

Risk Response for Asphalt Road Construction under Performance Based Contracts

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Risk Management has been one of the most developed and researched areas due to its inherent importance as a factor of any construction project success. A significant output of the risk management process is the risk response which determines the success and the effectiveness of the risk management process. This work is a part of a larger research study for risk management under performance based contracts (PBC) for hot mix asphalt (HMA) contractors. However, this manuscript will focus on the use and choice of the risk response strategies by HMA contractors under PBCs. An interview and survey of five contractors and a county department head which represents about 60% of the volume of HMA work in Colorado, USA were performed. Results point towards the tendency of the industry to accept most of the financial and force majeure risks while trying to control and mitigate most of the technical risks where they can have more influence on the risk exposure.

Key words: Risk Management, Risk Response, Performance Based Contracts, Hot Mix Asphalt Road Construction.

Introduction

Risk management has become one of the most important factors for a project's success in the construction industry. This paper discusses the risk management process in general for the hot mix asphalt (HMA) road construction industry under performance based contracts (PBC). HMA road construction contractors often take on projects with high complex, variable and risky nature in terms of dollar value, weather conditions, public competition and other issue like traffic control. PBC are considered a fairly new project delivery system that obligates the contractor to a longer term commitment than in other traditional delivery systems that are widely used for HMA road construction (Gruneberg, Hughes & Ancell, 2007). These long-term commitments can extend beyond construction to the maintenance phase, sometimes committing the contractor to a warranty period to enforce the performance goals for the required maintenance period that is considered as the warranty period in the contract (FHWA, 2009). These long-term commitments, performance goals, and warranty period make the contractor even more vulnerable to risks associated with this extended contracting period.

This paper is part of a larger research study for risk management for HMA road construction and maintenance under PBCs that includes the risk management process for contractors. The full research project studied the risk management process including the risk identification, assessment, and analysis phases. This paper, however, will only focus on the industry risk response strategies towards the different risks associated with the HMA construction phase under PBCs. This was determined through several interviews including a shortlisted questionnaire for the associated risks where the interviewees were asked to choose between several risk response strategies for each risk.

Literature Review

Risk is an inherent part of any construction project and the road construction industry has been plagued with risks due to project size and cost. In recent years, there has been increased interest in developing the risk management process and adopting new and effective risk management tools and techniques for the construction industry.

The authors conducted a literature review of the risk management processes and risk response strategies to explore the different methods and strategies used in the construction industry in general and specifically in the HMA construction phase.

Risk Management Process

Much research exists on the risk management process. One of the most comprehensive studies is by Williams (1995) that included 241 references about risk management and uncertainty where the oldest dated back to 1959. However, several authors have proposed different components and phases for the risk management process. The PMBOK third edition (2004) defines the risk management process in five main phases: (1) risk management planning, (2) risk identification, (3) qualitative/quantitative risk analysis, (4) risk response planning, and (5) risk monitoring and control. Others have a more detailed approach to the risk management process such as Chapman (1997) and then Chapman and Ward (2003) who break the risk management process into a nine-phase approach: (1) define, (2) focus, (3) plan, (4) structure, (5) ownership, (6) estimate, (7) evaluate, (8) plan, and (9) manage. Some have simplified the risk management process into only 3 phases: (1) risk identification, (2) risk ana
lysis, and (3) risk response (Buchan, 1994). Regardless of the different phases or the organization of the risk management process, "identification and assessment will be worthless unless responses can be developed and implemented which really make a difference in addressing identified risks" (Hillson, 1999).

Risk Response Strategies

Risk response can be considered one of the main risk management process outputs along with risk planning. This is what defines a successful risk management process implementation since it provides contractors with the backup plans, contingencies, and corrective actions to be taken in case of the risk occurrence or a preventive action to prevent the materialization of the risk in the first place. This depends on the adopted risk response strategy, whether to reduce the exposure of the risk or prevent it. It is worth noting that the risk response strategy is the larger aspect of the risk response stage, which leads to risk response techniques to be developed according to the project's complexity and conditions. Several authors have identified different risk response strategies. The PMBOK third edition (2004) listed the following strategies: (1) avoid (extending schedule, reducing scope, shutting down the project), (2) transfer (financial risk exposure, insurance, warranties, guarantees), (3) mitigate (taking early actions, adopting less complex processes, conduction of more tests, choosing more stable suppliers, prototyping, redundancy), or (4) accept (passive acceptance: no action except to document the strategy and leave it to the project team to deal with it; active acceptance: establishing contingency reserve for money, time, and resources). Hillson (1999) had a different simplified approach, also listing four different strategies without differentiating between active and passive acceptance: (1) avoid (seeking to eliminate uncertainty), (2) transfer (seeking to transfer ownership and/or liability to a third party), (3) mitigate (seeking to reduce the size of the risk exposure to below an acceptable threshold), or (4) accept (recognizing residual risks and devising responses to control and monitor them). No matter which response strategy is adopted, the aim is to adopt a proactive and effective manner to respond to the risk occurrence.

Risk Response under Performance Based Contracts

Risk response strategies can be very different from one delivery system to another depending on the risk exposure and the uncertainty associated with the project. The more uncertainty associated with the project, the more detailed and confrontational the response must be (Mills, 2001). Under PBCs, there are different factors that assert this fact and make the contractor change strategy based on the delivery system characteristics which are not limited to (Gruneberg et al., 2007):

- Longer commitment and liability period towards the project
- More risks allocated towards the contractor
- Longer time exposure to several risks including the maintenance period
- Fitness for purpose, and associated insurance risks
- Long-term cost increase and inflation through the performance period
- Resource availability issues

Method

The methodology for this research involved several activities that align with the risk management process including risk identification, risk assessment, risk analysis, and finally, the risk response which is the main focus for this paper

(Figure 1). A literature review was conducted along with using a risk breakdown structure (RBS) to identify the different risks associated with the construction phase.

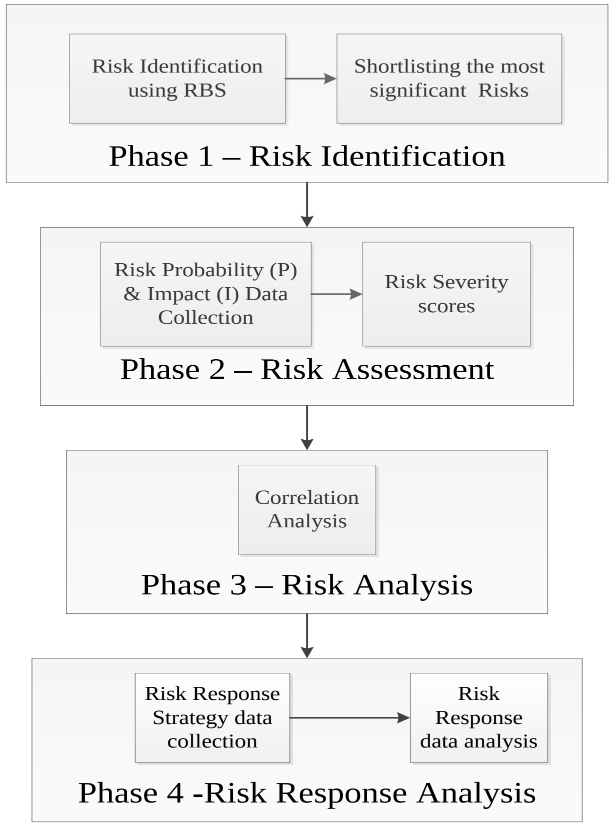

Figure 1: Methodology for full research study, while this paper focuses on Phase 4

Following the completion of the RBS, open-ended interviews were conducted with different expert professionals who combined have more than 60 years of HMA road construction and maintenance experience. Those professionals participants held several different positions including but not limited to; road and bridge department director, bidding and estimating department head, senior VP, risk manager and project manager. Participants were asked to share their expertise to shortlist the risks that were identified for construction and maintenance. The risks identified for the construction phase were shortlisted to the most significant ones as shown in Table 1.

The next phase was the risk assessment where the probability (P) and impact (I) values for each risk were collected to assess the severity (S) of each risk along with the risk response strategy chosen which will be explained in detail later in this paper. The P and I data were collected from 5 different contractors and the Larimer County roads department through different interviews where they were asked to provide the P and I values for each risk and their response strategy for that risk. The sample size of those 6 interviewees represents about 60% of the monetary volume of Colorado HMA road construction and maintenance. Following the assessment phase, a correlation analysis was conducted to study the association between the different risks throughout the construction and maintenance phases.

Table 1
Shortlist of the most significant risks associated with the construction phase

Level/Process	Construction Risks	Risk Definition/explanation
Throughout the Construction phase	Risk of Investment in Innovations	The risk of investment in research developments to achieve the performance goals.
	Price Fluctuation	Price increase during the performance or warranty periods.
	Bonding Capacity	Fewer chances for bidding on other projects due to the bond portions still held for the maintenance warranty period under PBC.
	Delayed Owner Payments	Delayed owner payments affecting contractor's financial ability.
	Weather Changes	Negative weather effects on quality or schedule.
HMA Mixing Facility	Emergency Repairs	HMA Emergency repairs production interruption.
	Changing Mixes	Changing from one mix to another in a drum mix facility may result in the production of undesired mix proportions.
	Voids Control	Inefficient void measures can result in the loss of the mixture density
	Long-Term Storage	Long term storage causing drainage & oxidation of the asphalt cement.
Transportation	Segregation at Dumping	Multiple dumps causing segregation on site during the paver feeding operation.
Paving	MTV – Availability	Use of MTV in transportation operations to provide improved surface smoothness and more paver mobility.
	Stoppage Time	Paver stoppage which may cause surface undulations resulting in bad leveling.
	Paving Speed	Change in paving speed affects the smoothness of pavement and screed undulations.
	Screed Adjustments	Keeping the screed elevation of the tow point constant in response to any change in the paved profile surface.
Compaction	% of crushed Aggregate Mass	Percentage of crushed particles in aggregate mass which are directly proportional to the angle of internal friction resulting in compaction difficulty.
	Compaction Speed	Speed increase adversely affecting the density.
	Distance to Paver	Distance of the compactor to paver affecting the cooling rate of HMA and length of time the material is hot enough to be compacted.
Handing over	"Go no Go" Approach	Stopping during the paving process due to rejection by inspection for not meeting the required performance specifications for the project, causing delay of the whole construction phase due to a controllable section of the road being rejected.

The risk response analysis and investigation will be the main purpose of this paper which involved 2 main stages: risk response strategy data collection and risk response data analysis.

Risk Response Strategy Data Collection

The risk response strategies were collected from the 6 interviewees after defining and explaining the different possible strategies:

1) Risk Avoidance: This strategy can be achieved by trying to eliminate the risks or the uncertainty. This can be done by adopting a different approach in the project (e.g. not bidding on the high-risk portion of the project) or what many researchers refer to as a complete risk transfer to a third party.

2) Risk Mitigation: This strategy aims towards reducing the overall risk exposure but not totally eliminating or transferring the risk. This is done by reducing the risk severity by reducing one or both of its components represented in the probability or the impact of the risk.
3) Risk Acceptance: This strategy recognizes the risks and monitors them through the project and builds in some (underestimated) contingency to account for it if happens for a minimum loss encounter.
4) Accept-Mitigate: A combination of (2) and (3) depending on the project circumstances and contractual conditions.
5) Accept-Avoid: A combination of (1) and (3) depending on the project circumstances and contractual conditions.
6) Avoid-Mitigate: A combination of (1) and (2) depending on the project circumstances and contractual conditions.

The above mentioned strategies were explained to the respondents in a manner where the avoidance strategy is considered the best and the most aggressive approach to eliminate the risk completely. The mitigation strategy is the next choice which is usually selected to reduce exposure and the last resort is to accept the risk unless it can be addressed by any other strategy. Finally, the combinations of the risk response strategies are there to give the experts the choice if they see that the risk is very circumstantial or situational to the project nature.

Risk Response Data Analysis

The risk response strategies data for the construction risks identified in Table 1 were collected in table format where the respondents were asked to fill their choice of risk response strategy according to those six strategies proposed and explained above. Every respondent chose one of the strategies for each risk. After the collection, the risk response strategies were tabulated and graphed into a column frequency diagram for analysis.

Results

The results for the risk response data for the construction risks from each respondent are shown in Table 2.

Table 2
Risk response strategy raw data

Risk Name	**Risk Response Strategy**					
	Contractor 1	Contractor 2	Contractor 3	Contractor 4	Contractor 5	Larimer County
Risk of Investment in Innovations	Acceptance	Acceptance	Acceptance	Acceptance	Acceptance	Acceptance
Price Fluctuation	Acceptance	Mitigation	Acceptance	Acceptance	Accept-Mitigate	Accept-Mitigate
Bonding Capacity	Acceptance	Avoid-Mitigate	Acceptance	Acceptance	Acceptance	Accept-Mitigate
Delayed Owner Payments	Acceptance	Accept-Mitigate	Acceptance	Acceptance	N.A	Accept-Avoid
Weather Changes	Acceptance	Avoid-Mitigate	Acceptance	Acceptance	Acceptance	Acceptance
Emergency Repairs	Acceptance	Mitigation	Avoid-Mitigate	Acceptance	Acceptance	Avoidance
Changing Mixes	Acceptance	Mitigation	Avoidance	Avoid-Mitigate	Avoid-Mitigate	Accept-Avoid
Voids Control	Mitigation	Avoid-Mitigate	Avoid-Mitigate	Avoid-Mitigate	Avoid-Mitigate	Avoidance

Long-Term Storage	N.A	N.A	Avoidance	N.A	N.A	Avoid-Mitigate
Segregation at Dumping	Mitigation	Mitigation	Mitigation	Accept-Mitigate	Mitigation	Mitigation
MTV – Availability	N.A	Avoidance	N.A	N.A	N.A	Avoidance
Stoppage Time	Mitigation	Mitigation	Mitigation	Mitigation	Mitigation	Mitigation
Paving Speed	Mitigation	Accept-Mitigate	Mitigation	Mitigation	Accept-Mitigate	Mitigation
Screed Adjustments	Accept-Mitigate	Accept-Mitigate	Mitigation	Mitigation	Accept-Mitigate	Mitigation
% of crushed Aggregate Mass	Accept-Mitigate	Mitigation	Avoid-Mitigate	Avoid-Mitigate	Avoid-Mitigate	Avoidance
Compaction Speed	Avoid-Mitigate	Mitigation	Avoid-Mitigate	Avoid-Mitigate	Avoid-Mitigate	Mitigation
Distance to Paver	Avoid-Mitigate	Avoidance	N.A	Mitigation	Avoid-Mitigate	Mitigation
"Go no Go" Approach	N.A	N.A	N.A	N.A	N.A	Avoidance

Based on the collected data, interviews, and survey responses, the following results were summarized in Table 3. Risks most commonly accepted by contractors include: risk of investment innovations, weather changes, and bonding capacity. Risks that contractors attempt to mitigate include: stoppage time, segregation at dumping, and paving speed. Also, more than half the respondents chose the "Avoid-Mitigate" response for: voids control and compaction speed. Finally, most of the respondents had no risk response strategy for three risks: go-no-go approach, long-term storage, and MTV availability.

Table 3
Risk response strategies for the construction phase

Risk Name	Acceptance	Mitigation	Avoidance	Accept-Mitigate	Accept-Avoid	Avoid-Mitigate	No Response	Total Responses
Risk of Investment in Innovations	6	0	0	0	0	0	0	6
Price Fluctuation	3	1	0	2	0	0	0	6
Bonding Capacity	4	0	0	1	0	1	0	6
Delayed Owner Payments	3	0	0	1	1	0	1	5
Weather Changes	5	0	0	0	0	1	0	6
Emergency Repairs	3	1	1	0	0	1	0	6
Changing Mixes	1	1	1	0	1	2	0	6

Voids Control	0	1	1	0	0	4	0	6
Long-Term Storage	0	0	1	0	0	1	4	2
Segregation at Dumping	0	5	0	1	0	0	0	6
MTV – Availability	0	0	2	0	0	0	4	2
Stoppage Time	0	6	0	0	0	0	0	6
Paving Speed	0	4	0	2	0	0	0	6
Screed Adjustments	0	3	0	3	0	0	0	6
% of crushed Aggregate Mass	0	1	1	1	0	3	0	6
Compaction Speed	0	2	0	0	0	4	0	6
Distance to Paver	0	2	1	0	0	2	1	5
"Go no Go" Approach	0	0	1	0	0	0	5	1

The results were further examined and analyzed in Table 4 where it shows the number of times each response strategy was selected along with the percentage of the selection.

Table 4
Risk response strategy frequency for all risks

Risk Name	Acceptance	Mitigation	Avoidance	Accept-Mitigate	Accept-Avoid	Avoid-Mitigate	No Response
Total No. of Response Selection	25	27	9	11	2	19	15
% of Response Selection	23%	25%	8%	10%	2%	18%	14%

Finally, a frequency column diagram was created to graphically represent the frequency of the usage of each risk response strategy as shown in Figure 2.

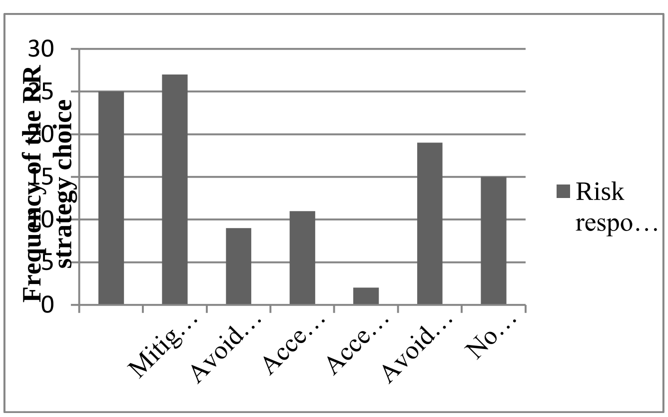

Figure 2: Frequency diagram for risk response (RR) strategies

Discussion

According to Tables 3 and 4 along with Figure 2, it is clear that contractors favor the acceptance and mitigation strategies in dealing with most of the risks associated with the construction phase. The acceptance and mitigation strategies singled and combined account for about 60% of the total strategies. When taking into account that 14% of the results were “no response,” this percentage increases to 68%. A closer look at those two strategies will find that for most of the risks originating from financial or force majeure, contractors were adopting the acceptance strategy as in the case of risk of investment in innovation, bonding capacity, and weather changes. Strategy for technical risks leans towards a more mitigating strategy. This can be attributed to the competitive nature of the construction industry along with the recent financial crisis that has pushed contractors to accept more financial risks and try to reduce the severity of most of the technical risks that they can influence by adopting mitigation strategies.

Another finding is that the Acceptance-Avoidance strategy did not have much frequency of use since these are two strategies that are fairly divergent from each other no matter what the project circumstances and conditions are. An interesting finding is that the voids control risk was always avoided or mitigated by all the respondents. This is due to the fact that the voids control risk is a very dependent risk that can be associated with many other risks which can be backed by the findings by the research conducted by Hashem and Guggemos where the voids control was significantly correlated with risks like percentage of crushed aggregate, stoppage time, paving speed, screed adjustment and insufficient compaction. This research can help HMA contractors by emphasizing their risk strategies tendencies, which can be a step forward towards providing a more sophisticated and advanced risk response strategies that confront the industry risk in a more aggressive manner. It can also contribute to future development on how to deal with those newly identified risks that materialize only under PBC delivery system. Finally, this research can be a solid step towards a holistic approach that revolutionizes the risk management process under PBC.

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