CONCRETE DECISION ANALYSIS IN SOUTH AFRICA

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ABSTRACT

PURPOSE

In certain parts of the world, especially in a developing country such as South Africa, the determinant of either project failure or success is found in the quality of decisions and actions. In particular, project team decisions often lead to poor project performance. The procedure used to make project decisions has come under scrutiny on many occasions, especially in relation to concrete work. The purpose of this study to report on how to reduce the manifestation of poor decisions that always produce defects and rework in concrete tasks.

RESEARCH METHOD

The case study research design was used in the study with the aim of understanding how choosing by advantages (CBA) would chart a pathway for solutions to poor decision-making. The case studies were developed on actual projects and had multiple team perspectives. The data analysis involves triangulation of multiple sources of evidence from interviews and on-site observations.

QUESTIONS

The research sought answers to “what are the causes of defects and rework in the concrete task; and how the decision-making mechanism is defining the completion of the concrete task?” To answer the research questions, multiple case studies were adopted to gain an in-depth understanding regarding the decision-making method chosen when working with concrete tasks while introducing the application of CBA method.

FINDINGS

The results show that decision-making process among the project team often leads to poor project performance regarding concrete tasks. The results also show that lack of experience (poor working experience), and lack of education in concrete task influences poor performance, although team decisions are influenced by the concrete placement methods, specification, cost, quality and time.

LIMITATIONS

Future research is needed to monitor and evaluate the project team decision-making process through the CBA frame model.

IMPLICATIONS

The study proposes that it is time to expose site management and workers to structured decision-making tools such as CBA. Such exposure through education and training will revise negative concrete task completion outcomes in the near future.

VALUE OF PAPER

Project teams keen on improving their concrete decisions can use the CBA frame model.

KEYWORDS

Concrete Task, Decision-Making, Defects and Rework, Performance, Project Team

1. INTRODUCTION

The economic development of either developed or developing country is influenced by the construction industry because developments set the benchmark for business operation[1]. For instance, businesses depend intensely on the infrastructure projects such as buildings, roads, bridges, water supply and energy supply to operate[1]. However, infrastructure projects are often a victim of poor performance related to scope, period and process difficulties since the most persuasive and common component is change in construction[2]. The construction industry is determined or influenced by change or innovative thinking initiated by the project team. Innovation has been defined as the invention of new knowledge in the construction industry, made up of new projects, new construction methods, social change and structural change[3].

Change or innovation in construction has encouraged clients to seek projects, which are large and complex in scope and in most cases; large and complex projects are designed and executed by competitive project team[4]. In the fast-growing construction development, most projects are constructed through the adoption of international methods, which are introduced with the aim of improving local construction methods. The problems come as the result of failure to apply international methods appropriately because in most cases, the project team fails to reach the standard of the adopted international methods and this affects project performance negatively[4]. For example, concrete defects continue to be the unavoidable existence of poor performance that continues to be one of the primary causes of schedule and cost overrun in construction[5].

The project team, especially the construction site manager, is responsible for the concrete quality management and often fails to address the project challenges[5]. Poor performance in construction is influenced by the project team decisions when project complexity increases[6]. In terms of opportunities for project performance improvement, this study proposed to eliminate or reduce the impact of poor decisions that always produce defects and rework in the concrete task with the use of CBA method.

2. CONCRETE TASK RESULTS

Innovative construction materials are used by the project team to improve and simplify construction methods and outcome, but concrete work remains a task with possible failure in expectation despite the evident change in construction[6]. More so, the quality of concrete in a structural project is designed by the structural engineer, and will impact the long-term performance of the structure[7]. Furthermore, the durability of concrete is explained, and that it should be cast or placed in a manner that will minimise defects such as honeycombing and internal shrinkage to provide a durable structure[7]. The explanation of 'Love' regarding concrete reinforce the notion that defects still occur on site in construction[8].

Either through manual work or automated processes, a concrete task involves the preparation of construction materials such as sand, cement, aggregates, water and reinforced steel bar. The process of casting concrete starts when the site manager or foreman who supervise how to install the reinforced steel bars, then set the formwork around the reinforced bars, then pour concrete, and allow the concrete to cure, and remove the formwork. While in most cases, the concrete process ends with a durable product, there have been instances where the product is unwanted. In fact, it has been stated that the construction industry is producing common waste with timber formwork and unused concrete, and is further causing pollution to the environment[9]. Accordingly, 15% of construction cost and one-third of the structural cost for reinforced concrete works are influenced by formwork, payroll and material cost[10]. A study further explains the state of production with the results of poor project delivery, quality and cost because formwork operation depends on skilled workers, and skilled workers are aging[10]. As an illustration, Figure 1 shows the operational process of formwork. The installation and removal of formwork that is required for the concrete task to proceed are not without its problems.

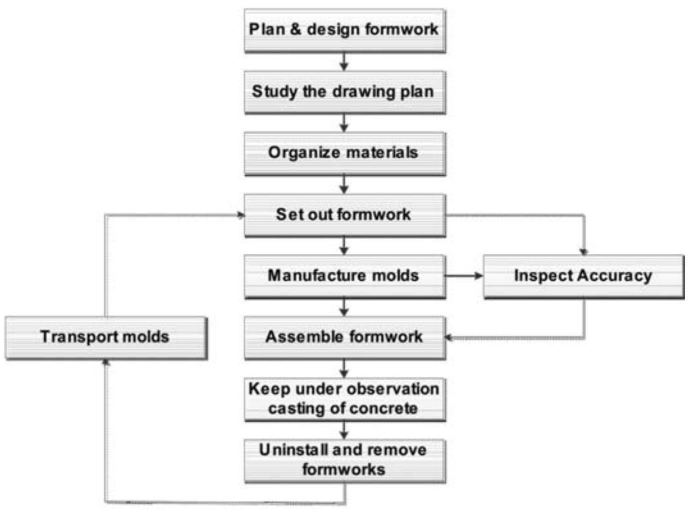

Figure 1: Formwork operational flows[10]

It is difficult for the project team to avoid wastage (both process and physical waste) and rework on projects because every project is unique and unpredictable due to the scope of work[7]. However, it is important for the project team to reduce concrete waste, as explained, waste reduction increases the production capacity because the sum of work and waste in the system is the same as the total capacity of a production system[11].

Moreover, it is further explained that concrete wastage does not add value and is unnecessary for clients to spend money for uncertain work[11].

3. THE PRINCIPLES OF CHOOSING BY ADVANTAGES

The CBA technique is a decision-making method used to define alternatives, and escalate the number of ideas, examine the modifications of alternatives explicitly, determine the importance of those modifications, appropriately consider cost modifications, and anchor information to the relevant facts[12, 6]. The method is gaining traction in terms of adoption among construction professionals in the United States of America (USA) because larger companies are exposing their workers to the five stages of the complete process[12, 13]. In brief, the five stages of a typical CBA method are described in Table1.

Table 1: Five Stages of CBA method Source[13]

@Q'Y _	Definition
Stage Settings	Explaining the purpose and establishing the problems, criteria, of the decision and who should be involved.
Innovation	Establishing the alternatives and evaluating the difference between them visibly and physically.
Decision-making	Listing the advantages of each alternative, choosing the importance of each alternative and selecting the alternatives that have higher score points
Reconsideration	Examining the draft decision to inspect if it serves its purpose effectively and does not create a collision
Implementation	Putting the decision practically to solve speeding up the construction

Source[13]

The purpose of CBA method, which a project team should understand include[12]:

- CBA is a problem-solving method, not a weapon to be used by project teams for their own benefit.
- CBA is a sound system of description, principles (value), models and methods of construction project.
- CBA allows a project team's decision to peacefully bridge the gap between data and the decisions.
- A sound decision must be based on the appropriate criteria, valid facts, and suitable viewpoints for the decisions

4. RESEARCH METHOD

The study aimed to understand the decision-making process executed by project teams when choosing the concrete type to be used for their project. The focus of the research was on the choice between two concrete alternatives namely; ready-mixed concrete and site-batched concrete. To understand the problems around the study purpose, a case study research was adopted [14]. A case study research design is defined as the practical reviews that explore an existing issue in detail and within its actual setting, particularly when the border between the phenomenology settings is not apparent[15]. The use of case studies i s to construct new theories and that researchers apply an inductive logic, with an objective of exploiting a variety of methods to collect the primarily qualitative data[16].

Three case projects were selected for this study in Bloemfontein with the aim of answering two research questions, which include, "what are the causes of defects and rework in the concrete task and how is the decision-making mechanism defining the completion of the concrete task"? The case studies were developed on actual projects. The cases had multiple team perspectives from members of the construction and consulting engineers team who were interviewed. Table 2 shows the case projects.

5. DATA AND DISCUSSION

Based on the data collected from all three case projects through semi-structured interviews and on-site observation, cross-case synthesis was adopted to analyse the data. Three case projects were selected for this study, the project teams made up of the member of construction, and the consulting engineer's team were interviewed. The members of the project team involved in each case were based on their concrete exposure and their role when making concrete work decisions.

Table 2: Cases of the study

Case type	Project Description	Project Type
Case project 1	New waste water treatment works	Civil Engineering Project
Case project 2	Road rehabilitation that include multiple bridges	Civil Engineering Project
Case project 3	Artisan training facility	Building Project

The project team for case project 1 was made up of two teams the members of the construction and the members of the consulting engineer's teams, for case project 2, was also made up of two teams also, the members of the construction team and the members of the consulting engineer's teams. Case project 3 was made up of one team as the project was a turnkey contract.

6. CBA APPLICATION ON CONCRETE TASK

This study proposes the application of CBA methods to improve the project team decisions, which often lead to concrete defects and rework. The impact of the CBA method of project delivery and performance, and how CBA method affects the performance of the project team were studied.

researcher and the interviewees, but their job titles have been retained for reference purpose.

After a CBA presentation, semi-structured interviews were conducted with the project team to investigate their decision-making process when choosing the concrete type: specifically, within their project and to answer the two research questions.

From the meeting with the project team of all three cases, two concrete alternatives were identified, namely; ready-mixed concrete and site-batched concrete. Furthermore, the project team identified the relevant factors, criteria, and attributes for this study. The project team determined the importance of advantages score (IofA) though a scale of 0 to 100.

The project team are the key drivers in the concrete decision-making process between two concrete alternatives when using the CBA method. Figure 2 shows the CBA application process used in the study to choose the concrete alternatives.

Table 3: Research sample

Project Cases	The Project Team		Response (No)	Rate (%)
	Members of the construction team	Members of the consulting engineer's team		
Project Case 1: New waste water treatment works	Construction Managers (2) Site Engineer (2) Quantity Surveyor (1) Foreman (1)	Resident Engineers (3)	9	41.0
Project Case 2: Road rehabilitation that include multiple bridges	Construction Managers (2) Foreman (2)	Resident Engineers (4)	8	36.0
Project Case 3: Artisan training facility	Project Manager (1) Construction Manager (1) Resident Engineer (1) Quantity Surveyor (1) Foreman (1)		5	23.0
Total interviewees			22	100.0

The project team was introduced to a CBA application through discussions and questions aided by presentations. In addition, the relevant information for the decision-making process was presented, and the process for obtaining the information, and assumptions behind the data. Table 3 illustrates the background information of 22 interviewees for all three case projects. The names of the participants are not mentioned because of a confidentiality clause signed by the

Notations relevant to Figure 2 highlights the CBA Frame Model constituting the outline of the research process. Step 1 in the figure, which is a green boundary; represents the project team problems about poor performance influenced by

7. CONCRETE DEFECTS AND REWORK

The project team from all three case projects answered the research question "what are the causes of defects and rework in the concrete task"?, by defining the term concrete defects and rework, identifying the causes of defects and rework and methods which could be adopted to prevent concrete defects and work. concrete defects and rework as the outcome of the project team decisions when placing or casting concrete. Step 2, which is the yellow boundary, represents the decision-making methods that provided the guidance to reduce and eliminate concrete defects and rework. The subsequent steps (3,4,5 and 7), which is the blue boundaries, were carried out or developed by the project team, while the CBA practitioner's analysed the results as outlined in Step 6,8, and 9. These constitute the red boundaries carried out by the researchers. These steps were also examined and discussed by the project team.

through the effect of incorrect quality control and mix design which might be influenced by the project team decisions during the mixing and placing of concrete'. However, in literature concrete defects are defined as the damages of concrete structures produced as the results of the incorrect workmanship, unsuitable materials and inappropriate construction methods[17]. Judging from these definitions it could be argued that the project team understand the concept of concrete defects.

9. Concrete rework:

The project team from case project 1, defined rework 'as the rectification of blunders which might either be cracks, voids, blisters, and honeycombing', while from case project 2 it was defined 'as the rehabilitation of the concrete surface which failed to meet its designed standard according to the design specifications'

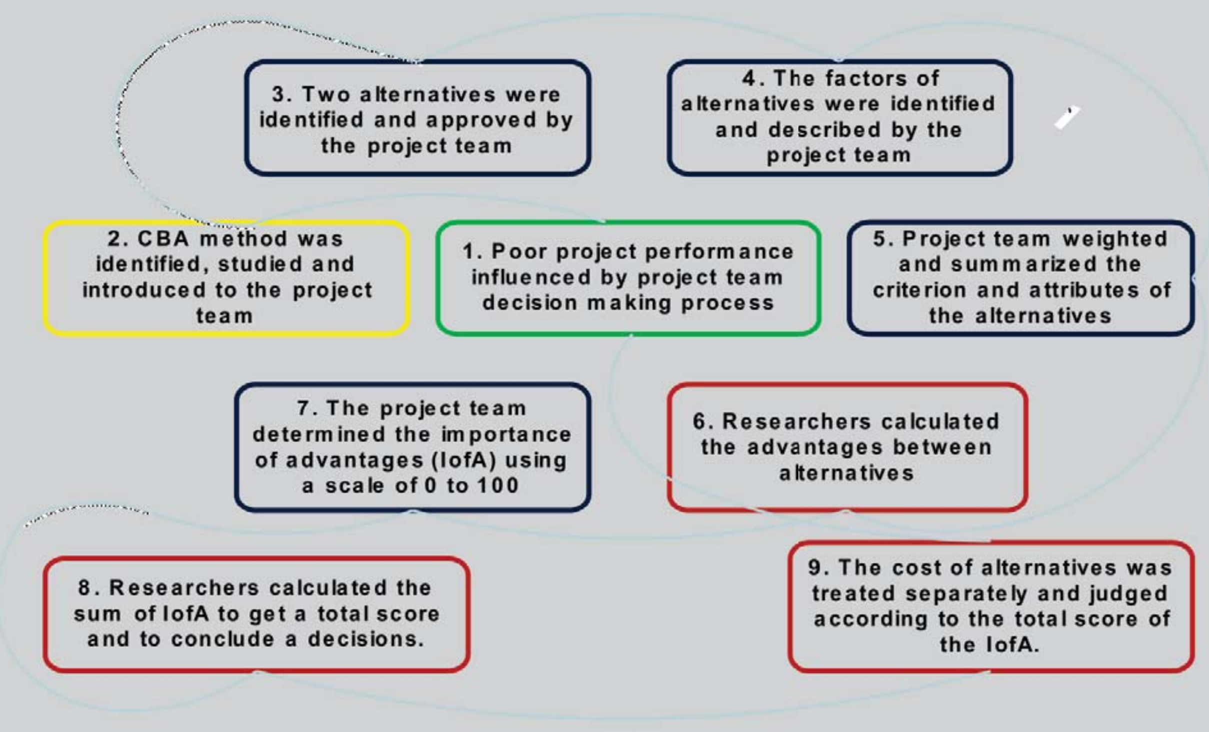

Figure 2: CBA frame model of choosing an alternative concrete solution

8. CONCRETE DEFECTS:

The project team from case project 1 defined concrete defects 'as the blunders which shows up on the concrete surface as a result of poor concrete management, and examples of blunders are either, cracks, voids, blisters, and honeycombing'. For case project 2, it was defined 'as the results of inadequate concrete produced

and for case project 3 it was defined as 'reconstructing of the placed concrete task in order to rectify the concrete errors'. These descriptions align with Love who says rework is the inessential determination of redoing an activity or damaged concrete structure because it was inaccurately done the first time[8].

10. Causes of concrete defects and rework:

The results show that the project team from all three cases understood the causes of defects and reworks, and methods that could be adopted to prevent concrete defects and rework. The project team identified factors, which lead to concrete defects as poor leadership skill within the construction team, handling of concrete on site, and formwork installation. Some of the responses say: "Concrete defects are produced by the foreman and labourer decisions or actions when working with concrete through either, poor concrete mix design, poor concrete vibration and curing, and long hours of handling concrete before placing it, and poor programme planning (rushing to complete the task or to reach the deadline of the project), and team member who does not know how to read the drawing plans and design formwork according to specifications."

Furthermore, the project team explained that concrete defects and rework could be prevented by 'designing effective method statement for the project in advance, designing concrete mix design to meet the standard and purpose of the project, and testing the concrete on site through slump tests and cube tests to keep the consistency of the concrete'. They further explained that the construction teams working with concrete must regularly attend concrete training or workshops provided by accredited concrete institutions, reputable companies, and universities. The project team working with the concrete task should be trained to make sound decisions through CBA method. CBA is a decision-making method, which helps the project team to improve their decisions because CBA separates the IofA score and the cost of alternatives that influences the concrete decisions. It is transparent and is based on the specific questions replicated in the criterion to explain the IofA score[18].

11. Observation results for concrete defects and rework:

The observation checklist results from case project 1 and 2 surpassed the results of case project 3. The reason why case project 3 did not produce the same results as case projects 1 and 2 is because the construction manager and foreman neglected the concrete work procedures on site, which resulted in concrete defects on the column and the foundation as indicated in Figure 3. The types of defects that were discovered were concrete cracking, voids and honeycombing. These defects are the results of poor formwork installation, neglecting to apply thin oil on the formwork, failing to vibrate the concrete properly and to cure the concrete properly. In the curing process, water was spread on the concrete in the morning and evening to increase the moisture in the concrete, which proved to be an unsuitable or reliable method to be used on a site.

Figure 3: Observation pictures case project 3

12. THE PROJECT TEAM DECISION-MAKING MECHANISM

This section shows the results of the second research questions which asks, 'How is the decision-making mechanism defining the completion of the concrete task'. From all three case projects, the results show that the project team was not using a defined decision-making method to make concrete decisions. Their project decisions were influenced by various factors. Some of their responses include "Concrete decision was influenced by concrete quality, money and period of the project, and also project specification and method statement plan designed by the company' and 'The engineer's team stated that they don't have a specific or defined decision method, but concrete decisions were influenced by the load applied to the structure, for example, the total weight of the vehicle to travel across the bridge and also the purpose of the bridge." However, the decision theory can be explained using an analogy relating to a Christopher Columbus' decision to sail off westwards across an unknown ocean[19]. It states that decision theory is the theory of rational decision-making and that the decision outcome depends on the true state of the world, which was partially known by Columbus when he sailed to the west[19]. For example, the project team's decision to use ready-mixed concrete would be judged by the project outcomes.

The results from all three case projects show that the most important factor influencing the project team decisions is the cost of concrete. The project team chooses ready-mixed concrete over site batched concrete because they wanted to avoid unforeseen cost. The supplier of the ready-mixed concrete was responsible for factors such as mix design, concrete strength, and quality. Furthermore, the ready-mixed concrete supplied to the site helped the construction team to avoid construction risks. Examples of mitigated risks include the reduction of the number of workers, concrete specialist, site managers, and plants. There is also the opportunity to reduce security and physical waste on site.

13. CONCLUSIONS

This study reveals that the project team decision-making process often leads to poor project performance, especially when working with the concrete task. The case study research design was selected for this study to understand the problems around decision-making by the project team and to develop the CBA framework to answer the research questions. The findings show that the members of the project team working with concrete must have sound concrete knowledge; an effective method statement must be designed well in advance, for instance, the quality of concrete delivered to the site must be tested through a slump and cube test. Moreover, the formwork must be assembled according to the drawing, design and the concrete must be vibrated slowly. The concrete must be cured correctly by adopting a method which will prevent the moisture of the concrete from evaporating instantly. The foreman must inspect the concrete delivered to the site by creating a checklist of items to handle the concrete on site. CBA methods should be used by the project team when making the project decisions.

The study further reveals that the decision-making mechanism of the project team is influenced by the construction method, the specification, and performance parameters. From the contractors' point of view, the cost of the project determines all the decision-making of the project. This perception should be meticulously addressed because cost is not an excuse for inconsistent decisions that could negate the intentions of task completion in projects.

The project team in the cases explained that should a contractor fail to address quality in a project; it would result in rework that is accompanied by penalties from the client. The project team from all three case projects have not adopted a defined decision-making method, although, they all agreed that it is useful for construction teams to use a decision-making method, especially when working with the concrete task. The construction team said that their reason for choosing ready-mixed concrete was based on the risk assessment plan and method statements because site-batched concrete has critical factors that can be avoided through ready-mixed concrete. Such factors include the quality of the concrete (concrete strength), the number of workers, concrete specialist, plants (trucks and batch plant), plant operators, material wastage and material security, especially for cement. These factors require costs to maintain them and can be eliminated by using ready-mixed concrete. More research work is however required to gain additional comprehension of the intricacies of decision-making by the project team in South Africa.

14. ACKNOWLEDGMENTS

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