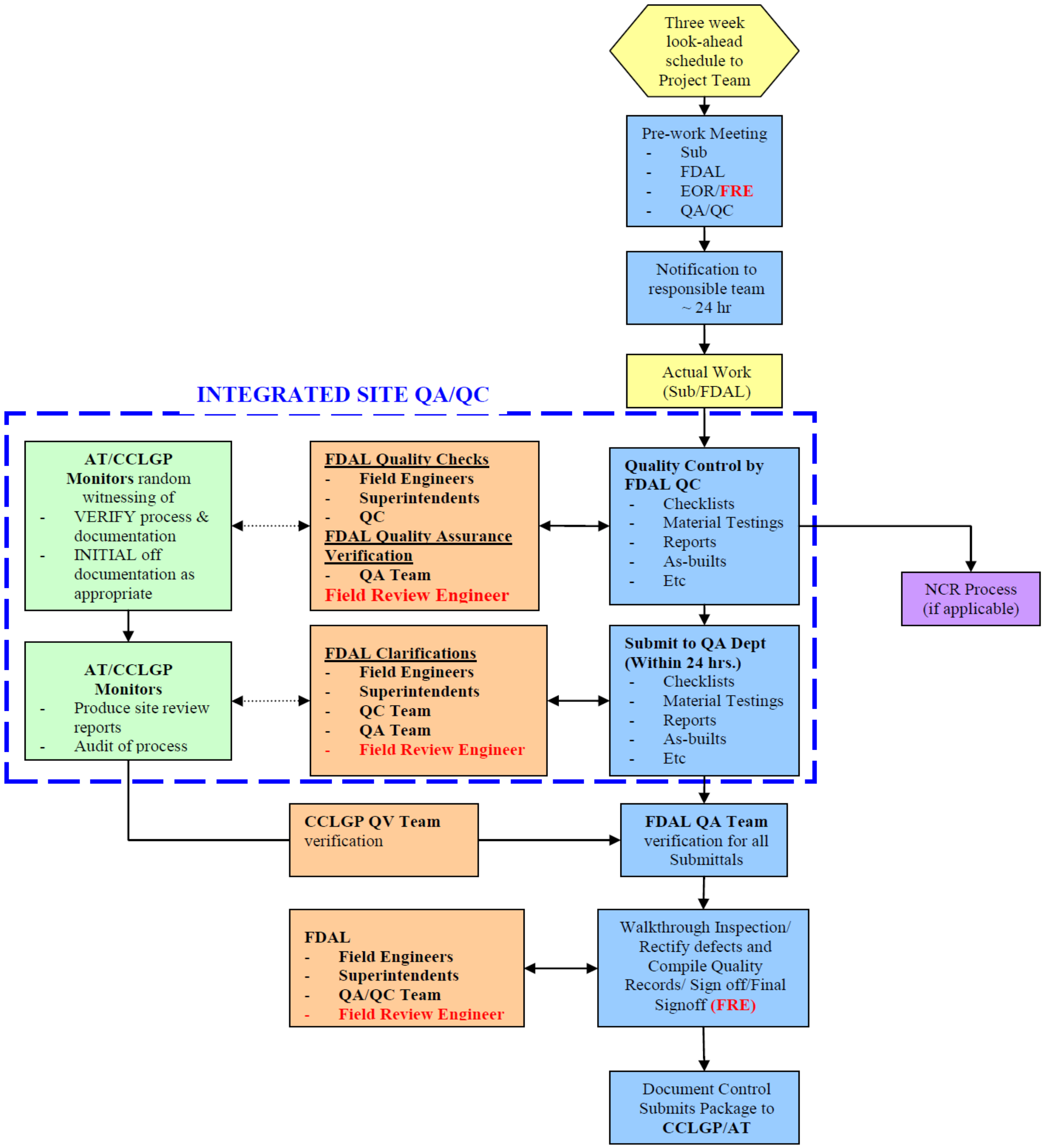

Figure 5: Work Flow with Integrated QMS in NEAHD Project

5 PROJECT-WIDE RISKS AND IMPACT OF INTEGRATED QMS

Under the NEAHD project contractual terms, CCLGP was liable to severe penalties if the roadway is not open to general traffic on Oct 1, 2016 and 'Construction Completion Certificate' (CCC) was not obtained within one year from the opening of roadway. The following requirements were to be met before the roadway could be open for general traffic:

- Completion of all construction, and no unfinished construction work that may interfere with road use
- Safety Certificate issued by Road Safety Auditor indicating the new construction is safe for public use
- Review of O&M quality management plan and Whole Life Management Plan by AT

For the issuance of CCC, all the documentation pertaining to project design and construction must be approved by AT. Some examples of documentation are:

- Design certificates for all structural, roadway, and drainage elements
- As-built drawings
- Documentation pertaining to quality control and assurance
- Close-out documentation for non-conformance reports (NCR)
- Construction Certificate[1] for each construction element by Field Review Engineer, who acts as a representative of Engineer of Record (EoR)

A common requirement for achieving the traffic availability to general public and obtaining the CCC is the resolution of NCRs. Once an NCR has been identified and issued by any of the QC and QA personnel, a proposal for remedial action to address the non-conformity must be prepared by the design-build contractor (FDAL). This proposal has to be approved by EoR, CCLGP and AT before the deficiency identified in NCR is addressed through repair, rebuild, or use as-is. Timely approval of the proposed remedial action is a critical element leading to a significant impact on project construction schedule. Without the approval of the proposed remedial action, construction of a project component may not proceed beyond a quality check point.

In the absence of an integrated QMS, the total duration required for only the review of a proposed remedial action is up to 24 business days. Given the short duration of roadway construction season in Edmonton, acceleration of time required for the approval of remedial action became a critical issue within the project. With the integrated QMS, quality personnel representing AT and CCLGP are simultaneously notified when an NCR has been identified and prior to the preparation of a proposal for remedial action. This enabled ongoing discussions regarding the potential remedial actions among all the parties involved. Furthermore, weekly meetings were arranged as a part of integrated QMS between AT, CCLGP, VSH and FDAL to resolve any potential and existing NCR issues. These meetings enabled consensus-building and decision-making regarding the risks being accepted by all the parties involved, and accelerated the review of the NCR process. This reduced the number of business days required for the review and acceptance of proposed remedial action to an average of 14 business days. By the scheduled date for the opening of roadway, the status of NCRs is as shown in Table 3.

Table 3: Status of NCRs on 1 October 2016

NCR status	Total Number
Issued	1270
Retracted	24
Closed	1167
Open	79

[1] Construction Certificate is a document issued by a Field Review Engineer, with a Professional Engineer designation, certifying that the construction has been completed according to the design specifications provided in the drawings issued for construction (IFC drawings) by the Engineer of Record

Only 6% of all the NCRs issued have remained open. Of these, 45% had the remedial action completed and were awaiting the final sign-off. Duration of six months from October 1 2016 was available within the project schedule to address the open NCRs.

In addition to the acceleration of NCR review process, integrated QMS has accelerated the documentation, review, and approval of quality records. As presented in Section 4.2, quality personnel representing FDAL, CCLGP and AT were in regular communication with the field construction personnel. This enabled generation of quality records and checklists, and subsequent review by the Field Review Engineer under an accelerated schedule. Furthermore, quality documentation and construction certificate issued by the Field Review Engineer has been submitted to CCLGP and AT for approval as the construction progressed through the records management process described in Section 4.3. Therefore, approximately 80% of the documentation required for CCC was submitted before the scheduled roadway opening to general public.

6 SELECTED EXAMPLES OF RISK REDUCTION

Among 47 bridge structures in the project, the connector bridge between the South bound Anthony Henday Drive to East bound Yellowhead Highway was the longest bridge with horizontally and vertically curved spans. It is a steel girder bridge connecting the two heavily used highways around the city of Edmonton. Figure 6 shows the completed bridge structure at the interchange between the two highways and indicates the importance of this structural element within the highway interchange. A total of 55 NCRs were generated during its construction, and the average duration of review and acceptance of the proposed remedial actions was 28 days. 71% of the documentation of this structural element that is required for CCC was submitted before the scheduled roadway opening to general public. This is the maximum possible percentage of documentation that could have been submitted before the scheduled roadway opening and six months ahead of the required due date.

Figure 6: Completed Connector Bridge Structure Between the South Bound Anthony Henday and East Bound Yellowhead Highway

The next longest bridges in the project were the two steel girder bridges across the North Saskatchewan River. Figure 7 shows the river bridges under construction. In addition to the steel girder bridges carrying vehicle traffic, the upstream bridge had an underslung bridge for pedestrian crossing as shown in Figure 7. A total of 45 NCRs were generated for the downstream bridge while 75 NCRs were generated for the upstream bridge. The average duration for review and acceptance of proposed remedial actions for all the NCRs was 29 days. 86% of the documentation pertaining to these bridges that is required for CCC was submitted and accepted before the scheduled roadway opening to general public. Following the contractual terms, the remaining documentation was scheduled to be submitted within six months from the roadway opening.

Figure 7: Steel Girder Bridges Crossing North Saskatchewan River during Construction (above) and the Under-slung Pedestrian Bridge (below)

7 DISCUSSION

7.1 Project Accomplishments

Integrated QMS has been introduced for the first time through NEAHD project within Alberta. AT has considered that the integrated QMS was an important component in achieving the schedule for roadway opening. The construction of NEAHD has been on budget and schedule in comparison to the previous highway P3 projects undertaken by AT, e.g., P3 projects related to Calgary ring road (Alberta Transportation, 2013).

In contrast to the previous highway P3 projects, VSH has been included in the integrated quality meetings and NCR resolution process through CCLGP. This has allowed for consideration of operations and maintenance aspects during the construction phase.

Furthermore, due to the record management process established as a part of integrated QMS, document submission for CCC was completed up to 80%, as mentioned earlier. This has also accelerated the documentation review and acceptance of over 65% of submittals by AT before the scheduled roadway opening. This is a significant accomplishment in comparison to the previous highway P3 projects within Alberta, which did not begin the document submission process until after the roadway opening.

7.2 Future Recommendations

The experience gained through application of integrated QMS process to a large highway P3 project has resulted in the following recommendations for its application in future projects:

- Inclusion of O&M subcontractor in the integrated QMS and a part of NCR approval process would improve the understanding of risk considerations associated with the non-conformities.
- Submission of project documentation must be included as a project task within the overall project schedule. Not including a formal schedule for project documentation submittals and approval could lead to inefficient management of the submittal process and the risk of delay in obtaining CCC. In particular, construction personnel turnover at the end of construction phase could delay the tracking and submission of project documentation.
- Improved awareness of integrated QMS during the procurement of suppliers and sub-contractors by the design-build subcontractor would enable an efficient work-flow for documentation submittals.

8 SUMMARY AND CONCLUSION

Integrated QMS is a novel concept employed in P3 model for transportation infrastructure project delivery during NEAHD project in Edmonton. Coordination and collaboration between the government agency, primary contractor and design-build subcontractor has reduced the risk of project schedule delays and substantial penalties for the primary contractor and subcontractors. This was also advantageous for the government agency due to the positive public response to the opening of the highway for general traffic. This approach was summarized in this paper to provide guidance for the implementation of this approach in large new infrastructure projects with P3 model project delivery.

Acknowledgements

Authors would like to thank Allan Neill, CEO of Capital City Link General Partnership for the support and encouragement provided in the preparation of this manuscript. Authors are also grateful for the permissions granted for the information used herein by Alberta Transportation, and Flatiron-Dragados-Aecon-Lafarge Joint Venture.

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