

ROLE OF HIGH-LEVEL PROJECT PROFESSIONALS' PERCEPTIONS ON QUALITY PROCESSES IN DIRECTING THE INVESTIGATION OF CAUSES OF PREMATURE PAVEMENT DISTRESSES: AN EXPLORATORY STUDY

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ABSTRACT

Following the observation of physical form of distress that leads to premature failure, investigations are usually initiated in order to identify causes or factors of the observed early pavement distress, which is often due to a combination of errors that may have occurred during the project design and/or execution. This paper discusses an exploratory study to examine the extent to which stakeholder perception on the practices adopted during the execution of the project can direct the investigation in identifying and evaluating the root causes of the observed pavement premature distresses. A semi-structured questionnaire based survey was conducted to gauge the perception of high-level stakeholders on two projects where premature pavement distresses was being investigated. While respondents on one project had a positive attitude towards the survey, the attitude of the respondents on the second project was negative. The outcome revealed that this approach, is a potential tool in directing technical assessments with regards to an investigation of causes of observed premature pavement distresses. The execution of such analysis on more projects where premature pavement failure are being investigated is required.

1. INTRODUCTION

Pavements exhibiting excessive forms of distress, such as cracking, loss of surfacing, rutting and even potholing, soon after construction are not rare occurrences. These distresses may induce a state of premature pavement failure, that is, the pavement deteriorates to a point where it no longer satisfies the criteria under which it was designed (Victorine et al, 1997). In other words, the term premature failure indicates nonconformity with design expectations (Rada et al, 2013). Good practice calls for failure analysis or a forensic investigation following such events in order to determine the causes or factors that have led to the observed premature distress. However, the extent of the investigation depends on the requirements of the client as provided in the scope of work, which ideally should be

targeted towards finding the cause of the observed premature form of distress or premature failure and whether it is required to apportion blame for the condition.

The fundamental principles of forensic investigation are that it should be objective, scientifically conducted, and systematically recorded. If not carefully planned and conducted, omissions may occur which can affect the subsequent analysis of results and findings on root causes of the observed distress or pavement failure. To this end, guidelines have emerged in recent years on how to conduct forensic investigations of construction project failures in general (Yates et al, 2002) and pavements in particular (Victorine et al 2013, Rada et al, 2013). The structure of the guides for conducting forensic investigation of highway pavement is procedural in nature, providing the steps for an effective investigation in a directed manner. Three main phases of effective investigation can be identified namely, the data collection phase, which deals with problem definition and data collection, the analysis phase, determining the contributing factors to the problem being investigated and finally providing the solution and recommendations.

Observed physical failures in construction are usually a result of a combination of failures that include errors arising from human factors such as design errors, inadequate quality control testing and procedures, poor communication between designer and contractor and inadequate construction supervision (Atkinson, 1998, Love et al, 2009, Love and Li, 2010). In general terms, errors can occur due to unawareness, inexperience, mistakes such as noncompliance and slips and lapses of attention (Love and Li, 2010). Previous studies on human error aspect has revealed that errors and omissions may be made at any time, irrespective of the skill level, experience, or training that individuals may have (Love et al, 2009). The consequences of errors only manifest themselves long after they have occurred and have been likened to pathogens, that is, they tend to reside in a system until they do become actual failures (Busby and Hughes, 2004).

The above mentioned studies reveal that there is dependency between practices adopted during design and construction and construction failure and in premature failure. It is the experience during site investigations that the assessment of the perception of high-level stakeholders, became a subject of interest. On the basis of the above mentioned studies, the assessment of the perception of high-level stakeholders with regards to certain aspects of the process quality of road construction projects was considered a potential tool for linking the process quality during execution of the project and the causes of observed premature pavement distresses. The explicit coverage of this aspect in the technical guidelines on conducting forensic investigation would add value to the process. This paper serves to show a first attempt towards achieving this goal. It is important to emphasise that this paper is limited to sharing the experience learned during this first attempt in implementing the approach. Two projects, from a SADC member country were deemed appropriate as test cases.

2. CASE STUDY CONTEXT

The premature pavement distresses this paper deals with in the case studies, are unwanted cracks (Project A) and extensive rutting (Project B), that appeared soon after construction. Sections of the road on Project A showed signs of early distress in the form of longitudinal cracking of the surfacing within a year after construction. Preliminary remedial measures in the form of crack sealing were undertaken as shown in Figure 1. On Project B, minor rutting was observed soon after the owner had taken over the project. Within three months the rutting had become severe at a number of locations along the road as can be seen in Figure 2.

Independent assessments were necessary to determine the extent of the observed distresses. It was during these investigations that an attempt was made to assess the response to perception of the high-level professionals ranging from contractor, consultant to client body involved in the two projects. The respondents, a focus group, included professional project managers and engineers, who have vested interests in the quality of the road as the final product.



Figure 1: Typical longitudinal cracking on Project A



Figure 2: Extent of rutting on Project B

3. ASSESSING PERCEPTION OF HIGH-LEVEL PROFESSIONALS

The assessment was conducted by means of a 21-item questionnaire covering selected issues considered to be indicators of good practice in quality control processes. In addition, participants had to provide information on their age, gender, years of experience in the industry, years with the firm, years on projects of similar nature, whether they were client representatives, contractor representatives or consultant representatives. The participants were then required to indicate their rating to a particular item on a five point scale with the following options: (i) strongly agree, (ii) agree, (iii) not sure, (iv) disagree (v) strongly disagree. Table 1 shows the selected questionnaire items, applicable to the projects.

Table 1: Selected items on stakeholder perception

Item No	Description
1	The construction engineer communicated project specification to the contractor correctly?
2	In your opinion, was the skills-set of the construction engineers in line with the requirements of this project?
3	In your opinion, was the skills-set of the contractor in line with the requirements of this project?
4	Do you believe that the General Specifications of the project were understood by the contractor?
5	In your opinion, the project tender documents were understood by the contractor
6	Do you think that any scope of work for this project changed during the duration of the project?
7	In your opinion, scheduling (time) was managed properly in this project
8	In your opinion, any change in scheduling was communicated to Contractor
9	In your opinion, the contractor was competent to undertake this particular project
10	In your opinion, there was regular communication between construction supervision consultant and resident engineer
11	In your opinion, regular in-situ testing was carried out during the duration of the project
12	Unforeseen/unnatural events outside the project affected this project adversely?
13	Do you think that quality check for materials was NOT done routinely?
14	Laboratories that conducted quality checks in this project can be relied upon
15	Do you believe that laboratory reports can be influenced?

On Project A the questionnaire was handed over to the participants following a discussion on project background in which the issues on the questionnaire were also covered. On Project B, the questionnaire was emailed to the participants following the project meeting.

4. PERCEPTION OF HIGH-LEVEL PROFESSIONALS

Table 2 summarizes background characteristics of respondents on Project A. Respondents had to indicate their level of education and role on the project. The respondents comprised of 2 Contractor representatives, 4 Construction Supervision Consultant representatives and 2 representing the Client Body. The group was 100% male. All had obtained a tertiary level of education. The information in Table 2 only represents the group on Project A, as no one from Project B responded. Possible reasons for this will be discussed in section 5.

Table 2: Background characteristics of respondents on Project A

Respondent job history profile	Number responded	Total	Average	Minimum	Maximum
Age (in years)	8	376	47	29	60
Years employed with present company	8	90.4	11.3	1.5	25
Number of years working in similar projects like the current one	6	23	2.88	0	10

To avoid any misunderstanding, the assessment is not on stakeholder perception of project success. The assessment is on the perception of high-level stakeholders on specific items as listed in Table 1 above that may provide preliminary insights in directing an investigation on premature pavement distress. While the respondents indicated their role on the project, the assessment of perception does not group the stakeholders by their role on the project.

4.1. Overall rating of Project A

The respondents were asked to rate the project, compared to other projects of similar nature that they have previously worked on. 75% rated the project “Good”, 12.5% rated it “Average” and another 12.5% rated it “Excellent”.

4.2. Perception on communication

There were three items related to communication and Table 3 shows the results of the responses with respect to communication. In this paper we have used the term positive rating for the percentage sum of the responses to “Agree” and “Strongly Agree”.

The results indicate a positive rating of at least 75% with respect to communication on the project. The highest positive rating at 87.5% is on correct communication of project specification to the Contractor. The item on communication regularity shows conflicting responses.

Table 3: Perception on communication

Item	Response (%)				
	Strongly Agree	Agree	Not Sure (Missing)	Disagree	Strongly Disagree
Construction Supervision Consultant communicated project specification to the Contractor correctly	12.5	75	12.5	0	0
Change in scheduling was communicated to Contractor in time	25	50	12.5	12.5	0
There was regular communication between Construction Supervision Consultant and Contractor's engineer	25	50	(12.5)	0	12.5

4.3. Perception on skills-set of project implementation personnel

All respondents “Agreed” that the skills-set of the Contractor were in line with the requirement of the project, with a positive rating percent of 100 on whether the Contractor was competent to undertake the project. While all items have a strong positive indicator, i.e. a positive rating percent of greater than 75, the item on the skills-set of the Construction Supervision Consultant has a positive rating percent of 87.5, compared to 100 percent for the other two items.

Table 4: Perception on skills-set

Item	Response (%)				
	Strongly Agree	Agree	Not Sure (Missing)	Disagree	Strongly Disagree
The skills-set of the Construction Supervision Consultants were in line with the requirements of this project	25.0	62.5	12.5	0	0
The skills-set of the Contractor were in line with the requirements of this project	0	100	0	0	0
The contractor was competent to undertake this particular project	25	75	0	0	0

4.4. Perception on document understanding

A positive rating of less than 50 percent is a weak rating. The perception is that the General Specification and the tender documents were not entirely understood by the Contractor.

Table 5: Perception on document understanding

Item	Response (%)				
	Strongly Agree	Agree	Not Sure (Missing)	Disagree	Strongly Disagree
The General Specifications of the project were understood by the contractor	12.5	50	0	37.5	0
The project tender documents were understood by the contractor	0	50	0	25	25

4.5. Perception on quality of testing

The responses indicate a positive rating of greater than 75 percent for the first three items in terms of regular testing, quality control of materials and reliability of results. However, there is a mixed response to the issue on whether laboratory reports can be influenced. Although showing a weak positive rating of 25 percent, with 50% not sure, it does raise a concern that the perception exists that it is possible laboratory reports can be influenced. Laboratory reports provide the evidence for the quality of materials used on the project. One would have expected a high negative rating to this item, to reflect confidence in the results of material testing.

Table 6: Perception on quality of testing

Item	Response (%)				
	Strongly Agree	Agree	Not Sure (Missing)	Disagree	Strongly Disagree
Regular in-situ testing was carried out during the duration of the project	12.5	75	0	0	12.5
Quality check for materials was NOT done routinely	0	0	12.5	50	37.5
Laboratories that conducted quality checks in this project can be relied upon	37.5	62.5	0	0	0
Laboratory reports can be influenced	12.5	12.5	50	25	0

4.6. Perceived perceptions on Project B

As previously stated, no responses were obtained from Project B, although the funding agency representative supported the idea of conducting the survey. The observation by the Principal Investigator during the forensic study was that there was obvious suspicion and mistrust between the Contractor, the Client Body, and the Construction Supervision Consultants. An “alliance” of sorts seemed to exist between the Client and the Construction Supervision Consultant representatives.

However, it was possible to get the high-level stakeholder perspective on the issues on the questionnaire from information provided in their responses to the draft report on the investigation. Table 7 presents a summary of the perceived perception on project B. It is interesting to note that while other stakeholders were of the opinion that the project specifications were adequate, the Contractor found them insufficiently strict enough to ensure performance of the asphalt surfacing. Both the Road Authority and Consultant representatives questioned the skills set of the Contractor. The Contractor’s perception was that the Road Authority representative lacked the skills set for the project. The perception on quality control is of concern, as each stakeholder perceived other stakeholders not to have maintained adequate quality control. The demand to meet the quality control requirement is key to the subsequent performance of materials and therefore the pavement as a system.

Table 7: Perceived perception on Project B

Perception	Contractor	Road Authority	Eng. Consultant	Funding Agency
Cause of the Defect	External environment (climate, traffic loading, speed bumps) placing demands on the asphalt surfacing that exceeds the performance limits of the material	Poor workmanship, design, materials that result in inferior performance of the asphalt surfacing	Poor workmanship / design / materials that result in inferior performance of the asphalt surfacing	Not clear
Project Specifications	Project specifications insufficiently strict to maintain	Adequate	Adequate	Adequate

	performance			
Skill Sets	Believes its own skills set was adequate Questioned the skills set of the Road Authority	Believes its own skills set was adequate. Questioned the skills set of the Contractor	Believes its own skills set was adequate Questioned the skills set of the Contractor	Not Clear
Budget	Not Clear	Not Clear	Not Clear	Not Clear
Unforeseen Events	Did not play a role.			
Quality Control	Believes its own results- mistrusts those of the other parties set was adequate	Believes its own results- mistrusts those of the other parties set was adequate	Believes its own results- mistrusts those of the other parties set was adequate	Not Clear
Investigation Outcome	Rutting was found to be as a result of poor mix design, and a lack of project specifications and quality control.			
	Rejected the findings	Accepted the findings with reservations	Accepted the findings with reservations	Not clear

5. DISCUSSION

5.1. Overall perception

This exploratory study was aimed at examining the extent to which stakeholder perception on the practices adopted during the execution of the project can be used as a complementary tool in directing the investigation towards identify and evaluate the root causes of observed pavement premature distresses.

The results of the survey with respect to Project A, reveal that the respondents were satisfied with the practices adopted on the project, as most of the issues have a strong positive rating of more than 75 percent. In spite of the observed premature failure, the respondents perceived the project as successful.

There was no consensus with respect to Project B, based on the information provided in their comments on the draft investigation report. Both perspectives are not unique. Using an inductive thematic analysis (Davis, 2014), it was found that among some senior management, project core team and project recipients, there were no common factors on the perception of project success. At this stage of the study, the focus is on identifying practices adopted during project execution or factors with low rating and how they may be linked to causes of observed excessive premature distresses.

5.2. Potential indicators

On the basis of the responses from Project A, it shows that three items have a positive rating of less than 75 percent; understanding of *General Specifications* (62.5), understanding of tender documents (50) and whether laboratory reports can be influenced (25, Disagree). With respect to project B, the perception is that there were problems with quality control, skills set of the Contractor and project Specifications from the Contractor's view point.

Specifications are linked to the construction phase of the project, which is the phase when quality requirements should closely be monitored. Lack of understanding of *General Specifications* or poorly compiled *Special Technical Specifications* will lead to errors of omissions and errors due to noncompliance. However, specifications form part of the tender documentation. Discussions with the Contractor's representative revealed that the lack of understanding of tender documents was linked to the lack of clarity of information in the *Special Technical Specifications* to address specific issues related to the project.

The consequences of influencing laboratory reports is that problems or errors in test results will in most cases manifest themselves once the road is open to traffic, which is long after the errors have occurred. Both the lack of understanding of, or poorly compiled Specifications, and problems with quality of laboratory results, are strongly linked to problems relating to the pavement structure.

The forensic investigation of Project A revealed that the procedure in handling stabilised material during construction was the cause of the cracking. The root cause was therefore a procedure-based error that has remained uncorrected over the years as a practice. On Project B, the rutting was found to be as a result of poor mix design, a lack of project specifications and quality control. In both cases, an understanding of the material behaviour and correct interpretation of the *General Specifications* in order to provide appropriate *Specific Technical Specifications* in dealing with the pavement materials was more likely to have mitigated the problems.

Based on the perception of the respondents, the common problem areas relate to quality control of materials and specifications. But quality control requirements are stipulated in the *General Specifications* or in the *Special Technical Specifications*, which provide guidance that ensures quality project delivery. The perception of the respondents on the quality of the specifications or level of material quality control on the project can highlight the critical problem areas during investigations. The view point that stakeholder perception on the influence of practices adopted during project execution can direct the investigation on identifying and evaluating the root causes of premature distresses of pavements seems reasonable.

6. CONCLUSION

An exploratory study to investigate the value of the perception of a high-level focus group of project professionals in directing the investigation on identifying and evaluating the root causes of premature pavement distresses was conducted on two projects where premature pavement distresses were already being investigated. This involved an assessment of the perception of the high-level professionals on practices adopted during project execution. The objective is to link perception and extent of awareness of quality processes during project execution to the identification of root causes of premature pavement distresses.

Problems in administering the questionnaire were encountered on one project. The attitude of respondents on one project was positive towards the survey while the attitude of respondents on the second project was negative. The outcome of the exploratory study has shown areas that require improvement for future studies. For example, channelling the questionnaire through the project funder was more likely to have resulted in a response to the survey by the professionals on Project B.

The exploratory study has highlighted the potential that assessment of stakeholder perception can play a role and should form part of the investigation process of premature pavement distresses. However, additional assessment on more projects and improvement on the questionnaire is still required.

REFERENCES

Atkinson, A. R (1998), The pathology of building defects: A human error approach, *Eng., Constr. Archit. Manage.*, vol. 9, no. 1, pp. 53–61, 1998.

Busby, J.S and Hughes, E.J (2004), Projects, pathogens and incubation periods. *International Journal of Project Management* Volume 22, pp. 425–434.

Davis, K. (2014), Different stakeholder groups and their perceptions of project success. *International Journal of Project Management* 32 (2014) 189–201.

Love, P.E.D and Li, H (2010) Quantifying the Causes and Costs of Rework in Construction. *Construction Management and Economics*, Volume. 18, No. 4, pp. 479 – 430.

Love, P.E.D, Edwards, D.J, Irani, Z and Walker, D.H.T. (2009) Project Pathogens: The Anatomy of Omission Errors in Construction and Resource Engineering Project. *IEEE Transactions on Engineering Management*, Volume. 56, No. 3, pp. 425 – 435.

Rada, G.R, Jones, D.J, Harvey, J.T, Senn, K.A and Thomas, M. *Guide for Conducting Forensic Investigations of Highway Pavements*. NCHRP Report No. 747, Transportation Research Board, Washington D.C. 2013.

Victorine, T, Zhang Z, Fowler D. W, and Hudson W. R. *Basic Concepts, Current Practices, and Available Resources for Forensic Investigations on Pavements*. Report No. FHWA/TX-98/1731-1, Center for Transportation Research. The University of Texas at Austin. 1997.

Yates, J.K and Lockley E.E (2002), Documenting and Analyzing Construction Failures. *Journal of Construction Engineering and Management*, January/February, pp 8-17.