COMPARATIVE STUDY OF DESIGN-BID-BUILD AND DESIGN-BUILD-MAINTAIN CONTRACTS DELIVERRY METHODS FOR HIGHWAY PROJECTS IN RWANDA

A THESIS

Submitted by

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DECLARATION

I, Fabrice KWIZERA, with Reg. No. 221027807, from University of Rwanda College of Science and Technology, School of Engineering; Department of Civil, Environmental and Geomatics Engineering, following studies of Master of Science in Highway Engineering and Management Programme, hereby declare that this work is of my original and has never been submitted for any academic award in any other University or Institution or anyone else where he/she had the same purpose.

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CERTIFICATION

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ABSTRACT

This thesis examines the performance of two contract delivery methods—Design-Bid-Build (DBB) and Design-Build-Maintain (DBM) within Rwanda's highway construction sector. The research places special emphasis on the DBM model when applied using Output and Performance-Based Road Contracts (OPRC). Given the persistent issues of cost overruns, schedule delays, and inadequate long-term performance in Rwanda's road projects, the study seeks to understand how contract delivery methods influence these outcomes.

A mixed-methods approach was used, including surveys, interviews with professionals from government agencies and consulting firms, and case studies of completed highway projects. The research focuses on six key performance indicators: cost control, time management, construction quality, lifecycle performance, maintenance outcomes, and stakeholder satisfaction.

Findings consistently show that the DBM approach, especially when combined with OPRC, outperforms the traditional DBB method across all indicators. DBM projects demonstrated more predictable costs, faster completion timelines, superior construction quality, and improved maintenance performance. This is attributed to the DBM model's integrated structure, where the contractor is responsible for design, construction, and long-term maintenance,encouraging accountability and efficient resource management.

In contrast, DBB projects showed higher vulnerability to cost overruns, design changes, and fragmented responsibilities, resulting in diminished performance and stakeholder dissatisfaction. The study also found that DBM projects, through their built-in performance monitoring and aligned incentives, foster higher stakeholder confidence and satisfaction. Although DBM may involve more complex planning and procurement, it provides better long-term value through reduced lifecycle costs.

The thesis concludes that for Rwanda's infrastructure goals, centered on efficiency, sustainability, and cost-effectiveness the DBM approach, especially when implemented through OPRC, is more suitable and should be prioritized in future highway projects.

Keywords: **Road Projects, Design-Bid-Build, Design-Build-Maintain following OPRC, Contract Delivery, Project Performance**

List of Acronyms and Abbreviations

AC	Asphalt Concrete
CM-R	Construction Management at Risk
DBM	Design Build and Maintain
DBB	Design -Bid -Build
OPRC	Output Performance Based Road Contract
DBIA	Design Build Institute of America
DBST	Double Bitumen Surface Treatment
DS	Design Standard
EOI	Expression of Interest
EOT	Extension of Time
MININFRA	Ministry of Infrastructure
NST1	National Strategies for Transformation
RTDA	Rwanda Transport Development Agency
GOR	Government of Rwanda
ICB	International Competitive Bidding
WB	World Bank
NCB	National Competitive Bidding
PDM	Project Delivery Method
RFP	Request for Proposal
ROW	Right of Way
VO	Variation Order
AASHTO	American Association of State Highway and Transportation Officials.

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CHAPTER ONE: GENERAL INTRODUCTION

1.1. Background of the study

The design-bid-build (DBB) method is a traditional project delivery approach in which the project is divided into three distinct phases: design, procurement and construction. The owner contracts separately with a designer for project plans and specifications and then with a contractor through evaluating bids for construction (FHWA, 2018). The DBM Method combines design, construction and maintenance to one contract. The contractor is responsible for both the design and construction of the project and will maintain the highway infrastructure while the contractor carries on for a specified period after completion (AASHTO, 2020).

The delivery of highway infrastructure projects is a crucial aspect on national development, directly impacting economic growth transportation efficiency and public safety. Many contract delivery methods have been adopted globally with Design-Bid-Build (DBB) and Design Builder Maintenance (DBM) being among the most commonly implemented approaches. Rwanda's government has recently been investing heavily in highway projects to enhance connectivity and facilitate trade. However, selecting the most effective contract delivery method remains a challenge as each approach has unique implications for costs time quality and risk allocation. DBB follows a traditional sequence where design and construction are separately contracted while DBM integrates design, construction and maintenance into one contract, potentially reducing project delivery time and ensuring long-term sustainability.

In Rwanda, the development of road infrastructure between 2011 and 2024 has undergone a notable transformation, significantly influenced by the use of different project delivery methods particularly Design-Bid-Build (DBB) and Design-Build-Maintain (DBM). While DBB separates the design and construction phases into distinct contracts, the DBM approach integrates design, construction, and maintenance into a single contract. This integrated method has been increasingly adopted to enhance project efficiency, lifecycle performance, and accountability. As a result of these evolving approaches, Rwanda’s national road network has seen a marked shift in pavement status, with many roads transitioning from unpaved to paved. Table 1 below illustrates these changes, reflecting the outcomes of diverse procurement strategies and contract models applied across various national road projects.

Table 1 Evolution of Rwanda's Road Network and Pavement Status (2001–2024)

Year	Total Road Network (km)	Paved Roads (km)	Unpaved Roads (km)
2011	14,037	1,238	12,799
2012	4,814	1,321	3,493
2019	14,885	3,072	11,813
2024	16,185	5642	10,543

Comparative studies in other developing countries have shown mixed results. For instance, in Kenya and Ghana, DBM projects have reported improved construction timelines but also encountered legal and procurement complexities (Osei-Kyei & Chan, 2017). Rwanda, with its unique institutional and regulatory environment, requires localized studies to assess the applicability and effectiveness of DBM compared to the traditional DBB model. Such comparisons can offer insights into which contract model better supports the government's goals of durability, value for money, and project sustainability.

Moreover, international evidence suggests that DBM can deliver superior time and long-term maintenance performance at the expense of increased project planning and contractor expertise. Rwanda's recent shift to apply DBM in its priority highway works, including feeder road upgrading and urban road rehabilitation, is a trend toward more performance contracting. Notwithstanding that, there are still issues in aligning local capacity, procurement processes, and monitoring systems to match integrated delivery models' demands (World Bank, 2021). It then becomes imperative to learn about such institutional readiness and policy frameworks for DBM projects to be implemented effectively.

Therefore, this study seeks to comparatively analyze DBB and DBM delivery methods for highway projects in Rwanda. It will examine multiple performance indicators, including cost control, construction duration, quality standards, and long-term maintenance outcomes. By leveraging data from past and ongoing highway projects, as well as expert interviews, the study aims to provide actionable recommendations for infrastructure policymakers and stakeholders in

Rwanda and compare these two methods within the context of Rwanda's highway projects to identify their advantages, limitations and suitability based on key performance metrics.

1.2. Problem Statement

Highway infrastructure plays a vital role in national development, but the success of road projects particularly in terms of cost, time, quality, and sustainability largely depends on the procurement method used. In Rwanda, as in many developing countries, the **Design-Bid-Build (DBB)** method has traditionally been the standard approach for road construction. While familiar and straightforward, this model often suffers from issues such as cost overruns, delays, fragmented responsibilities, and limited accountability for long-term maintenance.

Globally and regionally, there has been a shift toward more integrated project delivery methods, such as **Design-Build (DB)** and **Design-Build-Maintain (DBM)**. Studies from neighboring countries, including Tanzania and Ethiopia, have shown that transitioning from DBB to DB models can improve cost efficiency and reduce project duration. For instance, the Ethiopian Road Administration (ERA) and researchers like Shilla (2022) and Asaminew (2013) have demonstrated that DB tends to outperform DBB in budget control and schedule adherence—though challenges such as contractor capacity and institutional resistance to change remain. However, these studies mostly focus on the DB model and do not examine the **long-term maintenance component** introduced in DBM, which is crucial for infrastructure sustainability in Rwanda. And by conducting this study it can save the maintenance cost for the roads in rwanda

Beyond Africa, international research comparing procurement methods also supports the advantages of integrated models. Evidence shows that DBM can enhance project quality and lifecycle performance through unified responsibility for both construction and maintenance (SBUF, 2012; WJARR, 2024). However, these studies are typically based in high-income countries with well-developed institutional and contractual systems—conditions that differ significantly from the Rwandan context.

The traditional **Design-Bid-Build (DBB)** model has long been the prevailing procurement approach for highway infrastructure projects in Rwanda. While its procedural clarity and widespread familiarity have made it a default choice, it is increasingly associated with recurring challenges such as **cost overruns, schedule delays, fragmented risk allocation, and the absence of contractor accountability for long-term maintenance**. These issues often undermine the value-for-money and sustainability of road investments.

In response to these limitations, both global and regional trends have shifted toward more **integrated procurement models**—notably **Design-Build (DB)** and **Design-Build-Maintain (DBM)**. These approaches aim to enhance project delivery through consolidated responsibilities, improved coordination, and a stronger focus on lifecycle performance. While existing literature supports the efficiency of DB in terms of cost and time, the **DBM model**, which further incorporates long-term maintenance obligations, remains **underexplored**, particularly in developing contexts.

In Rwanda, the **adoption of DBM especially through Output and Performance-Based Road Contracts (OPRC)** is gaining momentum. However, there is **a lack of empirical evidence** evaluating its performance relative to DBB, particularly in local highway infrastructure projects. Critical performance dimensions such as **cost control, schedule adherence, quality assurance, risk management, stakeholder satisfaction**, and **maintenance effectiveness** have not been adequately studied.

This study seeks to address that gap. By systematically comparing DBB and DBM in Rwanda's highway projects, it aims to uncover which delivery method better serves the country's development goals and resource constraints. Ultimately, the findings are intended to help policymakers, engineers, and project managers make more informed decisions about **which contract delivery best balance short-term performance with long-term sustainability** in Rwanda's road infrastructure sector

1.3. Research Questions

1.3.1. Main Research Question:

- In the context of Rwanda's highway infrastructure projects, how does the Design-Build-Maintain (DBM) project delivery method compare to the traditional Design-Bid-Build (DBB) method with respect to cost efficiency, schedule adherence, risk management, quality assurance, stakeholder satisfaction, and long-term maintenance performance?

1.3.2. Sub-Research Questions:

1. What are the primary differences in cost performance between the Design-Bid-Build (DBB) and Design-Build-Maintain (DBM) delivery methods in Rwandan road infrastructure projects?
2. In what ways do DBB and DBM approaches differ in terms of risk allocation and risk management across various stages of the project lifecycle?
3. To what extent does the DBM method influence quality assurance and construction outcomes in comparison to the DBB method within Rwanda's highway sector?
4. How do key project stakeholders—including clients, contractors, and consultants—perceive and evaluate their satisfaction with project outcomes under DBB and DBM delivery models?
5. What are the long-term implications of assigning maintenance responsibilities under DBM contracts for the sustainability and performance of road infrastructure in Rwanda.

1.3. Significance of the study

Selection of an appropriate contract delivery method can greatly affect the success of highway projects in terms of cost efficiency, scheduling decisions, quality, and life-cycle maintenance. This study will provide information on the comparative effectiveness of Design-Bid-Build (DBB) and Design-Build-Maintain (DBM) methods on the field. Based on an analysis of project outcomes under both approaches, the study will provide insight into cost management, adherence to schedule, and risk mitigation. The findings of this research will enable Rwanda Transport Development Agency and project managers to take up best practices that can improve efficiency and thus cut down on cost overruns in highway construction. In addition, it will contribute towards

sustainability enhancement of the highways utilizing one of the DBM-DBB comparative advantages.

Besides the policy and project management implications, study wide open interesting academic and industry interests, especially in the African context, where research on highway procurement methods has remained scant. This study will thus bring the resolve to the scholars, engineers, and constructors support that would go on to help streamline future research and practical applications. In this sense, the study will, through client satisfaction analysis, assess how procurement methods actually affect the end user's experience, and hence address an improved public-service deliverer. The procurement findings will guide the decision-makers in selecting appropriate procurement methods for future highway works in Rwanda, availing better infrastructure performance and long-term cost savings.

1.4. Objectives

1.4.1. General Objective

The main objective of this research project is to compare the Design-Bid-Build (DBB) and Design-Build-Maintain (DBM) contract delivery methods for highway projects in Rwanda by examining the factors influencing their selection and evaluating their respective impacts on project performance, risk management, and stakeholder satisfaction.

1.4.2. Specific Objectives

- To determine the key factors that influence the choice between DBB and DBM delivery method in Rwandan highway projects.
- To assess the performance of DBB and DBM delivery methods in terms of cost efficiency, time management, quality, and lifecycle outcomes.
- To analyze how risk is allocated and managed within DBB and DBM contract delivery method.
- To investigate levels of stakeholder satisfaction associated with DBB and DBM delivery method.

1.4.3. Hypotheses

This study will explore the following hypotheses:

- **H_0 (Null Hypothesis):** There is no significant difference between DBB and DBM in terms of performance, risk allocation, and stakeholder satisfaction in highway projects in Rwanda.
- **H_1 (Alternative Hypothesis):** The DBM procurement method performs better than DBB in delivering highway projects in Rwanda, particularly in terms of cost, time, quality, risk management, and stakeholder satisfaction.

1.5. Scope of the Study

This study focuses on highway infrastructure projects in Rwanda, specifically those executed using either DBB or DBM contract delivery methods. The research will assess completed and ongoing projects, considering financial, technical, and administrative perspectives. The study will be limited to major national roads managed by the Rwanda Transport Development Agency (RTDA) and other key stakeholders involved in procurement and contract management. The table 1 describes the scope of this research in different perspectives.

Table 2: Scope of the project in different perspectives

Geographic scope	This study will be conducted in Rwanda, focusing on highway projects implemented under different contract delivery methods. The research will analyze Design-Bid-Build (DBB) and Design-Build-Maintain (DBM) procurement methods within selected highway projects in Rwanda, assessing their impact on project cost, time, quality, and sustainability.	
Variable scope	Variable	Measurable indicator
	Procurement method selection	Decision criteria, stakeholder interviews, policy/document analysis
	Cost performance	Cost overruns, final project cost vs. initial estimate

	Time performance	Schedule adherence, frequency and duration of delays
	Quality and lifecycle outcomes	Compliance with specifications, long-term road condition, maintenance needs
	Risk management strategies	Number and type of identified risks, risk response effectiveness, risk allocation patterns
	Stakeholder satisfaction	Survey results and interview feedback from key stakeholders (clients, consultants, contractors)

1.6. Justification of the Study

The delivery of efficient, sustainable, and cost-effective highway infrastructure is a cornerstone of national development, contributing directly to economic growth, regional integration, and improved public service delivery (World Bank, 2021). In Rwanda, transportation infrastructure particularly highways serve as a critical enabler for trade, rural connectivity, and poverty reduction. The Government of Rwanda has made substantial investments to upgrade its road network, shifting from unpaved to paved roads and expanding national coverage (MININFRA, 2023). However, despite these efforts, road infrastructure projects implemented through traditional procurement approaches, particularly the Design-Bid-Build (DBB) method, continue to face persistent challenges such as cost overruns, project delays, fragmented contractual responsibilities, and inadequate maintenance planning (RTDA, 2022).

In response to these limitations, Rwanda has begun exploring more integrated procurement models such as Design-Build-Maintain (DBM), particularly under Output and Performance-Based Road

Contracts (OPRC), with the goal of enhancing project performance and long-term asset sustainability (World Bank, 2021). As Rwanda progresses toward long-term strategic plans, including Vision 2050 and the National Strategy for Transformation (NST1), it becomes critical to evaluate the effectiveness of these procurement models in the local context.

This study is therefore justified on the following grounds:

a) Policy Relevance and Strategic National Importance

The research aligns with national infrastructure development objectives that prioritize sustainable, value-for-money investments. Given Rwanda's gradual shift towards performance-based contracting mechanisms, as observed in the piloting of OPRC frameworks (World Bank, 2021), understanding the implications of DBM within Rwanda's regulatory and institutional environment is timely. This research will generate empirical evidence to support decision-makers, including the Ministry of Infrastructure (MININFRA) and Rwanda Transport Development Agency (RTDA), in selecting procurement approaches that align with policy objectives related to lifecycle asset performance and budget efficiency.

b) Addressing an Empirical Gap in the Local Context

While extensive global research particularly in high-income countries supports the benefits of integrated models like DBM in reducing lifecycle costs and improving delivery timelines (SBUF, 2012; AASHTO, 2020), there is a notable paucity of empirical studies focused on DBM versus DBB in developing countries, particularly in sub-Saharan Africa. Regional studies, such as those conducted in Kenya, Tanzania, and Ghana, have shown that DBM can offer improved performance outcomes but also come with implementation challenges due to legal and institutional capacity constraints (Osei-Kyei & Chan, 2017; Shilla, 2022). However, such findings cannot be directly generalized to Rwanda without contextual validation. Therefore, this study aims to fill this knowledge gap by providing localized, evidence-based insights into how DBM performs compared to DBB in Rwanda's highway sector.

c) Sustainability and Lifecycle Performance Considerations

Traditional DBB contracts often do not include contractor obligations for post-construction maintenance, leading to premature road degradation and increased public expenditure on rehabilitation (FHWA, 2018). In contrast, DBM introduces accountability for both construction and long-term maintenance, thereby aligning contractor incentives with asset longevity (AASHTO, 2020). This research will evaluate the extent to which DBM contributes to enhanced lifecycle performance and infrastructure sustainability in the Rwandan context.

d) Enhancing Project Management and Operational Efficiency

The study has practical relevance for construction professionals—including engineers, contractors, and consultants—by analyzing procurement approaches across key project performance dimensions such as cost control, time management, quality assurance, and risk mitigation. International experiences have shown that DBM can minimize coordination issues between design and construction phases, reduce variations, and improve project execution efficiency (WJARR, 2024). This research will test the applicability of such outcomes within Rwandan road projects, offering actionable recommendations to improve operational performance.

e) Academic Contribution to Infrastructure Procurement Research

From a scholarly perspective, this research contributes to the growing body of literature on public procurement and construction management in developing economies. By establishing a comparative framework between DBB and DBM, the study offers methodological and empirical insights that are transferable to similar low- and middle-income countries with comparable procurement and governance systems. Furthermore, it provides primary data that can inform future academic inquiries in the fields of infrastructure economics, public-private partnerships (PPPs), and engineering project management.

f) Stakeholder-Centered Evaluation

Finally, the inclusion of stakeholder satisfaction as a performance indicator adds a participatory dimension to the study. While most procurement research focuses on technical and financial metrics, this study also explores how key actors—such as clients, consultants, and contractors—perceive the effectiveness of each procurement model. This approach enhances the validity and

practical relevance of the findings by grounding the analysis in the lived experiences of those directly engaged in infrastructure delivery (Asaminew, 2013).

the study is justified by its potential to inform infrastructure procurement policy, improve project delivery performance, and support the achievement of Rwanda's long-term development goals. By addressing both theoretical and practical gaps, the research introduces a robust, context-sensitive framework to evaluate the comparative effectiveness of DBB and DBM procurement methods in Rwanda's evolving highway infrastructure sector.

1.7. DEFINITONS OF TERMS

Construction/ Project: This is a set of activities which involve the utilization of Construction Materials, labour, equipment, money and procedures so that a visible structure is erected or realized.

Construction industry: often referred to as the building or construction sector, encompasses a wide range of activities related to the planning, design, construction, and maintenance of buildings, infrastructure, and other physical structures.

A contractor: is an individual, company, or organization that enters into an agreement, known as a contract, to provide specific goods, services, or work to another party, typically referred to as the client or the contracting entity.

Consultants: This is a firm or Individuals with professional skills that are responsible with controlling; quality cost and time of the project during its implementation on behalf of

Delays: This is the extra time the construction projects take to be completed away from the contracted period.

Project owner/Client: This is an individual, or an organization which tie interest to invest in the implementation of the project. In essence the Client employs both the contractor and the consultant for a particular project.

Construction Professionals: These are individuals with specialized education, training, and experience who work in various roles within the construction industry. Examples include: Architects, Engineers, Contractors, Project Managers, Quantity Surveyors, Other professionals: Inspectors, surveyors, safety specialists, construction workers with specific skills (carpenters, electricians, plumbers, etc.)

Construction Stakeholders: These are individuals or entities with an interest in the outcome of a construction project. This can include:

Project Management: An application of knowledge, skills, tools, and techniques to project activities to meet or exceed stakeholder needs and expectations.

CHAPTER TWO: LITERATURE REVIEW

2. 2. INTRODUCTION

Project Delivery Methods (PDMs) constitute the overarching frameworks by which construction projects are initiated, designed, procured, executed, and—depending on the contract—maintained. They establish the legal and operational relationships among the project's key stakeholders, including the owner, designer, contractor, and in some cases, maintenance entities. A well-chosen project delivery method aligns project scope, risk allocation, quality expectations, time constraints, and financial considerations to achieve successful outcomes (Miller et al., 2000).

Over time, a variety of delivery methods have emerged to address the evolving complexities and limitations in infrastructure development, including financial constraints, limited internal capacity, and urgent delivery needs. While numerous hybrid models exist, the most commonly applied methods in the road construction sector—particularly in low- and middle-income countries—are **Design-Bid-Build (DBB)** and **Design-Build-Maintain (DBM)** models. The selection between these methods plays a significant role in influencing project cost performance, schedule reliability, quality control, and lifecycle efficiency.

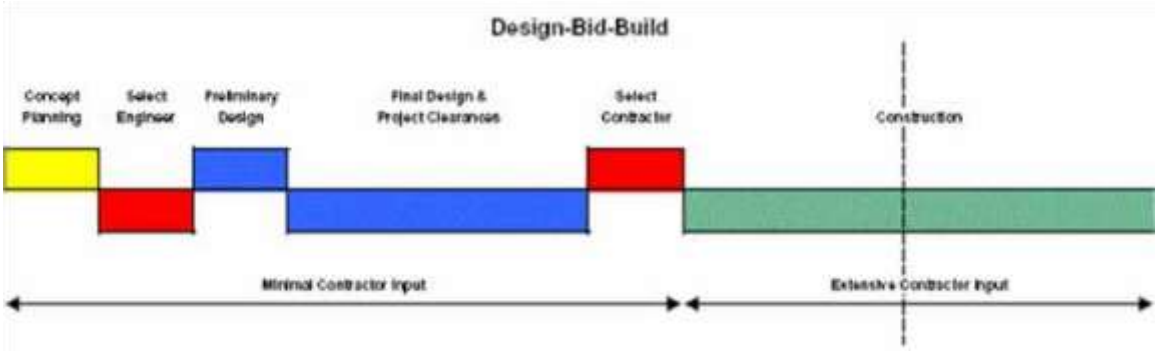
The **Design-Bid-Build (DBB)** method is the most traditional and widely used project delivery system in the public sector. It divides the project lifecycle into sequential stages: design, bidding, and construction. The employer typically contracts separately with a design consultant and a construction contractor. Once the design is complete and approved, the construction scope is tendered competitively, and the contract is usually awarded to the lowest responsive bidder (Sanvido & Konchar, 1999).

In this linear structure, the **design consultant** prepares engineering drawings, specifications, and bidding documents. These documents form the basis for soliciting construction bids. After the contractor is selected, the construction phase begins, typically under a fixed-price contract. The contractor is expected to execute the project according to the provided design documents, with minimal flexibility or involvement in design-related decisions (Bekerman et al., 2016).

Administration in DBB is characterized by distinct and limited collaboration among stakeholders. During the construction phase, the **consultant acts as the owner's representative**, overseeing the implementation of the design, verifying construction quality, and certifying payments. The consultant is also responsible for resolving technical queries and reviewing contractor submittals to ensure compliance (Miracle, 2013). Once construction is completed and the defect liability period concludes, the contractor has no further obligation to the project, and full responsibility for operations and maintenance falls back on the employer.

Although DBB promotes competitive tendering and clear role delineation, it is often criticized for poor schedule control, limited flexibility, fragmented communication, and increased risk of cost escalation due to change orders or unforeseen site conditions (Becker & Murphy, 2012). Owners typically retain the bulk of project risk, including design errors, coordination failures, and delays resulting from misalignment between design and execution.

Figure 2.2.1 Design-Bid-Build Project Delivery Method.

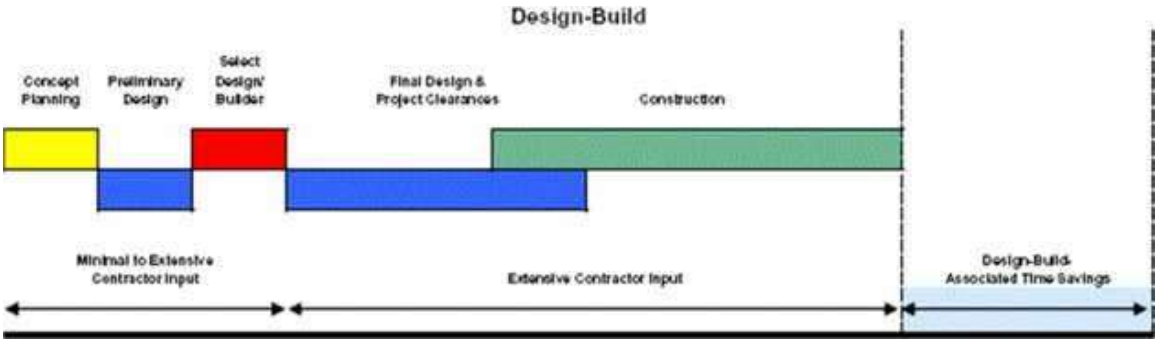


Source: Bekerman et.al, 2016

In contrast, the **Design-Build-Maintain (DBM)** delivery model integrates design, construction, and long-term maintenance into a single contract. It emerged as a response to the limitations of the DBB model, particularly for governments seeking value for money, time efficiency, and enhanced asset performance. Under DBM, the employer engages one entity (or consortium) responsible for designing the infrastructure, building it, and maintaining it over a defined period—commonly using **Output- and Performance-Based Road Contracts (OPRCs)** or similar frameworks (Hale, 2005).

The integration of functions fosters collaboration between design and construction teams from the earliest stages of the project. Contractors are incentivized to adopt **innovative, cost-effective, and durable design solutions** that minimize long-term maintenance liabilities. Moreover, since the contractor's performance is tied to asset condition during the maintenance period, there is a natural motivation to ensure higher initial construction quality (Bekerman et al., 2016).

Figure 2.2.2. Design -Build Project Activity and Time Schedule



Source: Bekerman et.al, 2016

The DBM procurement process typically begins with the owner issuing an **Expression of Interest (EOI)** outlining the project goals and expected service levels. Competing DBM teams submit conceptual designs, cost proposals, and execution timelines. The winning proposal is selected based on best value—not necessarily lowest price—considering design quality, lifecycle cost, and

contractor capacity. Once awarded, the contractor finalizes the design and commences construction, often overlapping phases to compress the schedule.

Time savings in DBM are achieved not only through **phase overlap** but also by eliminating multiple sequential procurement processes. The integrated nature of the contract significantly reduces coordination failures, approval delays, and scope fragmentation. However, project success under DBM depends heavily on proper **contract administration, monitoring frameworks, and capacity of the implementing agency** (Becker & Murphy, 2012).

Both DBB and DBM models offer distinct advantages and challenges. While DBB remains a straightforward approach with transparent tendering and control over design, it often underperforms in terms of schedule certainty and lifecycle efficiency. DBM, on the other hand, enhances performance by aligning long-term outcomes with contractor incentives, though it requires more sophisticated procurement, higher initial costs, and effective oversight mechanisms.

In developing contexts such as Rwanda, where there is a growing demand for rapid, cost-effective, and sustainable road infrastructure, understanding the trade-offs between these models is crucial. The choice of project delivery system should reflect local capacity, project complexity, and policy objectives related to quality, speed, and budget control.

2.3. Performance assessment of cost efficiency, time management, quality, and lifecycle outcomes:

2.3.1. Project quality:

The **Design-Build-Maintain (DBM)** procurement model integrates the design, construction, and long-term maintenance responsibilities under a single contractual entity. This integration creates strong performance-based incentives for contractors to prioritize long-term asset quality. Because contractors are accountable for maintaining the infrastructure over an extended period, there is a natural inclination to ensure high construction quality from the outset. Specifically, DBM contractors are motivated to (i) use durable, high-quality materials, (ii) ensure accuracy and

compliance during design implementation, and (iii) minimize the likelihood of defects that could result in future maintenance liabilities.

Empirical evidence supports this premise. A study by **Chan et al. (2018)** on UK highway projects found that DBM contracts were associated with a **20% reduction in post-construction defect rates** compared to traditional DBB projects. This improvement was largely attributed to stricter quality assurance protocols and more effective material selection processes. Similarly, **Ssegawa et al. (2021)**, in a study conducted in Uganda, reported that DBM roads exhibited significantly fewer structural and surface defects. The researchers attributed this improved quality to enhanced coordination between the design and construction teams, along with the long-term accountability embedded in DBM contracts.

In contrast, the **Design-Bid-Build (DBB)** model while widely adopted due to its clear separation of design and construction phases and its ability to promote competitive bidding—often presents limitations in delivering consistent construction quality. One of the principal challenges stems from the **segregation of responsibilities**, whereby the design is completed before the contractor is engaged and the contractor has no obligation for post-construction performance. As a result, there is minimal incentive for contractors to prioritize lifecycle durability or invest in higher-grade materials beyond what is required for initial compliance.

According to **Ssegawa et al. (2021)**, DBB highway projects in Uganda required **approximately 30% more post-construction repairs** than comparable DBM projects. The root causes identified included the use of **lower-quality materials** to remain within tight bid margins, **misinterpretation or incomplete understanding of design specifications**, and a **lack of coordination** between design and construction teams. This fragmentation often results in construction defects, rework, and elevated long-term maintenance costs for the project owner.

Summary of Comparative Quality Findings

The comparative analysis of DBB and DBM highlights several key differences in quality performance, as outlined in Table below:

Quality Indicator	DBB	DBM
Post-construction defect rate	Higher (baseline)	20% lower than DBB (Chan et al., 2018)
Pavement durability	Moderate, contractor-dependent	Improved due to integration of design and maintenance planning
Structural defects	More frequent; ~30% higher repair needs	Fewer defects due to better quality materials (Ssegawa et al., 2021)
Accountability for long-term performance	Limited	High, due to maintenance obligations
Quality control rigor	Medium	High; proactive measures enforced by long-term accountability

In summary, the DBM model demonstrates superior quality performance in highway construction compared to the DBB model. This is primarily due to the alignment of contractor incentives with long-term infrastructure functionality and maintenance efficiency. The DBB model, while offering initial cost benefits and procedural familiarity, often falls short in quality outcomes due to its fragmented responsibilities and limited post-construction accountability. For owners prioritizing long-term durability and reduced maintenance liabilities, the DBM approach presents a more effective procurement strategy.

2.3.2. Project Time Performance:

Timely delivery is a fundamental success factor in highway infrastructure projects, influencing not only financial performance but also stakeholder satisfaction and public utility. In road construction, **project delivery time** directly impacts cost escalation, contract performance, and the realization of socio-economic benefits. Thus, the choice of project delivery method (PDM) significantly influences time performance.

The **Design-Bid-Build (DBB)** method follows a sequential approach in which the owner contracts separately for design and construction. According to **Nurkowski (2011)**, the DBB timeline is composed of distinct phases: the owner hires a consultant to prepare designs and bid documents;

bidding is then conducted; and finally, the construction is executed under the supervision of another consultant. This **linear process** can result in elongated project schedules due to:

- The need for full design completion before construction starts
- Administrative delays during procurement
- Potential for redesign due to constructability issues not identified during the design phase

Furthermore, **fixed-date contracts** in DBB projects may impose rigid deadlines, but still allow for extensions only under specific conditions such as design errors or major disruptions. The need to resolve disputes between designers and builders also contributes to **frequent time overruns**, particularly when roles are siloed and collaboration is limited.

A study by **Fenta et al. (2022)** in Ethiopia showed that DBB highway projects had an **average completion period of 36 months**, with **40% of projects reporting significant delays**.

By contrast, **Design-Build-Maintain (DBM)** integrates design and construction under a single contractual entity, allowing overlapping of phases and reducing administrative burdens. Under the DBM approach, **construction can begin before design is fully complete**, enabling schedule acceleration and early mobilization. This streamlined workflow allows for better coordination and fewer conflicts between design and construction disciplines.

Hale (2005) and **Nurkowski (2011)** note that DBM's integrated structure fosters enhanced collaboration and faster decision-making. Moreover, since contractors are accountable for long-term maintenance, they are incentivized to complete work efficiently and avoid delays that may compromise quality or performance.

Empirical evidence supports this advantage. In their comparative study, **Fenta et al. (2022)** reported that DBM projects in Ethiopia were completed in an **average of 29 months**, with **only 20% experiencing delays**. Similarly, **Assaf and Al-Hejji (2019)** found that DBM projects were typically delivered **20% faster** than their DBB counterparts due to reduced design-bid-construction transition periods.

However, it is important to note that DBM's time efficiency is not guaranteed in all contexts. **Gkritza et al. (2021)** emphasize that project complexity and contractor competence significantly affect schedule performance. In poorly managed DBM projects, coordination breakdowns between in-house design and construction teams may still result in time overruns. **Mthembu et al. (2023)** documented such issues in South Africa, where ineffective contract administration in DBM projects led to unanticipated delays despite the integrated approach.

Table 3: Average Completion Time for Highway Projects

Procurement Method	Average Completion Time (Months)	Delays Reported (%)
DBB	36	40%
DBM	29	20%

(Source: Fenta et al., 2022)

From a time, performance perspective, **DBM offers significant advantages over DBB** through its integrated, collaborative framework that enables **faster project initiation, streamlined execution, and reduced administrative delays**. However, the success of DBM in achieving timely completion depends heavily on contractor expertise, project complexity, and contract management efficiency. While DBB remains a viable method in contexts where design control and competitive bidding are priorities, its sequential nature and fragmented responsibilities inherently expose it to higher schedule risk. For infrastructure programs aiming to accelerate delivery—such as in Rwanda's national development agenda—**DBM presents a more time-efficient alternative** if implemented with proper oversight and capacity.

2.3.3. Cost Performance Comparison

In traditional **Design-Bid-Build (DBB)** contracts, the initial investment is often lower as it covers only the design and construction phases. The employer retains full control over the design, which can help manage early budgeting. However, this lower initial cost frequently comes with hidden future expenses due to unanticipated changes, scope gaps, or maintenance needs.

By contrast, **Design-Build-Maintain (DBM)** projects typically require **higher initial investment** because they incorporate not only design and construction but also long-term maintenance. For

example, Fenta et al. (2022) reported that DBM contracts in Ethiopia required approximately **20% more upfront capital** compared to DBB, posing challenges for budget-constrained public agencies.

- **Cost Overruns and Budget Certainty**

Despite lower upfront costs, DBB projects are more vulnerable to **cost overruns** due to fragmented project phases, late design changes, and misaligned contractor incentives. Memon et al. (2011) found that cost overruns in DBB contracts often stem from unanticipated site conditions, design defects, and inefficient change management. This was supported by Massawe and Mkoma (2021), whose study in Tanzania showed DBB projects experiencing an **average cost overrun of 25%**.

In contrast, DBM contracts offer greater **cost control and predictability** due to the integrated nature of design and construction, as well as early risk mitigation. The same study showed DBM projects averaging only **10% cost overrun**. Additionally, Ogunlana et al. (2020) noted a **15% cost overrun reduction** in DBM projects in the UK compared to DBB.

- **Lifecycle Cost Efficiency**

One of the main advantages of DBM contracts is the contractor's responsibility for long-term maintenance, which **incentivizes lifecycle cost optimization**. Zhang and Chen (2013) emphasized that contractors in DBM frameworks consider durability and maintenance costs during the design stage, leading to more sustainable and cost-efficient infrastructure solutions over time.

While DBM may carry **higher initial costs** (Alhazmi & McCaffer, 2020), long-term studies support the view that DBM yields **greater value for money** when maintenance and operational costs are factored into total project expenditure.

Procurement Method	Initial Cost ($ Million)	Average Cost Overrun (%)	Final Cost ($ Million)
DBB	10.0	25%	12.5
DBM	12.0	10%	13.2

(Source: Massawe & Mkoma, 2021)

linear workflow where contractors quote work according to end designs. This can be utilized to produce realistic initial cost estimates but, otherwise, lead to cost overruns where there are design changes, inadequate coordination, or incomplete definition of scope during the earlier stages (Chan et al., 2002). According to Memon et al. (2011), the main causes of cost overruns in DBB projects include unplanned site conditions, design defects, and poor change management.

In comparison, the Design-Build-Maintain (DBM) methodology integrates design, construction, and maintenance in one contract that can facilitate better control of lifecycle cost. Through the unification of design and construction work in a single organization, DBM contracts can reduce the risks of cost overruns as a result of design mistakes and misunderstanding of scope (El Wardani et al., 2006). Furthermore, DBM contracts prompt contractors to include long-term maintenance costs in their considerations during the design phase, resulting in cost-effective and sustainable solutions (Zhang & Chen, 2013).

2.4 Risk Analysis within DBB and DBM contract delivery method.

In the **Design-Bid-Build (DBB)** method, risk is divided between multiple entities—the owner, designer, and contractor—with minimal overlap. The designer holds responsibility for the design, while the contractor is responsible solely for construction in accordance with those plans. This split can result in **design-construction disconnects** and disputes when project failures arise. Since the construction contractor does not influence or validate the design, they are not liable for design-related flaws (Culp, 2013).

In contrast, the **Design-Build-Maintain (DBM)** approach consolidates design, construction, and maintenance responsibilities under a single entity. This integration **reduces the likelihood of adversarial relationships** and clarifies risk ownership. However, it also **transfers extensive risk to the contractor**, including those arising from design errors, maintenance performance, and even unforeseen conditions, unless clearly excluded contractually (Tsai & Yang, 2009).

- **Dispute Potential and Legal Burden**

DBB projects are prone to higher legal contention. If an issue arises, the owner may face difficulty in assigning fault due to the **lack of a contractual relationship between designer and**

contractor. This often results in **"finger-pointing" disputes**, where the contractor and designer blame one another (Sellis, 2016). Additionally, claims against the designer often require proof of negligence, which sets a **high bar for legal relief** (Culp, 2013).

In DBM contracts, the **single point of responsibility** lowers this legal complexity. If the facility fails to perform as expected, the contractor is typically liable, reducing litigation costs and **simplifying resolution mechanisms**. However, this also increases the contractor's risk profile, potentially inflating bid prices to account for this added exposure.

- **Risk Pricing and Cost Certainty**

In DBM, transferring a large volume of risk to the contractor often aims to improve **price certainty** for the client. However, **over-allocation of risk** without properly accounting for the contractor's ability to assess and mitigate it can lead to inflated bids or claims during execution (Tsai & Yang, 2009). Risks such as **unforeseen ground conditions, third-party actions, or design interpretation issues** can become financially damaging for contractors—especially when margins are already tight.

In DBB, because the contractor only prices the construction scope and not the design risk, bids tend to reflect a more **accurate estimate of build costs**, although the owner must retain risk contingency for design errors or coordination gaps.

- **Collaboration and Flexibility**

DBM fosters early collaboration between design and construction teams, encouraging value engineering, innovation, and early risk identification. In DBB, the **sequential and siloed nature** of project phases restricts flexibility and limits risk mitigation opportunities until construction begins—by which time changes are costly.

2.5 Client Satisfaction Levels:

Client satisfaction is a crucial indicator of procurement success. Research by Abou-Zeid and El-Adaway (2022) suggests that DBM projects score higher in satisfaction surveys due to improved communication, risk-sharing, and reduced disputes. A study in Ghana by Asare and Adjei (2020)

confirmed that government agencies preferred DBM over DBB, citing faster delivery and better long-term performance. But client satisfaction in DBM projects depends on clear contract terms and contractor expertise. Some projects have experienced dissatisfaction due to unclear maintenance responsibilities (Asare & Adjei, 2020). Therefore, while DBM generally ensures higher satisfaction, its success depends on proper contract formulation.

Table 4: Client Satisfaction Scores

Procurement Method	Average Satisfaction Score (1-10 Scale)	Key Factors Contributing to Satisfaction
DBB	6.5	Delays, cost overruns
DBM	8.2	Faster delivery, fewer disputes

(Source: Asare & Adjei, 2020).

2.6. Considerations in Selecting Project Delivery Method

An Employer/ Client has several areas of concern when embarking on a construction program or project. It is necessary to choose an overall project delivery and contracting strategy that effectively and efficiently delivers the project. The following are some of the key considerations that will influence the selection of the project delivery method for a project:

- **Cost**

The employer has the obligation of all project costs. The construction cost is frequently the main concern of design and construction. Construction costs depend on the magnitude of the project, but in generall construction costs are very high and the employer has limited funds. To meet the defined budget is important, and it is the high priority of each and every member of the project team. (Gajurel, 2014)

The project must determine a realistic budget before design to evaluate project feasibility, to secure financing, to evaluate risk, and as a tool to choose from among alternative designs or project routes is a primary need. Once the budget is determined, the employer requires that the project be completed at or near the established budget figure. Employer must decide how quickly he need to establish final project costs and with what risk level of exceeding this cost.

- **Design**

The foremost importance thing to the employer is that the desired project function as envisioned while successfully fulfilling the needs of the employer and users. Therefore, the design team should be well qualified in the type of project being designed. In addition, the employer must ensure that the project needs are clearly conveyed to the design team. Since the design of the project must be buildable and design intent must be properly communicated, the employer requires that the design documents are constructible, complete, clear and coordinated. The documents should properly incorporate unique features of the site to include subsurface conditions, Material and Site Investigations further engineering documentations like Inception and Route Selection reports, Environmental Impact Assessment and Final Engineering Design Report will also be included. Hence, owners must decide how much control they need to have over the design elements of a project.

- **Time**

Time is the key factor of the agreement and may be an overriding criterion for completion. The project time available is generally established by the owner in the schedule developed during project conception. The delay in the delivery project may add extra costs on the total costs. Mostly the project is defined by the date of completion. The project includes the time frame within which the project has to be completed. Fulfilling the precise schedule would be the most essential consideration in determining how and when a project would be constructed. Delay would add extra costs to the owner. Meeting the schedule is crucial, especially when the interest rate is very high and capital for project is scarce because a small delay raises the costs of construction. ASCE Manual agrees that owner benefits from completion of a project as soon as Possible.

- **Risk Assessment**

Risk is the factor which needs proper management during construction. It should be handled properly to overcome the cost overrun. All project participants should make their best effort to manage and reduce the risks as the project unfolds. The key to reduce risk is to understand the project requirements by all the participants. (Gajurel, 2014) Issues of risk are closely tied to the status of the local construction market, on-site safety, the schedule and the budget. The owner

requires an understanding of the risks involved in construction, and should make a conscientious decision regarding allocation of these risks among project participants, so that all areas of exposure are properly understood. In considering risk allocation, the employer should strive to assign risks to those parties that can best exercise control over those aspects. For example, it would typically be problematic to require that the contractor correct problems due to design errors or changes at no extra cost since a contractor genRTDAlly has little control over the cause or magnitude of such errors or changes in DBB projects. An employer must decide how much project risk they are comfortable in assuming. Owner's Level of Expertise:

Some owners have more experience in project/program delivery than others. Owner's familiarity with the construction process, in-house expertise for project management have an impact on the level of how much outside expertise is required. This influences what project delivery method should be chosen. (Dobre, 2016)

2.7. Role of the Contracting Parties in Rwandan's context

2.7.1. The Client

The client in DB projects first clarify the scope of the project by working the concept design. The concept design may be done by in-house engineering staff or by hiring independent consultant to develop the parameter of the projects.

During the course of the project the Employer's duties and responsibilities are the following:

- Being responsible for the execution of the project, from the initial idea to implementation
- Implement a process to select the contracting parties who involved in all stages from design through construction
- Providing access to the site for the Contractor to undertake the works.
- Making of payments to the Contractor
- Taking over the works once substantially completed
- Terminating the Contract in the event of the Contractor failing to perform
- May also be financier and eventual owner of the project.

2.7.2 The Contractor

The role of the Contractor is to execute the construction and design of the work, for which he has submitted his Tender, within the time specified in the Contract. In addition he has an obligation to remedy any defects which appear during the Warranty Period.

The role of the Contractor includes:

- Provide qualifications proposal and initial renderings to demonstrate their vision of compliance with the criteria documents
- Confirm pricing with design team that meetings design criteria
- Design the project using qualified design professionals and obtain Owner approval of compliant design that meets the criteria documents
- Design team maintains engagement in project throughout construction
- Construct the project, draft changes, punch out and complete
- Carrying out the instructions of the Engineer and his representative.
- Providing a programme together with methods of working and updates.
- Providing for the safety and security of the site and all construction operations.
- Maintain budget and schedule throughout the duration of the project
- Provide clear and regular communication with Owner on project status and any changes

2.7.3 The Engineer

Most construction contracts define a third party "The Engineer" to act as the administrator of the contracts with pre-defined authority to ensure the Client's wishes are fulfilled and the Contractor's interests are protected as set out in the contract. This is the role in which the Consultant generally acts during the construction stage of most Projects. (RTDA, 2008).

The Engineers duties include

- Design review and approval of the contractor’s design

- The issue of information and instructions to the Contractor
- Ensuring that materials and workmanship are as specified
- Quality assurance during construction
- Agreeing measurements of work done
- Payment verification
- All other matters of an administrative nature
- Dispute resolution

2.8. Conceptual Framework

The conceptual framework for DDB delivery method involves a traditional way of delivery strategy whereby the feasibility study, detailed Engineering design and tender documents preparation has to be carried out by Employer by hiring Consulting firm and, the same being used for the procurement of the construction works contract. As the design is detailed, the Contractor is required to quote a price to every item of the project works. Payment is authorized later based on the measurement and payment mechanism for every executed work item. Whereas, in DB project delivery method, which is now being widely implemented in Rwanda and elsewhere in the World, the client will prepare by own staff or hiring a consultant a concept design document which then be used by the Contractor to review the concept design and the Employer's requirement to quote fixed rate (lump sum) amount for the total project volume.

For both type of project delivery methods in Rwanda, the client will hire a separate consultant to undertake the contract administration works and represent him in all aspects of the project. Further, the client assigns his own staffs to oversee the project work.

Based on the above literature review conceptual framework of the two delivery methods are developed for the purpose of the study.

Figure 2.8.1. Conceptual framework for Design-Bid-Build Delivery Method

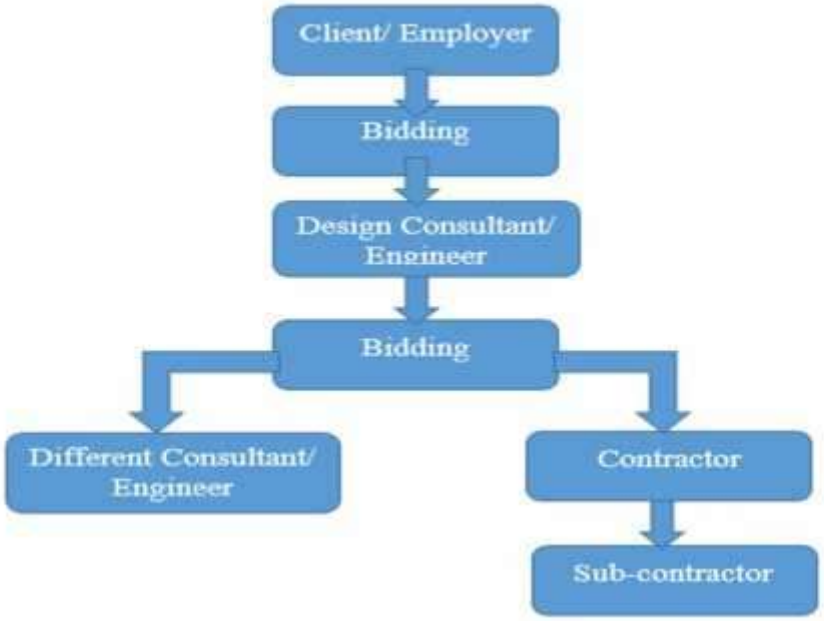
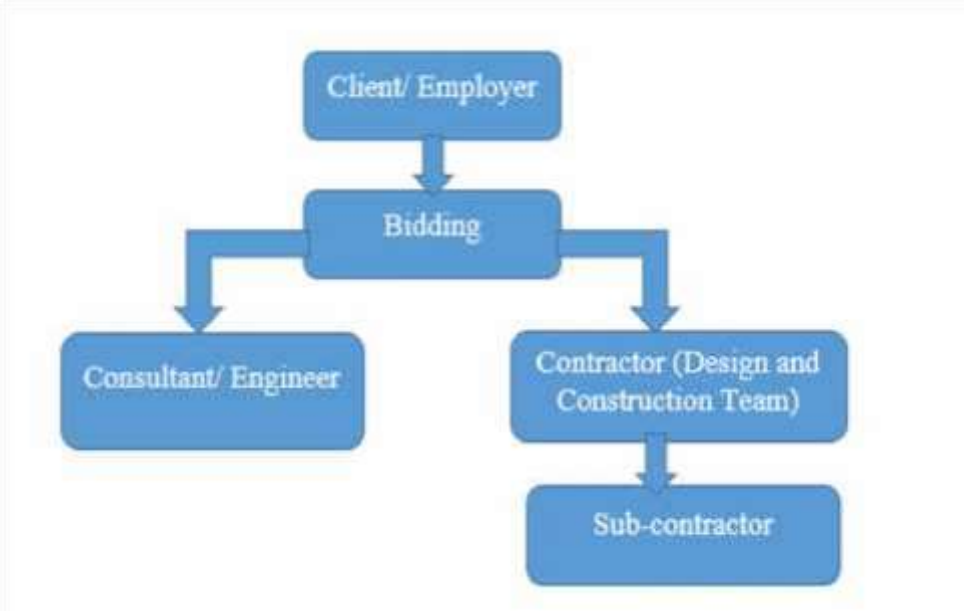


Figure 2.8.2. Conceptual framework for Design-Build Delivery Method



Source: Own survey, 2018

Source: Own survey, 2018

2.9. SUMMARY OF CHAPTER

This literature review underscores the strategic significance of project delivery method selection in road infrastructure development. While DBB offers predictability, competitive tendering, and control in familiar administrative structures, it is prone to inefficiencies in quality, time, and cost management. DBM, by contrast, promotes integration, accountability, and lifecycle optimization, albeit with higher complexity and capacity requirements.

In developing contexts like Rwanda—where time, budget, and sustainability are critical—DBM presents a compelling alternative if institutional and technical readiness can support its successful implementation.

CHAPTER THREE: RESEARCH METHODOLOGY

3.0 Introduction

This chapter outlines the methodology adopted to investigate the comparative performance of Design-Bid-Build (DBB) and Design-Build-Maintain (DBM) contract delivery methods in highway road projects in Rwanda. As defined by Kothari (2004), research methodology is a structured approach that details how a study is planned, executed, and analyzed. It involves identifying research objectives, selecting suitable data collection methods, and applying appropriate analysis techniques.

The study adopts a **mixed-methods approach**, combining quantitative and qualitative data to capture a holistic understanding of project performance across key indicators such as cost, time, quality, risk management, maintenance efficiency, and client satisfaction. The integration of primary data (surveys, interviews, field observations) and secondary data (official project reports, cost records, contract documentation) ensures both breadth and depth in analysis.

3.1 Research Design

This study adopted a **mixed-methods research design**, integrating both qualitative and quantitative approaches to enable a comprehensive comparison of the Design-Bid-Build (DBB) and Design-Build-Maintain (DBM) contract delivery methods in the Rwandan highway sector. The rationale behind using a mixed-method approach lies in the complexity of the research problem, which involves both measurable performance indicators and contextual, experience-based insights from stakeholders. Quantitative data provided structured evidence for statistical comparison, while qualitative data captured perceptions, motivations, and real-world experiences of professionals involved in road infrastructure delivery.

3.2 Data Collection Methods

3.2.1 Structured Questionnaires

A structured questionnaire was administered to engineering professionals working on road projects across Rwanda. The survey included both closed and Likert-scale questions designed to assess the

perceived performance of DBB and DBM (including OPRC) across key metrics such as cost control, time management, quality of construction, and long-term maintenance performance. Respondents were selected using purposive sampling, focusing on individuals with direct experience in road project planning, procurement, or implementation.

3.2.2 Key Informant Interviews

To gain in-depth insights into the strategic and operational considerations that influence contract method selection, **semi-structured interviews** were conducted with key informants from the **Rwanda Transport Development Agency (RTDA)**, **Ministry of Infrastructure (MININFRA)**, and local **consulting firms**. These interviews provided qualitative data on the practical challenges, institutional perspectives, and lessons learned from implementing both DBB and DBM approaches.

3.2.3 Review of Completed Project Documents

The study also involved the review and analysis of **completed road project documentation**, including procurement files, project completion reports, performance evaluations, and maintenance records. This secondary data helped verify performance trends reported by respondents and added historical context to the comparative analysis.

3.3 Sampling Techniques

The study employed **purposive sampling** to target professionals with relevant expertise in highway project planning and implementation. This sampling method was appropriate due to the specialized nature of the topic and the need to gather informed opinions from those directly involved in infrastructure delivery in Rwanda. The final sample included engineers from RTDA, private consultants, and contractors with experience in both DBB and DBM projects.

3.4 Data Analysis Methods

To analyze the collected data, the study used a combination of **descriptive statistical techniques**, **comparative tabulation**, and **thematic coding**:

- **Descriptive Statistics** (e.g., means, frequencies, percentages) were used to summarize survey responses and highlight trends in stakeholder perceptions regarding performance indicators for DBB and DBM delivery systems.

- **Comparative Tables** were developed to visualize and compare the performance of DBB and DBM projects across different metrics, such as cost predictability, delivery time, and stakeholder satisfaction.
- **Thematic Coding** was applied to qualitative interview transcripts and open-ended questionnaire responses. Themes were developed based on recurring concepts related to contract performance, institutional challenges, and the perceived benefits and limitations of each delivery method.

3.5 Target Population and Sampling

3.5.1 Target Population

The study targets stakeholders directly involved in planning, execution, and oversight of road infrastructure projects in Rwanda, including:

- Engineers and project managers from the City of Kigali (CoK)
- Officials from the Rwanda Transport Development Agency (RTDA)
- Contractors
- Supervision and Monitoring firms

3.5.2 Sampling Technique

A purposive sampling approach will be applied to select highway projects based on key criteria such as project size, contract duration, and procurement type. Additionally, stratified random sampling will be used to identify survey respondents, mainly government officials from MININFRA, RTDA and CoK. The expected sample size consists of:

- 20 engineers and project managers involved in road construction from the City of Kigali
- 30 government officials from the Rwanda Transport Development Agency (RTDA)

3.5.3 Research Instruments

Data will be collected using multiple instruments to ensure validity and reliability:

- **Questionnaires**: Structured questionnaires will be used to gather quantitative data on project cost, time performance, and satisfaction levels.

- **Document Analysis**: Financial reports, project schedules, and contract documents will be reviewed to verify data accuracy.
- **Interviews**: Semi-structured interviews will be conducted with project managers and policymakers to gain qualitative insights into risk allocation and contract management.

3.5.3 Document Review

Key documents such as project completion reports, cost summaries, maintenance logs, and pavement condition reports will be reviewed to validate and enrich survey and interview findings.

3.5.4 Data Analysis and Interpretation

3.5.5 Quantitative Analysis

Quantitative data will be processed using **SPSS** software. The following techniques will be employed:

- **Descriptive statistics**: Means, standard deviations, and frequency distributions
- **Inferential statistics**:

  - ***Paired sample t-tests*:** To compare DBB and DBM on time and cost performance
  - ***Regression analysis*:** To examine how procurement method affects quality, satisfaction, and risk indicators
  - ***Chi-square tests*:** To test for categorical differences in defect rates and maintenance outcomes

Key indicators include:

Variable	**Measurement**
Cost Performance	Cost overruns, variance from initial estimates
Time Performance	Actual vs. scheduled duration
Quality	Pavement Condition Index (PCI), visual ratings
Maintenance	Post-construction defect rates
Risk Allocation	Frequency and resolution of disputes
Client Satisfaction	Survey scores, user feedback

3.4.2 Qualitative Analysis

Qualitative data will be analyzed through **thematic content analysis** using **NVivo** software. Emerging patterns related to procurement challenges, maintenance efficiency, and stakeholder perceptions will be grouped into themes. This approach supports context-rich interpretation of data and allows integration with quantitative findings.

3.5 Comparative Analysis Framework

A structured comparison will be drawn between DBB and DBM projects across all performance dimensions. The following framework guides this comparison

Table 5: Summary of Research Methodology and Analytical Approach

Step	Activity	Method	Data Type	Analysis Technique
1	Project Selection	Purposive Sampling	Secondary	Comparative Case Study
2	Surveys & Interviews	Questionnaires, Interviews	Primary	Descriptive & Thematic Analysis
3	Site Observations	Existing site visit reports	Primary	PCI, Defect Rate Calculation
4	Document Review	Reports, Cost Data	Secondary	Financial & Statistical Analysis
5	Data Processing	SPSS, NVivo	Mixed	Regression, Content Coding
6	Interpretation & Conclusions	Cross-Analysis	Combined	Comparative Framework

Chapter 4: Results and Discussion

This chapter presents a systematic comparative analysis of two prominent Project Delivery Methods (PDMs)—**Design-Bid-Build (DBB)** and **Design-Build-Maintain (DBM)**—as applied to highway infrastructure projects in Rwanda. Drawing on empirical data obtained through stakeholder surveys, interviews, and case studies, the chapter evaluates the performance of each method using a structured set of **Key Performance Indicators (KPIs)**. These include: cost control, schedule adherence, risk allocation, quality assurance, innovation capacity, and maintenance responsibility. These dimensions were selected due to their critical role in determining project success and informing procurement strategy.

As Rwanda continues to expand its road network amid growing budgetary and time constraints, the strategic selection of an appropriate PDM has become increasingly vital. Literature supports this need for project-specific procurement approaches, with El Wardani, Messner, and Horman (2006) highlighting the strong correlation between PDM selection and project performance outcomes such as cost efficiency, schedule compliance, and quality. Ashworth and Perera (2015) similarly argue that no single delivery model is universally optimal, underscoring the need for a context-sensitive, evidence-based selection process.

Historically, the **DBB model** has served as the standard delivery method in Rwanda's public road projects, favoring a sequential process of design completion, competitive bidding, and construction—often under unit price contracts. While cost-effective at the tendering stage, DBB frequently suffers from design-construction disconnects, resulting in schedule delays, cost overruns, and limited innovation.

In contrast, the **DBM model**, particularly when implemented under the **Output and Performance-Based Road Contract (OPRC)** framework, has gained traction in recent years. By integrating design, construction, and maintenance responsibilities under a single contractual entity, DBM promotes lifecycle accountability and performance optimization. It has proven especially useful for complex or time-sensitive projects requiring accelerated delivery and sustained operational standards.

The chapter further explores the practical implications of these PDMs in Rwanda's context. By synthesizing both **quantitative performance ratings** and **qualitative stakeholder insights**, it uncovers not only the relative strengths and limitations of DBB and DBM, but also the contextual factors—such as project complexity, institutional readiness, and contractor capability—that influence their effectiveness.

Ultimately, the findings presented in this chapter aim to support more strategic, informed procurement decisions in Rwanda's evolving infrastructure landscape, contributing to improved project outcomes and long-term sector sustainability.

4.1 Cost Performance

Cost control emerged as a significant point of differentiation between the two models.

- **DBB Projects**: Though awarded at the lowest initial cost, DBB projects often encountered **budget overruns** due to variations, change orders, and site-related uncertainties.
- **DBM Projects**: Demonstrated **greater cost predictability**, especially under fixed-price OPRC contracts. While initial costs were higher, these were offset by lower maintenance costs and extended asset lifespan.

These findings are consistent with Molenaar et al. (2000), who argue that integrated contracts tend to enhance cost certainty through risk bundling and single-point accountability.

Key Findings:

- DBM was widely perceived as more **cost-effective over the full lifecycle**, while DBB was associated with **lower initial construction costs**.
- Frequent cost overruns were reported more under DBB than DBM.
- Lifecycle cost-effectiveness was significantly higher under DBM due to its integration of long-term maintenance.

Supporting Data:

- Over 65% of respondents indicated **frequent to very frequent cost overruns** under DBB, versus a majority rating DBM as more controlled.
- Stakeholders emphasized that DBM's long-term outlook **minimized future repair and rehabilitation costs**.

Case Study Insight:

- **Huye-Kibeho Road (DBM)**: Demonstrated good lifecycle value with minimal maintenance disruptions over the years.
- **Ngororero-Muhanga Road (DBB)**: Reported higher short-term expenditure on repairs within the first five years post-construction.

Table 4.1: Perceived Cost Overruns Frequency

Method	**``Never**	**Rarely**	**Sometimes**	**Often**	**Almost Always**
DBB	5%	10%	35%	35%	15%
DBM	20%	30%	35%	10%	5%

4.2 Time Performance

Key Findings:

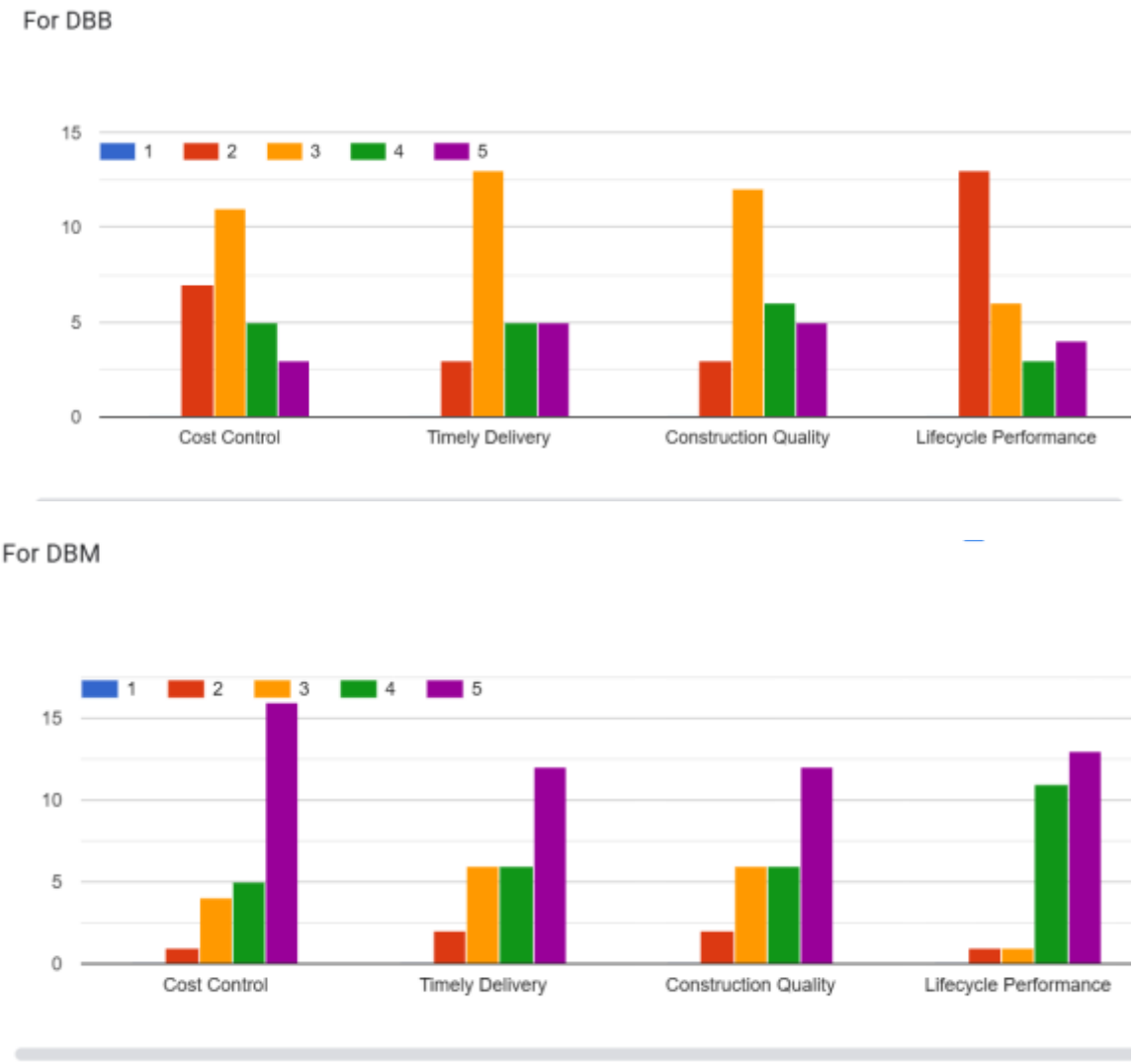
- DBM was consistently rated as superior in delivering projects **faster** due to concurrent design and construction phases.
- DBB, while allowing more design control, was perceived to experience more **delays due to sequential phases** and lengthy procurement processes.

Supporting Data:

- 70% of professionals rated DBM as "Good" to "Excellent" for timely delivery.
- Only 35% gave similar ratings to DBB.

Graph 4.1: Timely Delivery Ratings

(A bar graph comparing DBM vs DBB delivery performance from stakeholder scores.)



4.3 Risk Transfer

Key Findings:

- DBM provided **more effective risk allocation**, shifting greater responsibility to contractors, particularly for design errors and maintenance risks.
- In DBB, design-related risks were largely retained by the client.

Table 4.2: Risk Allocation Comparison

Risk Category	DBB Responsible Party	DBM Responsible Party
Design Errors	Client	Contractor
Cost Overruns	Shared	Contractor
Maintenance Accountability	Client	Contractor
Scope Changes	Client	Shared

Discussion:

The ability to align risk with the party most capable of managing it was viewed as a **distinct strength of DBM**, especially for complex projects or long-term performance goals.

4.4 Quality and Innovation

Key Findings:

- DBM showed a stronger association with **quality consistency** and innovation due to integrated responsibilities.
- DBB projects, though often well-supervised, had **fragmented accountability** between designers and constructors, leading to more frequent quality discrepancies.

Survey Response Summary:

- DBM received higher ratings for **construction quality** and **lifecycle performance**.
- Multiple respondents noted that DBM promotes innovation in construction techniques and materials due to performance-based incentives.

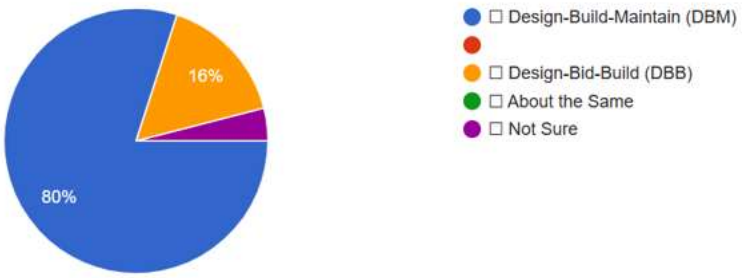
4.5 Maintenance Responsibility

Key Findings:

- DBM clearly outperformed DBB in delivering **sustainable maintenance outcomes**.
- With maintenance bundled into the contract, DBM encouraged contractors to focus on **durability** and **preventive measures**.

Survey Data:

- 80% of respondents selected **DBM** as achieving better maintenance results.
- DBB was noted to suffer from **budget constraints and fragmented follow-up** post-construction.



Case Example:

- **Huye-Kibeho Road (DBM)** has been maintained efficiently with low additional public expenditure.
- **Ngororero-Muhanga (DBB)** faced delayed repairs due to maintenance funding gaps.

4.6 Summary of Pros and Cons

Table 4.3: Comparative Analysis of DBB and DBM

Criteria	DBB	DBM
Initial Cost	Lower	Higher due to bundled maintenance
Lifecycle Cost	Higher due to future repairs	Lower, with integrated maintenance
Speed	Slower (sequential phases)	Faster (concurrent phases)
Risk Allocation	More burden on client	More burden on contractor
Quality Control	Fragmented responsibilities	Unified accountability
Innovation	Less incentivized	More incentivized
Maintenance	Client-led, often delayed	Contractor-led, proactive
Stakeholder Satisfaction	Mixed	Generally higher

4.7 Overall Discussion

The data and case studies demonstrate that **DBM offers superior performance** in contexts where **timeliness, risk transfer, and long-term maintenance** are critical. However, DBM demands **experienced contractors and robust project oversight**, which can be a limitation in local capacity settings.

On the other hand, DBB remains a **reliable choice for simpler projects**, especially when initial budgets are constrained or when the client prefers full design control.

The choice between these methods should therefore consider **project complexity, urgency, and the owner's institutional capacity**.

Chapter 5: Conclusion and Recommendations

5.1 Summary of Major Findings

This study examined the performance of two prevalent contract delivery methods—Design-Bid-Build (DBB) and Design-Build-Maintain (DBM)—within the context of highway infrastructure development in Rwanda. The analysis drew upon both stakeholder interviews and case studies, focusing on five key performance areas: cost, time, risk allocation, quality and innovation, and maintenance responsibility.

- **Cost Performance:** DBB projects generally provided more predictable and transparent cost estimates. However, cost overruns were common due to changes in scope, fragmented responsibilities, and delays. DBM projects, while initially appearing more expensive, demonstrated stronger cost control in the long run due to integrated design and maintenance incentives.
- **Time Performance:** DBM projects consistently outperformed DBB projects in meeting timelines. The integration of design and construction in DBM minimized coordination gaps and administrative delays, whereas DBB faced more delays due to separate phases and slower procurement processes.
- **Risk Allocation:** DBM contracts allowed for better risk transfer to the private sector, particularly in maintenance and performance outcomes. In contrast, DBB left most risks—especially post-construction maintenance risks—on the public sector, resulting in increased long-term liabilities.
- **Quality and Innovation:** DBM encouraged innovative solutions and quality improvements, driven by contractors' long-term maintenance obligations. DBB, with its rigid specifications and limited contractor involvement during design, limited opportunities for innovation and often led to quality shortfalls.
- **Maintenance Responsibility:** DBM provided a more sustainable approach by integrating long-term maintenance into the initial contract. This led to better-maintained infrastructure. DBB projects lacked a structured mechanism for post-construction upkeep, resulting in faster deterioration of assets.

5.2 Effectiveness comparison for Rwanda

Based on the collected evidence, the **Design-Build-Maintain (DBM)** method demonstrates **superior overall effectiveness** in the Rwandan context. DBM aligns more closely with Rwanda's

goals of timely project delivery, lifecycle cost efficiency, infrastructure sustainability, and enhanced performance accountability.

While DBB may remain appropriate for smaller, less complex projects or where institutional capacity to manage DBM contracts is lacking, DBM is better suited for large-scale or strategic road infrastructure projects requiring higher quality and sustained functionality over time.

5.3 Recommendations for Policy and Practice

To enhance the effectiveness for the afore-mentioned projects delivery in Rwanda, the following policy and practice recommendations are proposed:

1. **Gradual Expansion of DBM Contracts:** The government should promote the phased adoption of DBM for medium to large-scale infrastructure projects, particularly where maintenance funding and performance sustainability are crucial.
2. **Capacity Building:** Invest in the training of public procurement officers, engineers, and contract managers to build the necessary technical and legal expertise to manage DBM contracts effectively.
3. **Institutional Framework:** Develop standardized DBM contract templates and guidelines tailored to the Rwandan legal and operational context to reduce ambiguity and streamline implementation.
4. **Performance Monitoring Systems:** Establish independent oversight mechanisms and digital monitoring tools to track DBM contract performance metrics, including maintenance quality, user satisfaction, and long-term cost efficiency.
5. **Stakeholder Engagement:** Foster early and continuous collaboration between government agencies, private contractors, and local communities to ensure project alignment with public needs and minimize implementation conflicts.
6. **Funding Strategy Alignment:** Link DBM project financing with Rwanda's long-term infrastructure investment plans, possibly leveraging public-private partnerships (PPPs) or concessional loans for high-value road corridors.
7. In DBM project a clear and well-defined Employer's requirement has to be prepared by revising the available Employer's requirement and the lesson learnt from past experiences. Preparing a

well-defined Employer's requirement would have prevented the additional cost and time observed in the case study project. Hence, attention should be given to preparing a well-defined Employer's requirement for the upcoming new road projects.

8. For DBB types of Contracts, the design detail shall be exhaustive and, taking the lesson learnt from the vast experience of DBB type delivery method, similar kinds of design related risks shall be avoided.

9. RTDA should further evaluate the execution of the works by the DBB and DBM types of project delivery methods and should devise such mechanism/selection criterion for the selection of project delivery types.

5.4 Suggestions for Future Studies

To build upon the findings of this study, future research should:

1. **Expand the Sample Size:** Analyze a broader range of projects across different regions and road classes to capture more diverse outcomes and contextual variables.

2. **Include Quantitative Performance Metrics:** Incorporate measurable indicators such as lifecycle cost comparisons, pavement condition indices, traffic growth rates, and user satisfaction surveys to strengthen empirical conclusions.

3. **Evaluate Environmental and Social Impact:** Assess the environmental performance and social inclusiveness of DBB versus DBM, particularly in rural and environmentally sensitive areas.

4. **Study Long-Term Maintenance Outcomes:** Conduct longitudinal studies to assess how DBM's integrated maintenance performs over 10–15 years compared to traditional approaches.

5. **Compare Hybrid Models:** Explore the effectiveness of hybrid or modified DBM models (e.g., Design-Build-Operate or Performance-Based Maintenance) in achieving infrastructure goals under varying budget and institutional conditions.

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Appendix I: Questionnaire for comparative Study of Design-Bid-Build and Design-Build-Maintain following OPRC, Contract Delivery Methods for Road Projects in Rwanda

A. Introduction:

My name is Fabrice KWIZERA, a Master of Science candidate in Highway Engineering and Management at the University of Rwanda. I am conducting research on contract delivery methods for road projects in Rwanda.

This questionnaire is part of a study entitled **"A Comparative Study of Design-Bid-Build and Design-Build-Maintain Contract Delivery Methods for Road Projects in Rwanda."** The study aims to identify critical factors influencing contract delivery selection method, evaluate performance in terms of cost, time, quality, and lifecycle, analyze risk allocation, and assess stakeholder satisfaction within the Rwandan road construction sector.

As a professional working in the road infrastructure sector, your insights are vital to the success of this research. The questionnaire will take approximately 10–15 minutes to complete. Participation is entirely voluntary.

All responses will be treated confidentially, anonymized, and used strictly for academic purposes.

For any questions or clarification, please contact me at kwizerafabrice17@gmail.com or **+250787389719.**

Thank you for your valuable contribution to this study.

B. Section 1: Demographics (BIO-DATA)

1. Gender:

☐ Male

☐ Female

2. **Age Group:**

☐ 18-25

☐ 26-35

☐ 36-45

☐ 46-55

☐ 56+

3. **Highest Academic Qualification:**

☐ Bachelor's Degree

☐ Master's Degree

☐ Ph.D.

☐ Other (please specify): _____

4. Profession/Job Title: (Please select the option that best describes your primary role.)

☐ Road Manager

☐ Team Leader

☐ Resident Engineer

☐ Pavement and soils materials Engineer

☐ Highway Engineer

☐ Project Manager

☐ Structural Engineer

☐ Road Engineer

☐ Other (please specify): _____

5. Type of Organization:

☐ Consulting Firm

☐ Contracting Firm

☐ Government Agency

☐ World Bank

☐ AFDB

☐ COK

☐ Other (please specify): _____

SECTION 3: FACTORS INFLUENCING STRATEGY SELECTION

For each of the following factors, please rate its level of importance when choosing between Design-Bid-Build (DBB) and Design-Build-Maintain (DBM) Contract delivery methods in the context of Rwandan highway projects.

Use the following scale:1 = Not Important,2 = Slightly Important,3 = Moderately Important,4 = Important,5 = Very Important

Selection Factor	DBB Importance (1-5)	DBM Importance (1-5)
Minimizing initial construction costs	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Urgency of Project Delivery Timeline	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Integration of Long-Term Maintenance Responsibilities	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Risk Allocation Preferences	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Contractor experience	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Complexity and Technical Demands of the Project	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

5. In your experience, what are the main factors influencing the choice between DBB and DBM?

SECTION 4: PERFORMANCE ASSESSMENT

6. Please rate the performance of Design-Bid-Build (DBB) and Design-Build-Maintain (DBM) contract delivery methods in Rwandan highway projects across the following performance areas, based on your professional experience. Use the following scale:1 = Very Poor,2 = Poor,3 = Moderate,4 = Good,5 = Excellent

Performance Area	DBB Performance (1-5)	DBM Performance (1-5)
Cost Control	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Timely Delivery	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Construction Quality	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Lifecycle Performance	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

7. **Maintenance Outcomes:** In your professional experience, which method generally achieves better maintenance outcomes for Rwandan highway projects?

   ☐ Design-Build-Maintain (DBM)

   ☐ Design-Bid-Build (DBB)

   ☐ About the Same

   ☐ Not Sure

8. **Frequency of Cost Overruns:** How frequently have you observed cost overruns occurring in Rwandan highway projects using the following methods.
   Use the following scale:1 = Never,2 = Rarely,3 = Sometimes,4 = Often,5 = Almost Always

- DBB: ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
- DBM: ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

9. **Lifecycle Cost-Effectiveness:** Considering the entire lifecycle of a road (including design, construction, maintenance, and rehabilitation), which method do you believe is more cost-effective for Rwandan highway projects?

   ☐ Design-Build-Maintain (DBM)

   ☐ Design-Bid-Build (DBB)

   ☐ Not Sure

SECTION 5: RISK ALLOCATION AND MANAGEMENT

10. **Risk Allocation in DBB and DBM Contracts:** Based on your professional experience, how is the responsibility for each of the following risk categories typically allocated under DBB and DBM contract delivery methods in Rwandan highway projects?

    For each risk category, please indicate the primary party responsible under both DBB and DBM contracts. Choose one of the following for each method: Client, Contractor, or Shared.

Risk Category	**DBB: Responsible Party**	**DBM: Responsible Party**
Responsibility for design errors	☐ Client ☐ Contractor ☐ Shared	☐ Client ☐ Contractor ☐ Shared

Risk Category	DBB: Responsible Party	DBM: Responsible Party
Risk of cost overruns	☐ Client ☐ Contractor ☐ Shared	☐ Client ☐ Contractor ☐ Shared
Delays in Project Delivery	☐ Client ☐ Contractor ☐ Shared	☐ Client ☐ Contractor ☐ Shared
Accountability for maintenance	☐ Client ☐ Contractor ☐ Shared	☐ Client ☐ Contractor ☐ Shared
Risk associated with scope changes	☐ Client ☐ Contractor ☐ Shared	☐ Client ☐ Contractor ☐ Shared

11. **Effectiveness of Risk Management Stages:** How effective do you consider the following stages of the risk management process to be under each of the following contract delivery methods (DBM, DBB) in Rwandan highway projects, based on your professional experience

    Use the following scale:1 = Not Effective,2 = Slightly Effective,3 = Moderately Effective,4 = Effective,5 = Very Effective

Risk Management Stage	DBB Effectiveness (1-5)	DBM Effectiveness (1-5)
Risk Identification	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Risk Assessment	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Risk Response Planning	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Risk Management Stage	DBB Effectiveness (1-5)	DBM Effectiveness (1-5)
Risk Monitoring & Control	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

12. **Risk Alignment Definition and Choice:** In Rwandan highway projects, which procurement strategy best ensures that project risks are assigned to the party most capable of managing them effectively?
    (Risk alignment means assigning risks to the party best prepared to handle them)

    ☐ Design-Bid-Build (DBB)

    ☐ Design-Build-Maintain (DBM)

    ☐ Both equally

    ☐ Not Sure

SECTION 6: STAKEHOLDER SATISFACTION

13. **Perceived Stakeholder Satisfaction:** To what extent do you believe that stakeholders involved in Rwandan highway projects are satisfied with the outcomes of projects delivered using the following contract delivery methods?

    Use the following scale:1 = Very Low (Stakeholders are generally very dissatisfied)

    2 = Low (Stakeholders are generally dissatisfied),3 = Moderate (Stakeholder satisfaction is mixed),4 = High (Stakeholders are generally satisfied),5 = Very High (Stakeholders are generally very satisfied)

- **Design-Bid-Build (DBB):** ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
- **Design-Build-Maintain (DBM):** ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

SECTION 7: OPEN FEEDBACK AND RECOMMENDATIONS

14. What challenges have you encountered when using the DBB contracts?

    Answer:

15. What challenges have you encountered when using the DBM contracts?

    Answer:

16. Based on your experience, what are the advantages of DBM over DBB?

    Answer:

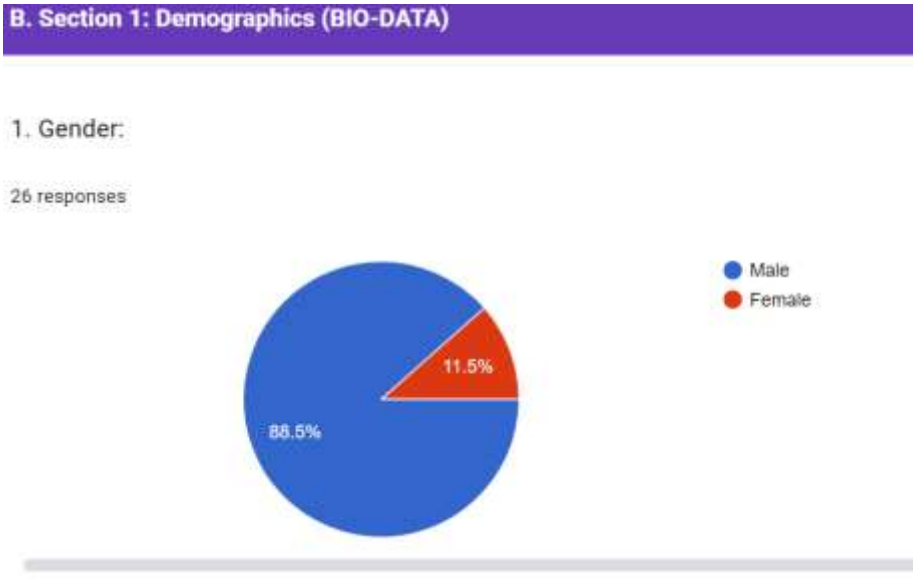
17. Under which project conditions would you recommend using DBM over DBB in Rwanda?

    Answer:

18. **Strategies for Enhanced Delivery**: What practical strategies could be implemented to enhance the efficiency and effectiveness of Design-Bid-Build (DBB) and Design-Build-Maintain (DBM) contract delivery for road infrastructure projects in Rwanda, based on your experience?

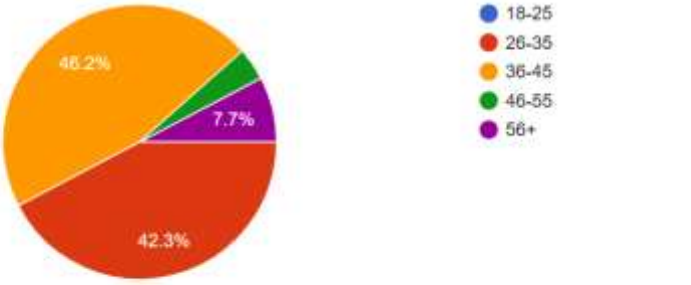
    Answer:

Appandex II: Answer statics



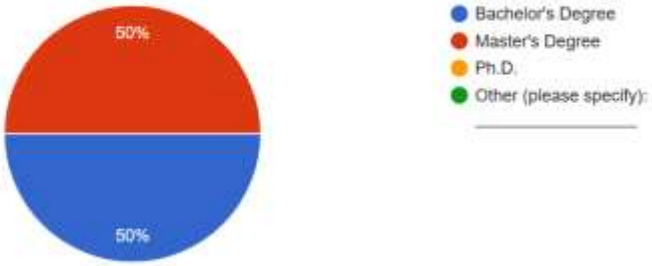
2. **Age Group:**

26 responses



3. Highest Academic Qualification

26 responses



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4. Profession/Job Title: (Please select the option that best describes your primary role.)

26 responses

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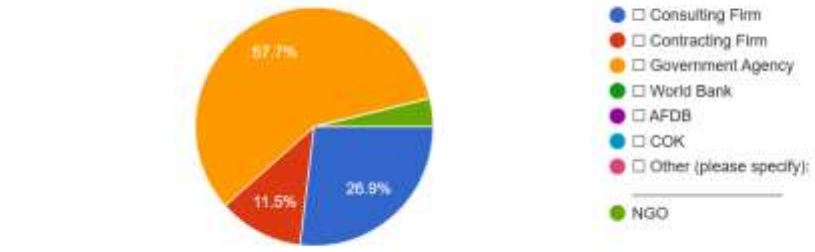
5. Type of Organization:

26 responses



SECTION 3: FACTORS INFLUENCING STRATEGY SELECTION

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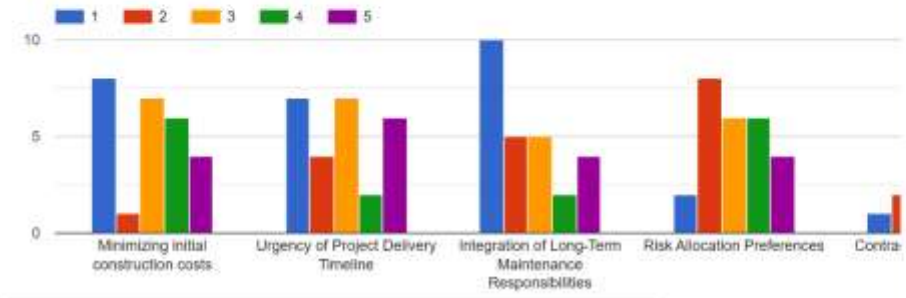
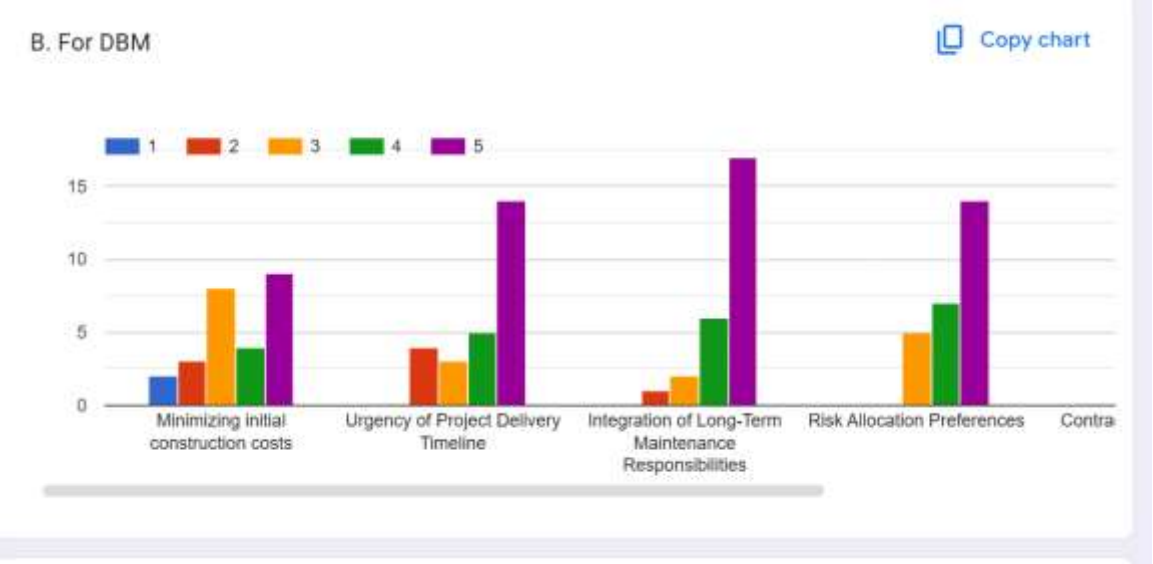
6. For each of the following factors, please rate its level of importance when choosing between Design-Bid-Build (DBB) and Design-Build-Maintain (DBM) Contract delivery methods in the context of Rwandan highway projects.

Use the following scale:1 = Not Important,2 = Slightly Important,3 = Moderately Important,4 = Important,5 = Very Important





Project Complexity: DBM is often preferred for complex projects requiring seamless integration between design, construction, and long-term maintenance, while DBB suits less complex, well-defined projects. 2. Time Constraints: When urgent delivery is critical, DBM is often more efficient due to concurrent design and construction phases. 3. Budget Priorities: DBB may be selected when minimizing upfront construction costs is a primary concern. 4. Maintenance Goals: DBM is more suitable when the government wants to ensure long-term asset performance and reduce lifecycle costs. 5. Risk Management: DBM allows better transfer of design and maintenance risks to the contractor, which is appealing for projects with performance uncertainty. 6. Local Contractor Capacity: The choice may depend on whether local firms have the technical and financial capacity to deliver under the more demanding DBM approach.

Project complexity, integration of long-term maintenance responsibilities

Professionalism, expertise, honesty, accountability, financial capacity.

in my experience, when comparing DBM (Design-Build-Maintain) to DBB (Design-Bid-Build), particularly within the framework of OPRC (Output-and Performance- Based Road contracts), DBM is often the preferred choice due to its emphasis on long-term asset management. Unlike DBB, which typically focuses on the initial construction phase, DBM integrates maintenance responsibilities, ensuring better preservation of the road over time. This results in greater cost efficiency for client by minimizing future repair and maintenance expenditures. moreover, DBM enables faster project delivery, as it generally bypasses the need

for a full feasibility study- unlike DBB- allowing urgent infrastructure projects to be initiated and completed more swiftly.

In my experience, when comparing DBM (Design-Build-Maintain) to DBB (Design-Bid-Build), particularly within the framework of OPRC (Output- and Performance-Based Road Contracts), DBM is often the preferred choice due to its emphasis on long-term asset management. Unlike DBB, which typically focuses on the initial construction phase, DBM integrates maintenance responsibilities, ensuring better preservation of the road over time. This results in greater cost efficiency for the client by minimizing future repair and maintenance expenditures. Moreover, DBM enables faster project delivery, as it generally bypasses the need for a full feasibility study-unlike DBB-allowing urgent infrastructure projects to be initiated and completed more swiftly.

Construction costs, Timeline and Contractor experience

DB projects are difficult to hand over, making it difficult to enter the maintenance period

DBM focuses on Contractor's full responsibility

the maintenance cost of the project and risk allocation

The complexity and urgency of the project

Budget and design expertise

For maintenance purpose I can choose DBM rather than DBB. However, the DBM requires experienced contractor. For the DBB, if the financial is stable and available it requires mature design team and mature consultant. For both, the client must be very vigilant in terms of management (site possession and project success in terms of quality)

Short time for procurement process and risk allocation to contractors

DBM enables faster project delivery while DBB allows urgent infrastructures to be initiated and completed.

Complexity and Technical Demands of the Project

Use DBB when: project is simple, owner wants full control over design, and future maintenance isn’t bundled. Use DBM when: life cycle cost and performance matter, faster delivery is needed, or the project is complex and benefits from integrated delivery.

Experience, reliability, performance

DBM works best over a large network such that economies of scale come into play.

If there is no urgency by implementing Agency it is preferable to construct throughout DBB

In my experience, when comparing DBM(Design-building-maintain) to DBB(Design-Bid-Build), particularly within the framework of OPRC (Output-performance-Based Road contracts), DBM is often the preferred choice due to its emphasis on long-term asset Management. Unlike DBB which typically focuses on the initial construction phase, DBM integrates maintenances responsibilities, ensuring better preservation of the Road over time. this results in greater cost efficiency for the client by minimizing future repair and maintenance expenditures. moreover, DBM enables faster project delivery, as it generally by passes the need for a full feasibility study-unlike DBB-allowing urgent infrastructure projects to be initiated and completed more swiftly

Risk allocation from client to contractor and timelines for achieving the outcome are so short.

The choice between Design-Bid-Build (DBB) and Design-Build-Maintain (DBM) depends on factors such as project complexity, time constraints, risk allocation, and the owner's technical capacity. DBB is often preferred when the scope is clear and the owner wants full control over design and construction, while DBM is more suitable for complex or time-sensitive projects where faster delivery and integrated responsibility are needed. DBM also ensures long-term performance through maintenance responsibility, making it ideal for infrastructure projects with lifecycle considerations.

Project delivery timeline and risk allocation.

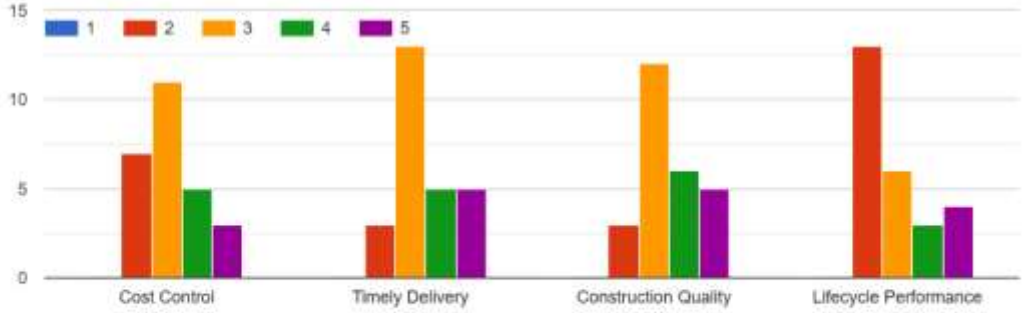
In my experience, when comparing DBM (Design-Build-Maintain) to DBB (Design-Bid-Build), particularly within the framework of OPRC (Output- and Performance-Based Road Contracts), DBM is often the preferred choice due to its emphasis on long-term asset management. Unlike DBB, which typically focuses on the initial construction phase, DBM integrates maintenance responsibilities, ensuring better preservation of the road over time. This results in greater cost efficiency for the client by minimizing future repair and maintenance expenditures. Moreover, DBM enables faster project delivery, as it generally bypasses the need for a full feasibility study—unlike DBB—allowing urgent infrastructure projects to be initiated and completed more swiftly.

Risk allocation and no amendments due to design challenges

Copy chart

8. Please rate the performance of Design-Bid-Build (DBB) and Design-Build-Maintain (DBM) contract delivery methods in Rwandan highway projects across the following performance areas, based on your professional experience. Use the following scale:1 = Very Poor,2 = Poor,3 = Moderate,4 = Good,5 = Excellent

For DBB



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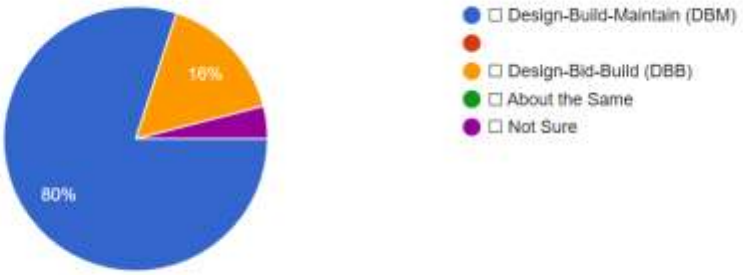
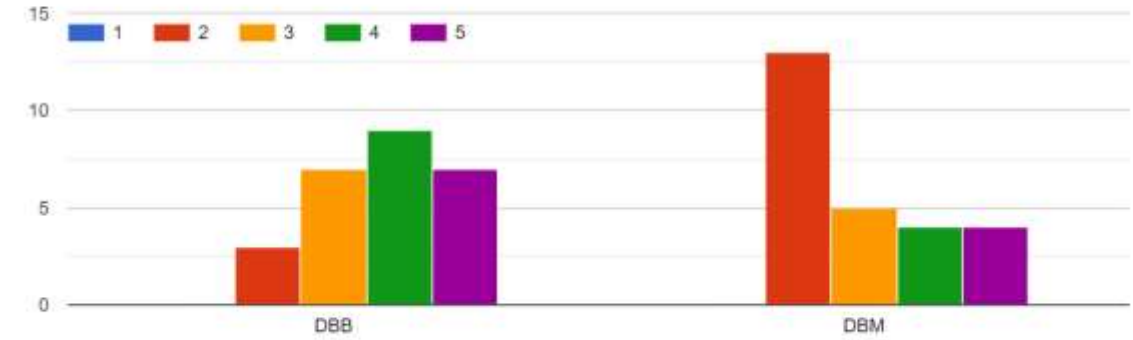
9. **Maintenance Outcomes:** In your professional experience, which method generally achieves better maintenance outcomes for Rwandan highway projects?

25 responses



10. Frequency of Cost Overruns: How frequently have you observed cost overruns occurring in Rwandan highway projects using the following methods.

Use the following scale:1 = Never,2 = Rarely,3 = Sometimes,4 = Often,5 = Almost Always



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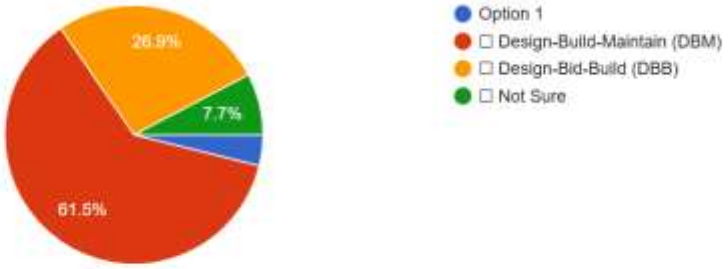
11. **Lifecycle Cost-Effectiveness:** Considering the entire lifecycle of a road (including design, construction, maintenance, and rehabilitation), which method do you believe is more cost-effective for Rwandan highway projects?

26 responses



12. **Perceived Stakeholder Satisfaction:** To what extent do you believe that stakeholders involved in Rwandan highway projects are satisfied with the outcomes of projects delivered using the following contract delivery methods?

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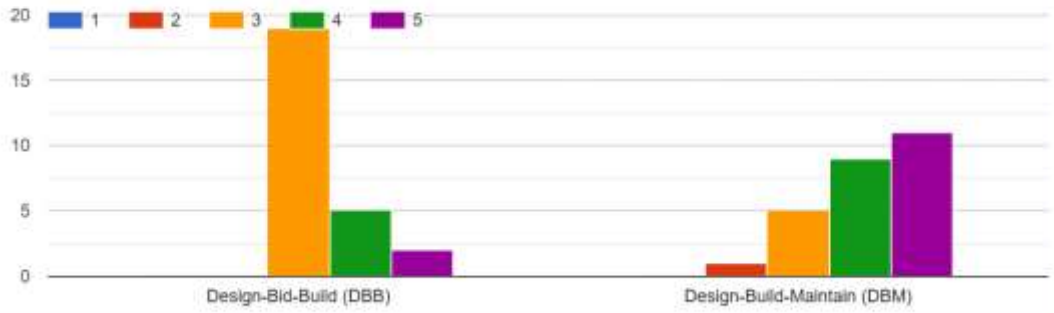
Use the following scale:1 = Very Low (Stakeholders are generally very dissatisfied)

2 = Low (Stakeholders are generally dissatisfied),3 = Moderate (Stakeholder satisfaction is mixed),4 = High (Stakeholders are generally satisfied),5 = Very High (Stakeholders are generally very satisfied)



Appendix III: Interview Questions

1. In your professional experience, how have Design-Bid-Build (DBB) and Design-Build-Maintain (DBM) contracts impacted the overall success of highway projects in Rwanda in terms of cost, time, and quality?
   Purpose: To gather in-depth insights on performance outcomes based on practical experiences.
2. What are the most significant risks you have encountered under DBB and DBM contracts, and how effectively were those risks managed or mitigated under each method?
   Purpose: To understand risk management effectiveness and responsibility clarity in both methods.
3. From your perspective, how do long-term maintenance responsibilities influence contractor behavior and project sustainability under DBM compared to DBB?
   Purpose: To explore whether bundling maintenance in DBM contracts leads to better long-term outcomes.