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## **RISK TRANSFER IN P3 INFRASTRUCTURE PROJECTS DUE TO CONSTRUCTION DEFICIENCIES**

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**Abstract:** The life-cycle performance of P3 infrastructure projects is measured in terms of reduced repair and maintenance costs, as well as short duration of down-time due to the maintenance activities. The financial success of P3 infrastructure projects depends on the project performance over its entire service life. In contrast to the traditional design-build project delivery method, the role of the concessionaire of a P3 project is to ensure successful design and construction within schedule and budget while meeting the contractual and regulatory requirements, as well as to ensure that there are no hidden risks transferred between design, build and maintenance contractors. This paper summarizes an innovative approach to construction quality management through an Integrated Quality Management (IQM) program that would involve design-build contractors, operations-maintenance contractors, owners and concessionaires to review and assess the impact of construction deficiencies on the infrastructure service life and to identify the sources of risk transfer during the design-build stage. Examples of risk transfer identified with the implementation of IQM program are presented.

### **1 INTRODUCTION**

Public-Private-Partnership (P3) infrastructure projects are bid to be design-build-maintain-finance by the concessionaires. The financial success of P3 infrastructure projects depends on the project performance over its entire service life. In the traditional design-build project delivery method, the role of the contractor is limited to ensuring successful design and construction within schedule and budget while meeting the contractual and regulatory requirements. In such cases, the focus is to optimize the design and construction elements, while the risk of maintenance costs is borne by the infrastructure owner. When a non-conformity arises, typical design-build approach is to consider the design intent and contractual approval by the infrastructure owner for addressing such non-conformity. In this case, any risk of service life performance is transferred to the infrastructure owner once the project is completed.

In the case of P3 projects, the role of concessionaire is not only to finance the design-build but also to maintain. Therefore, a successful project should seek to balance schedule and costs between the design, construction, operations and maintenance stages in order to provide the lowest overall life-cycle cost for the infrastructure to the owner. Any deficiencies at the design-build stage of the project could have negative implications throughout the project service life and affect the overall financial performance and ultimate success of the project. Therefore, it is important to not only consider the design intent for safety and minimization of construction costs, but also consider the implications of any actions on the overall durability. In some cases, infrastructure elements that have to be repaired or replaced during the construction stage

must be under a greater scrutiny to prevent the risk transfer from the construction stage to the greater operational costs during the operations and maintenance stage.

It may appear inefficient from the design-build point of view to repair or replace an element instead of accepting it as-is, but from the P3 life-cycle point of view, a better course of action may be to accept the cost and schedule delays during construction to prevent taking on greater financial risks during the service life. In such scenario, the construction quality management program is a key element to balance between the construction costs, maintenance costs and schedule delays. This paper summarizes an innovative approach to construction quality management through an Integrated Quality Management (IQM) program that would involve design-build contractors, operations-maintenance contractors, owners and concessionaires to review and assess the impact of construction deficiencies on the service life and to identify the sources of risk transfer during the design-build stage. Examples of hidden risk transfer modes identified through IQM are presented in this paper.

## **2 INTEGRATED QUALITY MANAGEMENT (IQM)**

### **2.1 Description**

A Quality Management System (QMS) developed according to ISO9001:2015 (ISO9001, 2015), defines a framework for management of project quality. In an integrated implementation of QMS with IQM, all the major stakeholders in the project (such as design-build contractor, concessionaire, and project owner) agree to establish common quality objectives and quality system procedures. This enables transparency and coordination among all the parties involved, and quality requirements can be met with greater efficiency. The implementation and success of IQM is heavily dependent on the willingness to coordinate among all the parties involved, including the project owner who sets out the project performance requirements. A full description of the IQM and a case study with its successful implementation are presented in Vemana and Koduru (2017). A brief description of the important elements in IQM is presented in the next two sections.

### **2.2 Implementation**

Successful implementation of the IQM is possible with the following three components, as discussed in Vemana and Koduru (2017), which are briefly summarized here:

**Quality objectives:** Performance measures to evaluate if quality objectives are met will be consistent between all the entities involved in the project due to common quality goals for the entire project. As the project progresses, the performance measures achieved at each phase will provide evidence for successful implementation of IQM, and allow for necessary corrections in the quality process at the earlier stages of the project. This provides additional oversight at key phases of the project, and reduces the possibility of hidden risk transfer.

**On-site communication:** The objective of on-site communication system is to increase awareness among all the entities involved regarding the construction progress, quality records generated and any non-conformities in the construction work. Any approach selected for schedule acceleration, documentation, and remediation of non-conformities, can be evaluated by multiple stakeholders. This will enable the selection of remedial measure that would agreeable all the stakeholders and balance the operations maintenance and construction costs.

**Records management:** Due to the large volume of documentation needed to evaluate performance measures and its accessibility to multiple entities, a consistent approach for records management is needed for all project phases. This requires clear articulation of the type of records to be maintained, record formats, approval authority for modification or release of records, and record review and approval process. As the review and approval process is progresses, records are accessible to all entities to evaluate possibility of risk transfer due to any non-conformity.

### 3 RISK TRANSFER MODES

Risk transfer occurs when the actions of one entity in the P3 agreement increases the costs for another entity. This could possibly occur between design and construction contractors due to non-conformity of the designs supplied for construction, and between construction and maintenance contractors where construction deficiencies may cause increased operations and /or maintenance costs. Three hidden risk transfer modes were identified between construction and operations-maintenance in P3 projects where IQM was implemented successfully. The modes of hidden risk transfer are as follows:

Increased frequency of repairs: Improper repair methods used to address construction deficiencies could lead to failure of such repairs leading to additional repairs to be conducted for the infrastructure maintenance.

Increased scope of scheduled maintenance works: Construction deficiencies that are not identified at the end of key construction phases, could impact service life performance and increase the scope and cost of maintenance actions to address the delayed outcome of the deficiencies.

Restoration: Construction deficiencies, as well as unawareness of durability impact of design basis, repairs of construction deficiencies and other non-conformities could lead to major costs due to possible replacement of project components before the end of the operations and maintenance term.

Examples of these three types of risk transfer are provided in the next section.

### 4 CASE STUDIES

#### 4.1 Risk of increased frequency of repairs

Surface imperfections in concrete, such as spalls have minor impact on the design requirements and are non-conformities due to contractual obligations and performance requirements. However, inappropriate repair methods that lack proper bonding between repair material and the concrete surface would increase the frequency of repairs, albeit minor in their scope. Figure 1 shows an example of repair performed to address a concrete spall. As the repair was performed without proper preparation of the concrete surface to increase the bonding between the repair material (grout) and native concrete, the repair resulted in a spall again. Figure 2 shows the spall at the location of the repair, where the lack of bonding between the native concrete surface and repair grout can be clearly seen at the located pointed out.



Figure 1: Improper Repair of Concrete Spall



Figure 2: Spall at the Repair Location due to Incorrect Repair Method and Lack of Bonding as Pointed

In addition to the failure of repair at the initial spall, concrete spall has extended during the repair spall, as seen in Figure 3. Incorrect matching between the repair grout and native concrete could increase the local stresses on the concrete surface leading to the extension of the initial concrete spall.



Figure 3: Spall Extension due to Incorrect Repair

#### 4.2 Risk of increased scope in scheduled maintenance events

Figure 4 shows the differential settlement on a roadway that lead to extensive cracking of the pavement. Since asphalt pavement is known to develop cracks that lead to potholes in cold weather regions, it is common to include the re-surfacing of the pavement in the scheduled maintenance works. Figure 5 shows the failure of newly resurfaced pavement, which indicates that the pavement settlement is due to the deficiencies in the sub-grade compaction or materials. At this stage, as the extent of sub-grade deficiencies are unknown, the scope and cost of schedule maintenance work increases significantly from resurfacing with asphalt to removing and replacing the pavement sub-grade.



Figure 4: Surface Cracking and Differential Settlement on a Roadway



Figure 5: Failure of a Newly Resurfaced Pavement

Figure 6 shows the extent of repair needed to maintain the road surface performance according to the project requirements. Such unanticipated increase in the scope and cost of the maintenance work results in a hidden risk transfer between construction and maintenance phases.



Figure 6: Extent of Repair Works Due to Deficiencies in Subgrade Compaction

#### 4.3 Risk of component replacement

Figure 7 shows an example of a newly placed bridge bearing with the elastomeric padding designed to meet the project requirements.



Figure 7: Elastomeric Bearing Pad in a Bridge Bearing

Figure 8 shows an example of elastomeric bearing pad failure through bulging and cracking before the end of its design service life. Inadequate material testing and quality control, and improper placement procedures could lead to the bearing pad failures before the anticipated design service life. However, in

order to meet the performance standards during the handback of infrastructure from the P3 concessionaire to owner, these bearing pads will need to be replaced. The unanticipated bearing pad failures could lead to extensive replacement costs well after the completion of construction, resulting in a hidden risk transfer between the design-build and operations -maintenance works.



Figure 8: Failure of Elastomeric Bearing Pad with Bulging and Cracking before the End of Service Life

## 5 CONCLUSION

In P3 projects, a successful project should seek to balance schedule and costs between the design, construction, operation and maintenance stages in order to provide the lowest overall life-cycle cost for the infrastructure to the owner. Any deficiencies at the design-build stage of the project could affect the overall financial performance of the P3 concessionaire and ultimate success of the project. In this paper an innovative approach to construction quality management, termed 'integrated quality management' (IQM) has been summarized. In this approach, all the major stakeholders in the project (such as design-build contractor, concessionaire, operations and maintenance contractor and project owner) agree to establish common quality objectives and quality system procedures. This enables transparency and coordination among all the parties involved, and quality requirements can be met with greater efficiency. During the application of IQM program in multiple transportation infrastructure P3 projects, hidden risks were identified through engagement of all the stakeholders, which could be transferred between multiple stakeholders. Three types of risk transfer are discussed in this paper; risks due to increased frequency of repairs, risks due to increased scope of scheduled maintenance works, and risks due to project component replacement. An example of each type of risk is presented through selected real world examples in transportation infrastructure projects.

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