



COLLEGE OF SCIENCE AND TECHNOLOGY

SCHOOL OF ENGINEERING

**DEPARTMENT OF CIVIL, ENVIRONMENTAL AND GEOMATIC
ENGINEERING**

**A THESIS
ON**

**APPLICABILITY OF DESIGN BID BUILD AND DESIGN BUILD MAINTAIN
DELIVERY METHODS TO ROAD SECTOR PROJECTS IN RWANDA**

Submitted by

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Submitted in partial fulfilment of the requirements for the award of

**MASTERS OF SCIENCE DEGREE IN
HIGHWAY ENGINEERING AND MANAGEMENT**

February 2021

DECLARATION

I hereby declare that the thesis entitled **APPLICABILITY OF DESIGN BID BUILD AND DESIGN BUILD MAINTAIN DELIVERY METHODS TO ROAD SECTOR PROJECTS IN RWANDA** submitted for the Degree of Master of Science in Highway Engineering and Management is my original work and the thesis has not formed the basis for the award of any Degree, Diploma, Associateship, Fellowship of similar other titles. It has not been submitted to any other University or Institution for the award of any Degree or Diploma.

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CERTIFICATE

This is to certify that the thesis entitled **APPLICABILITY OF DESIGN BID BUILD AND DESIGN BUILD MAINTAIN DELIVERY METHODS TO ROAD SECTOR PROJECTS IN RWANDA** is a record of the original bonafide work done by MUNANIRA Silas (REG.NO: 215035100) in partial fulfilment of the requirement for the award of Masters of Science Degree in highway engineering and management, College of Science and Technology, University of Rwanda during the Academic Year 2020-2021.

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ABSTRACT

The Government of Rwanda is investing much money for upgrading the size and quality of the roads infrastructures as the key factor of economic growth of the country. In order to meet this, the Government has established the Rwanda Transport Development Agency as the government institution in charge of the development and construction of the road projects and being sure that the projects are timely and cost effective. Every project is considered successful if it is completed with contractual cost, meet with contractual period and better quality of the end product. The roads projects in Rwanda experienced the cost and time overruns from the terms of the contracts. The main causes of these overruns are related to the variations and changes orders occurred during the projects implementation, there are many reasons in Rwanda which could cause the projects to be unsuccessful and the use of the various projects contracting methods which best fits with the projects can reduce the problems.

A project can be implemented through design bid build, or innovative methods which includes design and build, design build and maintain and construction Management at Risks. The present research analyzes the applicability of the DBM and DBB delivery methods to assess if one of them can be more advantageous compared to another in terms of cost and time. The factors which could influence the proper execution and successful of roads projects in Rwanda for both methods were explored through literature review.

The desk study, questionnaire survey and case studies are used in this research as the research instruments. Data were collected from fifteen samples projects of RTDA among of which six samples are the projects delivered through DBM and nine of them are the samples projects delivered through DBB method, the collected data have been evaluated, analysis and discussions are made on the results.

If Design Build and Maintain delivery method is used, there is more chance to complete a project within provided budget and time. Cost and Time overruns are higher in DBB projects compared with DBM. The causes of the cost and time overruns in the projects delivered with Design Bid and Build method are mainly due to the additional works, variations, design changes and ROW

Particularly, the following factors need to be considered for getting the better results from DBM:

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- ✓ Clients must be capable to certainly and explicitly define his expectations, definition of the requirement and end user needs
- ✓ Conclusions would retain effective fast-tracking on the design documents and construction.
- ✓ For preventing the quality issues over DBM, the approval of the design documents should be strict.

Keywords: Project delivery method, DBM, DBB, Construction schedule, construction cost

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List of Symbols and Abbreviations

NST1	National Strategy for Transformation one
DBB	Design Bid Build
DB	Design Build
DBM	Design Build Maintain
AfDB	African Development Bank
WB	World Bank
JICA	Japan International Cooperation Agency
RTDA	Rwanda Transport Development Agency
CM@R	Construction Management at Risks
LS	lumpsum
GMP	Guaranteed Maximum Price
USD	United States Dollars
FRW	Rwandan Francs
OPRC	Output and Performance Based Output Road Contract
ROW	Right of Way
RPPA	Rwanda Public Procurement Authority
NA	Not Applicable
%	Percentage
BCWS	Budgeted Cost of Work Scheduled
PV	Planned Value
BCWP	Budgeted Cost of Work Performed
EV	Earned Value

ACWP	Actual Cost of Work Performed
AC	Actual Cost
CV	Cost Variance
SV	Schedule Variance
PDM	Project Delivery Method
CPI	Cost Performance Index
SPI	Schedule Performance Index
BAC	Budget at completion
ETC	Estimate to complete
EAC	Estimate at completion

CHAPTER 1 INTRODUCTION

1.1. BACKGROUND

Rwanda as the developing country, has initiated and established development goals through the visions 2020/2050 programme among many others, vision and targets is to eradicate poverty and promote sustainable economic and social development. The infrastructures developments like roads construction are the key of economic growth and country development in general.

Since 2017, the government's 7-year programme & National Strategy for Transformation includes the rehabilitation of 3, 000Km of feeder roads and 800Km of national asphalt roads. These roads are believed to contribute to enhance trade and further to the economic development of the country (NST1).

Institutions in charge of transportation development and particularly road development have different options to select among the various delivery methods.

Recently different delivery methods like design build maintain and design build delivery methods were introduced to the roads sector development implementation programs of Rwanda especially to the projects financed by the World Bank (WB) and the Government of China. Design bid build method is commonly used particularly, to projects financed by the Government of Rwanda, African Development Bank (AfDB), JICA and the European Union.

The need to develop infrastructure at an optimum cost, limited cost and time overruns, on the side of the client and maximize benefits on the side of contractors are some of the main factors that affect a selection of the delivery method. It requires a thorough understanding of the different delivery methods.

A clear understanding of the merits and demerits of the delivery methods is vital in selecting the appropriate method to the given projects according to the financing arrangement, start and completion time requirements, payment modalities, etc.

1.2. PROBLEM STATEMENT

Every project is considered successful if it is completed with contractual cost, meet with contractual period and better quality of the end product. Among the road projects delivery methods which are available, there are no straightforward guidelines for selecting one method versus another. The necessities of meeting projects main objectives have pushed the clients to use the innovative construction(delivery) methods, some the alternative methods include design bid build and design build and maintain.

When deciding a road delivery method for any kind of the project, Client must deliberate different aspects which can happen such as definition of the technical specifications, unexpected circumstances, possible variations in the works, financing, risks transfer, constraints related to the budget and construction period, quality issues, besides others.

One of the main objectives of the contract is to assign the risks and profits among the contracting entities. Different projects contracting approaches were established to act in various manners by Clients, financing agencies, contractors and consulting firms and accept risk. Contract should be prepared in properly way so that it assigns the project risks to the contracting entity who accept them and of course should be paid for bearing the risks.

Consequently, the two mostly Road delivery (DBM&DBB) in Rwanda are evaluated and analyzed, their advantages, disadvantages, and selection criteria. There are four main data sources of this research which are Rwandan Transport Development Authority (RTDA), contractors, and consultants and Experts in industry, we are very confident that the data from them will allow us to draw the reliable inference. Documents review, discussion with the professionals and questionnaires are the main instruments of this research. Descriptive statics and desk study are used to design the research.

1.3. STRUCTURE OF THE THESIS

The approach used for the present thesis is based on qualitative study of exploratory types that analyses conditions, evaluate scenarios for good performance among the two projects delivery methods. The roadmap used for this thesis has 4 key parts as explained below:

- ✓ **Elaborating the base of the research:** for describing the research theoretical basis and elaborating the related questions,
- ✓ **Data collections:** for determining the most used road contracting(delivery) method in Rwanda,
- ✓ **Results analysis:** for analyzing the results(findings) from the case studies in relations of the theoretical proposals by using descriptive statistics,
- ✓ **Conclusions and recommendations:** for drawing the conclusions and recommendations from the research outcomes

the chart below illustrates strategy to the research

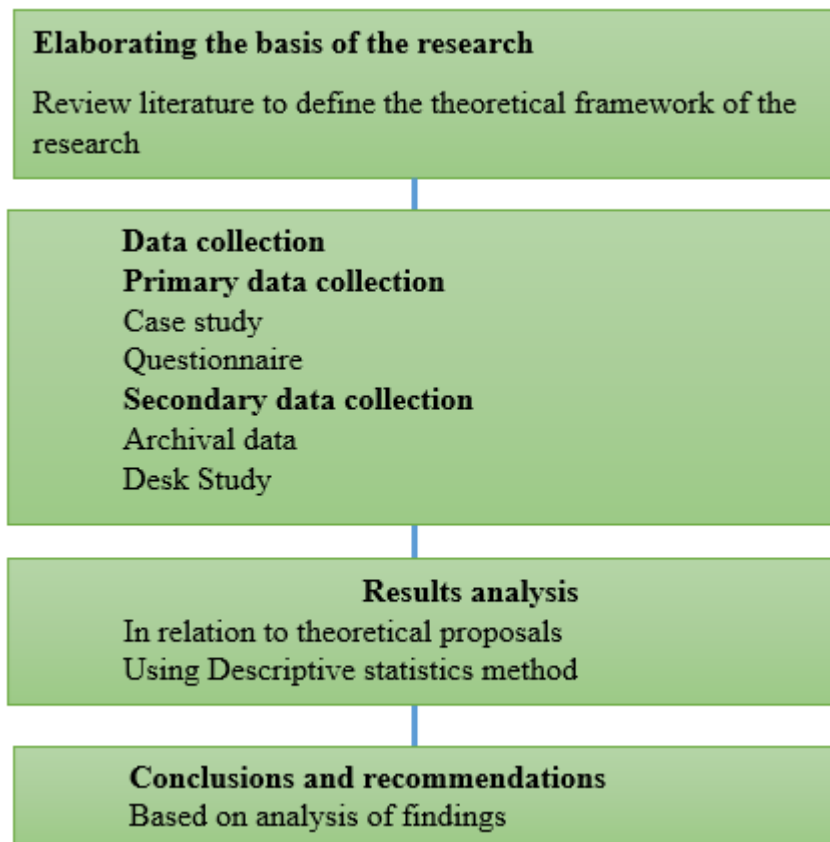


Figure 1-1 The Flow Chart of the research

1.4. OBJECTIVE

1.4.1. General Objective

The purpose of this research is to conduct comparison study between DBM and DBB road contracting methods in Rwanda in terms of construction cost and construction schedule.

1.4.2. Specific Objectives

- ✓ To collect data on the different project delivery methods presented in international literature.
- ✓ Compute the comparative schedule and cost variances for both contracting approaches
- ✓ Draw a complete assessment of the two delivery methods

1.5. THE RESEARCH QUESTIONS

Projects cost, completion dates and quality of the end products are the main three critically deliverables for the client. The main issue of the clients is how to monitor and be sure that those issues are addressed through project contracting methods. As per the main purpose of this research, assessment and analysis are done for evaluating which delivery method can be applied to the roads construction in Rwanda.

For selecting a road project delivery method, you have to consider the following questions:

- ✓ Which are the criteria to use for selecting road delivery method?
- ✓ For which conditions, one delivery method can be a good choice to road project?

1.6. SCOPE OF THE STUDY

The research starts with a literature overview in order to provide the theoretical context about Design bid Build and Design Build Maintain project delivery method in Rwanda Transport Development Agency. Data collection for different ongoing projects or completed projects about those two delivery methods was collected.

The collected data formed the basis for comparative analysis of the performance and development potential of the DBB and BBM road project delivery methods. Finally, the recommendations are drawn up in the conclusion Chapter 5.

The major challenge in this research is related to the number of projects delivered under DBM method that are still limited in Rwanda. As it is the new approach in Rwanda, it is challenging to get satisfactory information/data for the research concerning the projects under implemented with DBM method. By contrasting to DBM method, the DBB method has enough available data. Even if the DBM method in the new approach, recently introduced by Rwanda Transport Development Agency, the available data are analysed carefully for interpreting the outcomes of this research for other type of road projects delivery method.

Therefore, the merit of this research depends in involvement of the appreciation of the advantages of the suitable project's delivery methods, since it seems there is a relationship between projects delivery methods, time and cost overruns and projects performances.

1.7. OUTLINES OF THE RESEARCH

The research is divided into five Chapters. Chapter one is introduction and it discusses the background, problem statement, structure of thesis, objectives, the research questions, the scope of the research and a brief outline of the research. Chapter two describes the part related to the literature review of the research; it includes an overview about DBM and DBB, as well as their applicability in the projects delivery systems.

Chapter three describes the research methodology; it consists of the research strategies, design, data analysis and report writing. Chapter four describes the part related to discussion and analysis of the collected data. It includes the findings on the applicability of DBM and DBB delivery methods to road sector projects in Rwanda. Chapter five presents conclusions and recommendations of the research.

CHAPTER 2 LITERATURE REVIEW

2.0. Introduction

This is normally agreed that a project may be viewed as successful if it is completed by fulfilling the required and agreed specifications within the agreed price at the agreed time and safety. The key factor hindering the project's completion with in the expected time, cost, etc is the appropriateness of the delivery method selected and deployed (Martin R, Skitmore, & Love, Peter E.D 1995)

Projects mostly suffer from Cost and time overruns. The reason could be varied. These could mainly be due to variation orders changes in the site conditions and omissions in the contract documents (Anwar M. Omar 2007)

They exists numerous methods and amalgamations of methods to deliver a construction project. One such method is contact out of capital venture projects to the entrepreneur segment, which is actually being practiced in infrastructure projects. Outcomes of the studies clearly show that no considerably new projects contracting method, however adjustments from merely, or minor differences from the existing ones.

It requires a specific knowledge to the various types of the projects contacting methods to the client for selecting the most appropriate one for delivering a project with respect to specific project objectives.

Several researchers defined project delivery method in different ways though the basics and main acceptances are the similar but generally, it is defined as the relationship structure of the contracting entities, their mandates and detail description of the works/activities to perform for delivering a project. Whatever the method structure, they are three main entities involving in the project development such as Client, consultants and Contractor. The structure relationship and mandates of the involving entities may significantly differ according to the different projects delivery methods. Therefore selecting a project delivery method is key parameter that affects the success of the project. Every project delivery method has its own merits and demerits under different conditions, its appropriateness have to be considered separately according to the particularity of every project.

2.1. PROJECT DELIVERY METHODS

The way a project is designed and implemented is the crucial choice made by each client embarking on for a project execution. Through a diversity of delivery approaches in use today across the design and construction industry, it is conceivable to tailor a delivery method that greatest meets the unique requirements of every client and every project.

Major differences among delivery methods lie in:

- ✓ Contract Concept and importantly the entities to whom the risks and tasks are allocated,
- ✓ motivations to enhance the agreement necessities
- ✓ mission to carry out contract administration and additional services for managing the projects

The urgency, project size, complication, uncertainty and client participation affect the selection of the delivery method. Therefore, the client decides on how he will involve in the project, either by appointing in house project engineer, or by hiring a consultant for this role. The Engineer is the one who representing the client in delivering a project whatever the method is adopted. The client's staff is responsible for overall coordination of the project including the overseeing of the design, scheduling, project accounting and control of the construction works (Touran, Douglas D. Gransberg and Keith R. Molenaar, (2009).

They are three ways of structuring a project delivery method which includes the single, dual and triple sources of responsibilities. The projects are delivered through these fundamentals methods/structures together with a considerable available number of hybrids from merely methods.

The following section describe briefly main delivery systems used in the projects development

Design Bid Build (DBB): In a DBB project the owner initially enters into a contract with the designer for design services. The designer works with the owner to develop the owner's project requirements, from which point the designer develops a design. That design is then put out for bid, allowing the owner to select a constructor for the project. Upon the client's selection of a contractor based on the bids received, the project proceeds to construction. The project is designed with little, if any, input from the parties actually constructing the project. As a result, a significant amount of constructability and/or coordination issues are not discovered and resolved until construction (AIA, 2007 Version 1).

Design Build (DB): Design-Build is characterized by single point of responsibility for both design and construction activities. The Client often chooses Design Build to transfer risk and coordination

effort to one contractual entity and to assure a higher level of coordination. The owner's role in Design-Build has typically required heavy involvement early in defining the project criteria, followed by less management later on as the design-builder executes the project in conformance with the established criteria.

Many Clients choose Design Build in order to reduce project-based risk. By combining design and construction under single entity, coordination, constructability and cost of change is presumed to be improved. Most of the risk is borne by the design builder, often in exchange for retaining some or all of any savings identified.

The design-builder accepts the owner's design criteria and exerts greater control over the project from thereon. Project success is often measured by improved project delivery time or cost savings found by the design-builder as compared to the agreed-upon Guaranteed Maximum Price. The burden is on the owner to be clear on the acceptable level of quality expectations through descriptive, quantitative or performance requirements in the owner's design criteria

Design-Build procurement may take many forms including, but not limited to:

1) qualifications only selection, 2) best value selection with criteria documents provided by the owner, or 3) price driven selection with detailed bridging documents provided by the owner, this broad spectrum sets the stage for various levels of integration that may be possible under design-build (AIA, 2007 Version 1).

Design Build -Maintain (DBM): Design Build- maintain delivery method is a form of Design Build (DB) where Owner invest in design, Construct/Operate and Maintain a road project for a specific term. (John Walewski, G.Edward Gibson, Jr. Jason Jasper 2001)

Construction Management at Risks (CM@R): CMc offers the same direct owner-architect and owner-contractor contractual relationship as Design-Bid-Build: the advisory benefits of CMa, and the early cost commitment characteristic of Design-Build. It differs from Design-Build in that design remains the responsibility of an architect, who has contracted independently with the owner. The CMc delivery model introduces the constructor prior to construction to oversee scheduling, cost control, constructability, and to bring additional expertise to project management, building technology, and bidding or negotiation of construction contracts. In the CMc model, the constructor is typically selected through a qualifications-based selection early in the design phase and paid a fee for services performed in the design phase. The principles of integration suggest that the construction manager should be involved in the project as soon as possible. Indeed, in one variation of CMc,

Negotiated Select Team (NST), the client contracts with the CMc at the beginning of design, if not even earlier (AIA, 2007 Version 1).

The two delivery methods DBM and DBB are the subject of this research. Even if every method can appear in different organization forms but every method is based on various fundamentals commitments to the clients,

2.1.1. Design Bid Build (DBB)

Design bid build is defined as the delivery approach where a client hire an engineer under design service contract for performing the project study, preparing drawings and the technical specifications, then after at-risk construction, contracts with contractor by competitive bidding or negotiation (DBIA, 2007a).

It is the simplest process method to manage and well comprehensible by clients, consultants and contractors. Under design bid build approach, Client hire a consulting firm for preparing the documents of the contract including the drawings, bill of quantities and technical specifications. Once the design stage is completed and design documents are available, the advertisement of the works contact follow and contractors start the bidding stage. At this stage, Contractors note all project requirements and then make quotations and prepare the required documents and then submit their bids to the client at the required time and at the right place. After receiving the bids from contractors, the bids opening and their review take place, subsequently a company with most responsive offer is awarded a contract.

The figure 2.1 illustrates the relationship structure in the DBB delivery method (Shawn D. Moore, 1998)

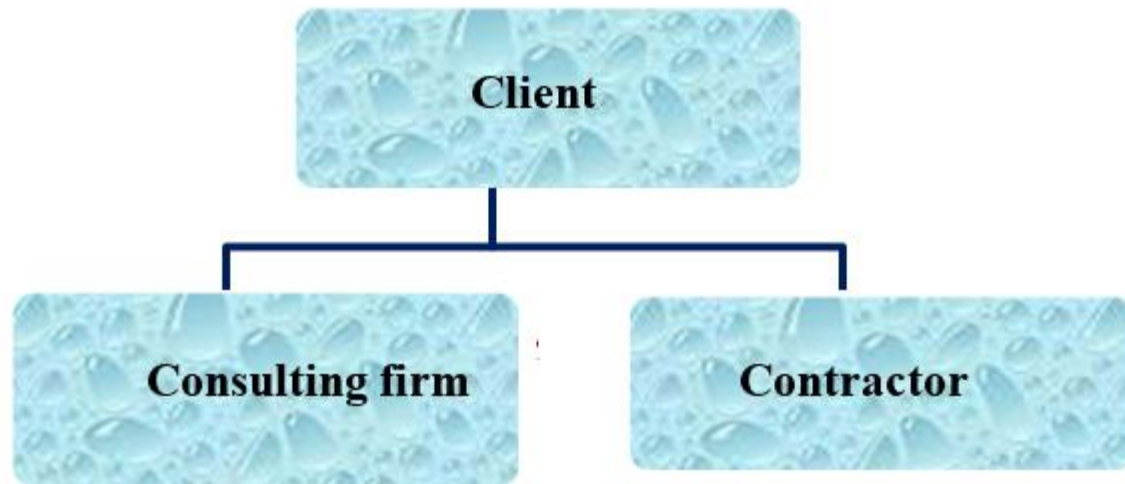


Figure 2-1 Relationship structure of the DBB Projects

The Design Bid Build (DBB) was the primary method used before innovative contracting was introduced in the last twenty years, primarily because of statutory public purchasing laws. In the traditional system, project award is based solely on cost, with no consideration of qualifications, schedule, or past performance. In a traditional delivery system, the design is 100% complete before the client is able to solicit bids. The process requires the longest overall project time to completion.

2.1.1. 1. Main stakeholders in Design Bid Build

The Normal contracting procedures in the design bid build approach involve three main stakeholders such as client, consultant and contractor.

The table below (Table 2.1) illustrates primordial roles of the key stakeholders involving in a public construction project under design bid build approach.

Table 2-1 Main stakeholders of DBB Delivery method

Main Stakeholders	Key responsibilities
Client/Owner	Financing the project works
	Define the project scope
	Make available of all requirements for providing the facility
	Key player of the project implementation

Engineer	Prepare the contract documents including the drawings, BOQ and technical specifications
	Contract management, control and supervise the project works
	Review of the outcomes from the project design
Contractor	Implement the project
	Managing various resources for constructing a facility
	construct a facility according to the study

Source: Major US construction Project David M, 2004

The characteristic of DBB approach includes the following:

- ✓ 3 linear stages: design, bid and build.
- ✓ Legally drafted careful and guidelines procedures
- ✓ Most responsive bidder with lowest price
- ✓ Availability of the design/contract documents beforehand the construction stage
- ✓ Comprehensive conditions/specifications which could guide to the best quality
- ✓ Clear understanding to all contracting entities of the end product

2.1.1.2. Time Line of DBB

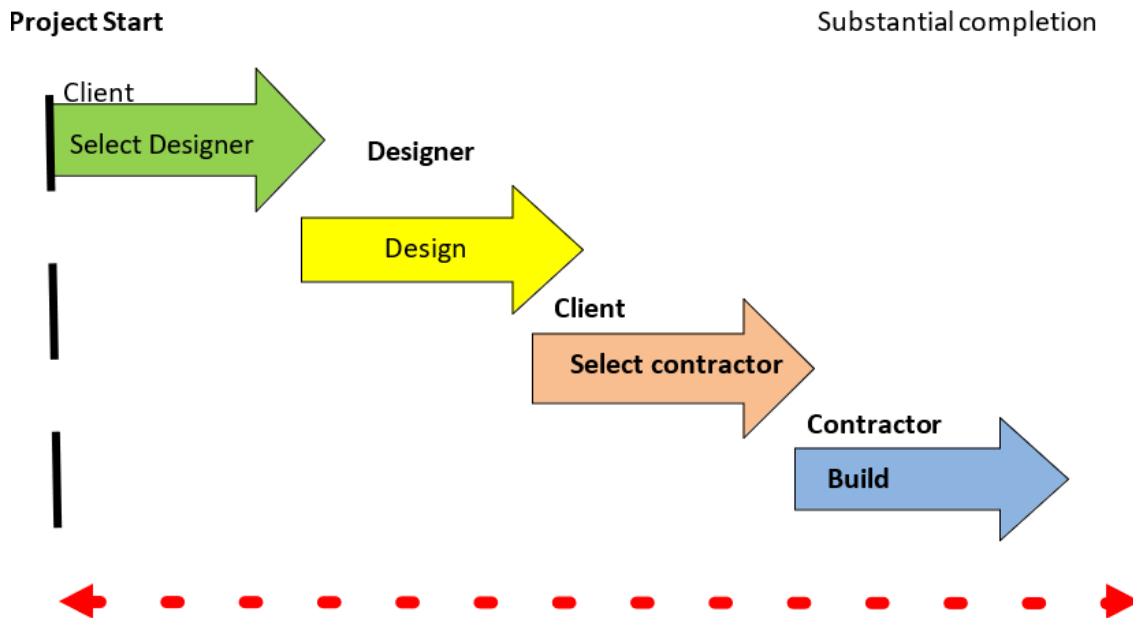


Figure 2-2 DBB timeline

The Client firstly hires and signed a contract with a design consultant for preparing the study/design documents of the project. The further step, Client prepares the request for proposals and invites the contractors to submit their bids for the project. A number of builders could submit their bids but he most responsive with lowest price bidder will be selected for signing a contract with a client.

The Figure 2.2 illustrates the sequences stages for DBB (Tenah K.A. 2001 Project Delivery systems for construction).

2.1.1.3 Merits and Demerits of Design Bid Build Project Delivery system

Merits

- ✓ The contractors bid according to the completed design documents for maximizing the built product for the price.
- ✓ The client selects a contractor based on the qualifications and ability.
- ✓ Explicitly definition of the reliabilities and responsibilities of both design and construction stages

- ✓ Client participation in the design processes
- ✓ Contractor know at early stage the methods and means required for delivering a project
- ✓ Method is most used by many institution for delivering the roads project
- ✓ Client monitor the design and construction works
- ✓ The constructional price is fixed at a contract award (until changes orders)
- ✓ Moderately easy of application
- ✓ Client control design or construction quality

Demerits

- ✓ Design Bid Build construction stages are consecutive and the bidding procedure might need more time
- ✓ The Client owns the risks of the final account of the project. The exact cost of the project remains unknown till the completion of the bidding and design review stages,
- ✓ Client is at risks to contractor for design errors
- ✓ The cost of the works remain unknown until award of the contract,
- ✓ No inputs from the contractor during the design stage
- ✓ Many risks remain with the Client
- ✓ The method may be arguable once the variations and request for time extension occurred frequently

2.1.2. Design-Build Maintain (DBM)

Design Build- maintain delivery method is a form of Design Build (DB) where Owner invest in design, Construct/Operate and Maintain a road project for a specific term. (John Walewski, G.Edward Gibson, Jr. Jason Jasper 2001)

DBM models have potential to deliver better value for money for the client than traditional models through risk transfer, long-term contracts, outcome emphasis, performance measurement and incentives, and private sector management skills. At the same time, DBM leads to increased international competition and involves more complicated procurement and tendering processes than other models. DBM requires that the project scheme is prepared further to allow setting appropriate

quality requirements, as often the biggest problems are associated with inadequately specified environmental issues. Also, the design directives have been too loose and allowed differing interpretations. As operation of roads requires highly specialized equipment and is generally delivered by specialist contractors, according to some sources, there may not be adequate synergies in including this into the DBM contract. Instead there are clear benefits in including periodic maintenance into the contract.

The viability of the project is dependent on risk identification and allocation. Delay and project risks are identified as the main risks affecting the success of a DBM project. Cost and legal risk are also considered significant. As these risks are transferred to the gathering best able to manage them, the price of risk management should be lower than traditionally. The client is typically in the best position to carry risks when:

- there are no risk management systems that would allow safe-guarding against the risk or spreading it
- the risk is so large that the authority is the only realistic risk manager
- determining risk probability and pricing of risk is very difficult.

DBM enables fast project delivery as a result of parallel design and construction and the lack of financial limitations. While short project duration decreases overhead costs and the capital tied in the incomplete road, it may in some cases actually increase construction costs.

Adequate and flexible private financing enables efficient schedules accompanied with efficient use of resources. This reduces project costs. The construction cost does not significantly differ from the DBB as most savings are made in maintenance and overhead costs.

DBM contracts may vary extensively, but the common de-nominator for the contracts is the responsibility assigned through a single contract to the private sector to design, build and maintain the asset for the contract period. Thus, DBM replaces the purchase of an asset with the purchase of services. In DBM the customer classifies the project's desired end result and service levels, and defines clearly the scope of work. Customers prepare a technical and price proposal showing how they intend to deliver the project. The assortment can be based on quality, price or on a price/quality combination. Combining design, construction and maintenance and operation creates a single point of responsibility.

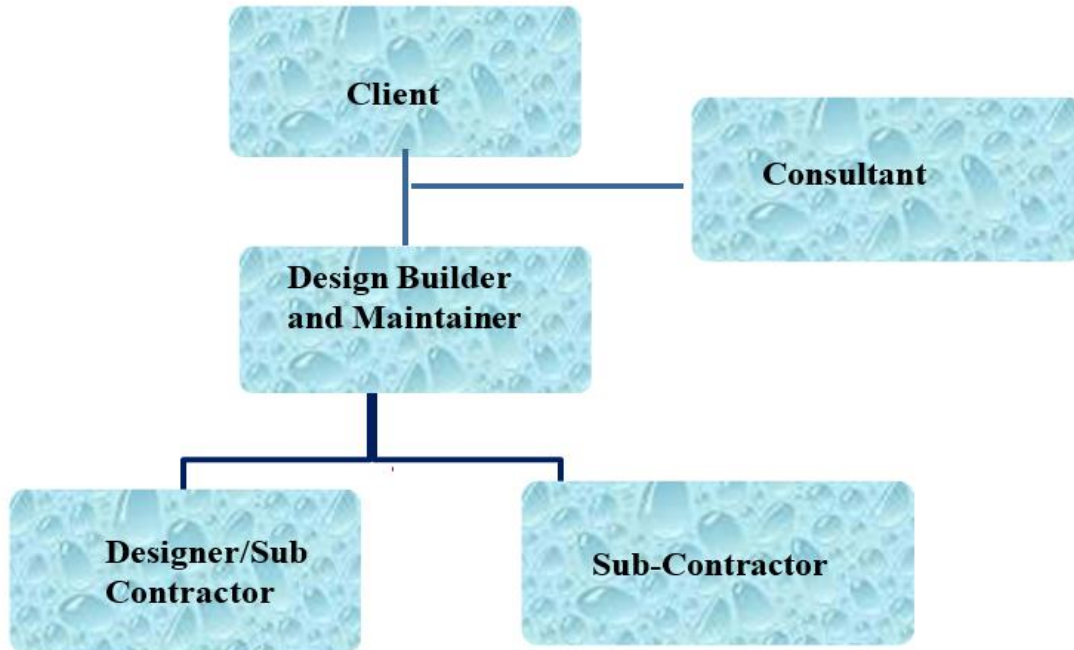


Figure 2-3 relationship structure of the DBM Projects

Source: John Walewski, G.Edward Gibson, Jr. Jason Jasper 2001

2.1.2.1 Time Line of DBM

The Client prepares the RFP and inviting the contractors to bid for carrying out both design and construction works of the project.

It is not necessary to wait until 100% of the design works for starting the construction works, for instance, the design build firm may prepare and complete the design of a certain road segment, then contractor can start the construction works of that section while the design is being done for the remaining part of the road.

The Figure 2.4 illustrates the sequence stages for DBM contract (Tenah, K.A. 2001).

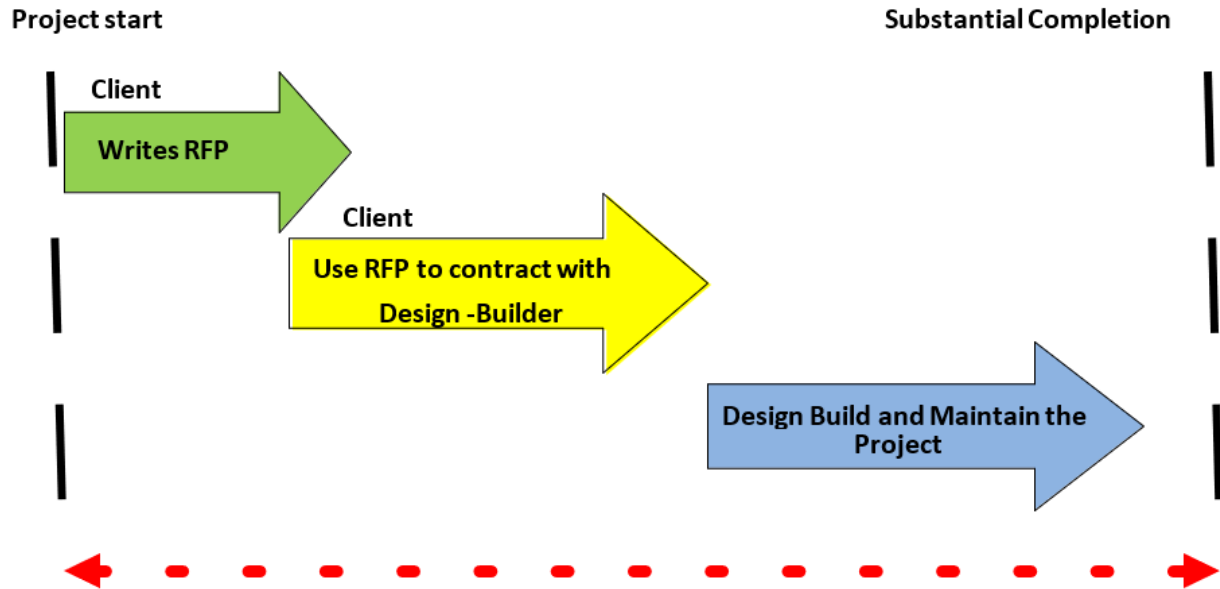


Figure 2-4 DBM Timeline

2.1.2.2. Merits and demerits of DBM Project Delivery method

Merits due to time management

- ✓ Initially contractor participation that allows construction engineering deliberations to be combined into the design phase and improves the constructability of the engineered project plans.
- ✓ Begin pursuing of the design and constructing part of the project, by concurrency of design and construction phases for various sections of the project;
- ✓ Eliminating the distinct construction contractor bid phase following accomplishment of the design stage.

Merits of cost saving

- ✓ Effectiveness of information sharing and completeness between design, construction engineering, and construction team members through project schedule;
- ✓ Saving of the design cost on the client's side
- ✓ Less changes and variations orders
- ✓ Decrease possible ligations and claims that may be raised after the project completion

Table 2-2 merits and demerits of DBM project delivery method

No	Merits	Demerits
1	It is not necessary to complete the whole project design before the contract award	Client participation in the design stage is generally limited.
2	Flexible to start the construction works before the approval of the final design documents	Contractor can deliver the end product of the low quality for maximizing his profit
3	Creates single entity contractual responsibility	Construction cost commitment is made before completing the design documents, therefore the divergences on the design intentions and the quality of the end product may arise later
4	Reduces errors, omissions, and rework claims	conflict of interest with role as designer and contractor
5	Time saving	Competition is limited. It requires only the big companies
6	Early cost and scheduling commitment	design team may not independent from the construction contractor

2.2. ASSESSMENT CRITERIA FOR EVALUATING DBB AND DBM DELIVERY METHODS

The main parameters to consider for evaluating/selecting the suitable method between the available delivery methods are mainly the following:

- ✓ Certainty of the project duration
- ✓ Project cost
- ✓ Quality of the end product
- ✓ Reduction of the client's burden for administrative control of the project

Relevant literatures on DBM approach project delivery shows that advocates practice the same parameters for assessing the effectiveness and applicability of the DBM and related hybrid for delivering the projects. With the help of the merits and demerits of practicing the DBM over DBB the present research use the below parameters for assessing the efficiency of the DBM over DBB delivery methods in Rwanda:

- ✓ Project period, includes the following phases:
 - Project conception to tender award
 - Tender award to contract completion
- ✓ Project cost, includes the following :
 - Planning of the project
 - Management of the project
 - Project study/design
 - Project implementation/construction

Generally the Clients consider the project period/duration as the key parameter for motivating the funding agencies to try the DBM approach. Alongside of the relationship based to the contract, both delivery methods are distinct with the chronological activities as per the below figure (figure 2.5).

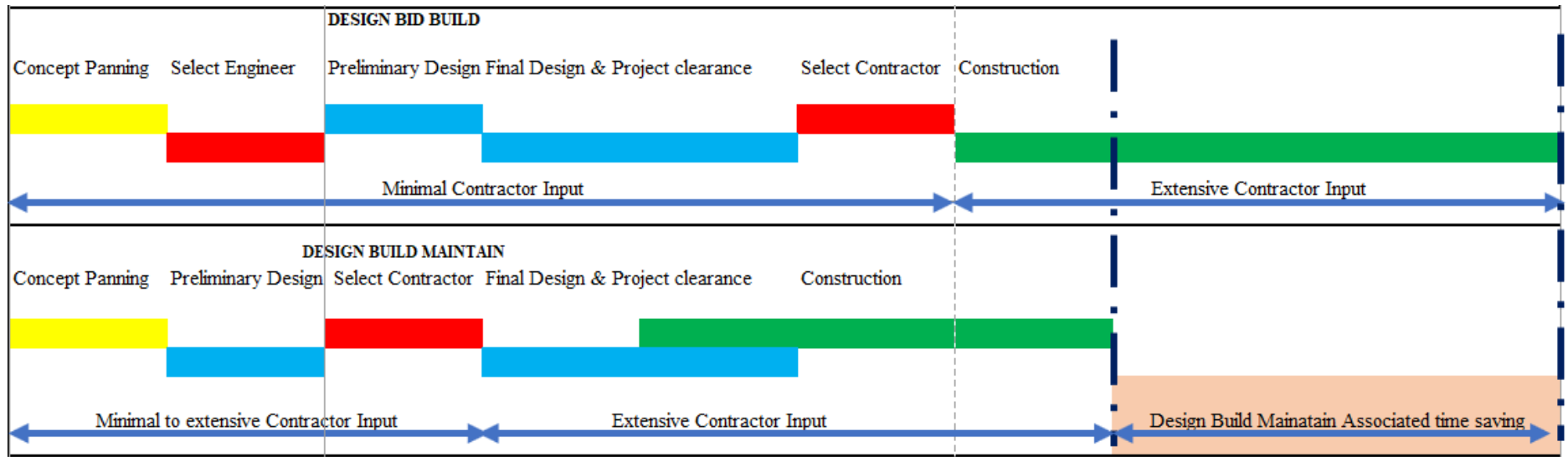


Figure 2-5 illustration of the time saving of DBM versus DBB

Source: Dr. Keith Molenaar, University of Colorado at Boulder

The second important parameter for choosing DBM is the cost control of the project, especially the clients who wishing to reduce the impacts of the variations orders related to the cost of the project. The quality issues are important criteria of the project for which clients emphasizing irrespective of the applicability of both deliveries approach. Furthermore, fairness and competitive level are the important subject in the debate of the DBM over DBB delivery approach.

The more parameters to consider for judging the performance of the DBM approach includes the following:

- setting of single point of responsibility to the contractor;
- assign the risks to the contractor
- Minimize the client's burden (administratively) after the contract award.

2.3. CAUSES FOR SCHEDULE DELAY ON PDM

They are two causes/sources of schedule delay in the project delivery method such as internal and external causes. The internal ones come from the four main stakeholders namely client, design consultant, contractor and supervising consultant. The external sources are from per example lack of materials, from supplier, weather, etc.

The researchers have elaborated the aspects which could cause the schedule delay in the construction projects and grouped them in four categories as per the below paragraphs according to Ahmed et, al (2003) and Alaghbari et, al 2007):

2.3.1. Contractor's responsibilities

Contractor's responsibilities are mainly related to the following:

- ✓ Delay in delivery of materials to site
- ✓ Shortage of material on site
- ✓ Construction mistake and defective work
- ✓ Poor skills and experience of labor
- ✓ Financial problems
- ✓ Poor project management

- ✓ Shortage of equipment on site

2.3.2. Engineer's responsibilities

The Engineer's responsibilities are mainly related to the following factors:

- ✓ Absence of the consultant's staff on site
- ✓ Lack of experience of the consultant's site staff
- ✓ Lack of experience of the consultant firm
- ✓ Slow in decision making and in giving instructions
- ✓ Incomplete documents

2.3.3. Client's responsibilities

The client's responsibilities are mainly related to the following factors:

- ✓ Lack of working knowledge
- ✓ Slow in decision making
- ✓ Lack of project coordination
- ✓ Contract modification
- ✓ Financial problems

2.3.4. External causes

The external factors are mainly related to the following:

- ✓ Lack of material on the market
- ✓ Lack of equipment and tools on the market
- ✓ Poor weather condition
- ✓ Poor site conditions
- ✓ Poor economic condition
- ✓ Changes in laws and regulations

2.4. METHODS OF CONTRACT AVAILABLE TO THE CLIENTS

Contracting options

Agreement and compensation techniques for professional services and constructional services will normally fall into one of three classes;

- ✓ Lump Sum (LS)
- ✓ Guaranteed Maximum cost (GMP)
- ✓ Reimbursable

These options are not exact to any specific delivery method, and might be applied to contracting for professional services, such as design, engineering, and constructional administration, as well as contracting for construction services.

Lump Sum contracting is when a client makes an agreement with another entity to carry out the works of the fixed scope and the payment is performed on lump sum basis.

GMP contracting is an arrangement in which a client contracts with an entity to achieve a secure scope of work in exchange for a practice that is certain to not exceed a stated maximum cost. Typically GMP will include the best price along with several allowances and possibilities that, depends on their eventual practice, may result in a final price below the stated GMP. Once “savings” may fall to the proprietor or may be shared with the entity providing the GMP.

Reimbursable contracts come in variability of forms, and are sometimes attached with a not-to exceed maximum cost. With payable contract, a proprietor contracts with an entity to perform a fixed or variable possibility of work in exchange for a payment based on some approved calculation method

The forms of reimbursable contracts include:

- Unit Price – payment is based on actual quantities at set unit prices.
- Cost Plus Fixed Fee – payment is based on actual cost plus a fixed fee.
- Cost Plus Incentive Fee – payment is based on actual cost plus an incentive-based fee.
- Cost Plus Award Fee – payment is based on actual cost plus a performance-based fee.
- Time Spent – payment is based on actual hours spent at set billing rates.
- Time and Materials – payment is based on actual costs with a fixed markup on costs.

2.5. EARNED VALUE

Current performance is the best indicator of future performance, and, therefore, using trend data, it is possible to forecast cost or schedule overruns at an early stage in a project. The most comprehensive trend analysis technique is the Earned Value method (by Duncan Haughey)

Earned Value is an approach where you monitor the project plan, actual work, and work completed value to see if a project is on track. Earned Value shows how much of the budget and time should have been spent, considering the amount of work done so far.

It help the manager to identify the risks which could occur in the project, subsequently the manager could prepare the mitigation measures on work progress, actual cost and actual schedule. As a set of guideline, it helps in the company management system.

The following are the basic parameters to use for the cost performance analysis by using earn value approach:

- ✓ Budgeted Cost of Work Scheduled (BCWS) or Planned Value (PV)
- ✓ Budgeted Cost of Work Performed (BCWP) or Earned Value (EV)
- ✓ Actual Cost of Work Performed (ACWP) or Actual Cost (AC)
- ✓ Cost Variance (CV)
- ✓ Schedule Variance (SV)

BCWS or PV is the sum of budgets for all work packages scheduled to be accomplished within a given time period. BCWP or EV is the sum of budgets for completed work packages and completed portions of open work packages. For illustration and graphical representation see figure 2.6

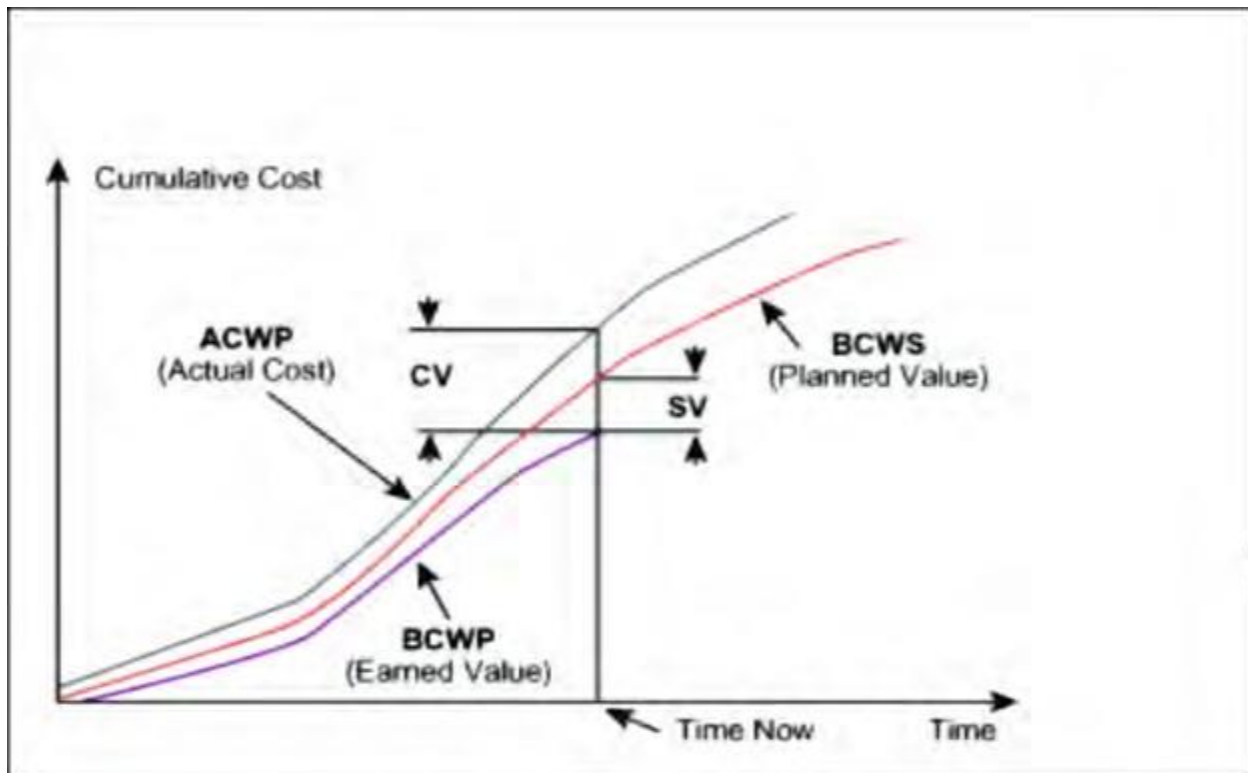


Figure 2-6 S-Curve for Earned Value Analysis

Source: Public Procurement Best Practice Guide 2.9.1

2.5.1. Earned Value Analysis

Earned Value Analysis is the project management tool that can objectively status cost and schedule performance in real time (Design www.pierdesign.ca).

The earned-value system is used to monitor the progress of work and compare accomplished work with planned work. The BCWS is the amount of money that was planned, or budgeted, at each time period in the project. It is determined by cost loading the CPM diagram to determine the distribution of cost in accordance with the project plan. The S-curve for a project represents the BCWS. The ACWP is the actual amount of money that has been spent at any point in time during the project. It is determined from accounting records or the responsible party that keeps records of actual expenditure of money. The BCWP is the amount of money earned based on the work that has been completed. It is determined by multiplying the percent completed by the budgeted amount for the work. Below is a summary of the terms used in an earned-value analysis.

Earned-Value Analysis:

BCWS = Budgeted cost of work scheduled (Planned)

ACWP = Actual cost of work performed (Actual)

BCWP = Budgeted cost of work performed (Earned)

Variances:

CV = BCWP – ACWP (Cost variance = Earned - Actual)

SV = BCWP – BCWS (Schedule variance = Earned - Planned)

Indices:

$$CPI = \frac{BCWP}{ACWP}$$

$$Cost\ Performance\ Index = \frac{Earned}{Actual}$$

$$SPI = \frac{BCWP}{BCWS}$$

$$Schedule\ Performance\ Index = \frac{Earned}{Planned}$$

Forecasting:

BAC = Original project estimate (Budget at completion)

$$ETC = \frac{BAC - BCWP}{CPI} \text{ (Estimate to complete)}$$

EAC = (ACWP + ETC) (Estimate at completion)

Ratios are used in the earned-value system to predict the cost to complete a project. The CPI is used to predict the magnitude of a possible cost overrun or underrun. It adjusts the budget based on past performance. The SPI is used to predict the magnitude of a possible time advance or delay. It adjusts the schedule based on past performance. The following examples illustrate the calculations in an earned-value analysis. The examples progressive analysis of the project with an interpretation of the results based on the earned-value system for assessing project performance.

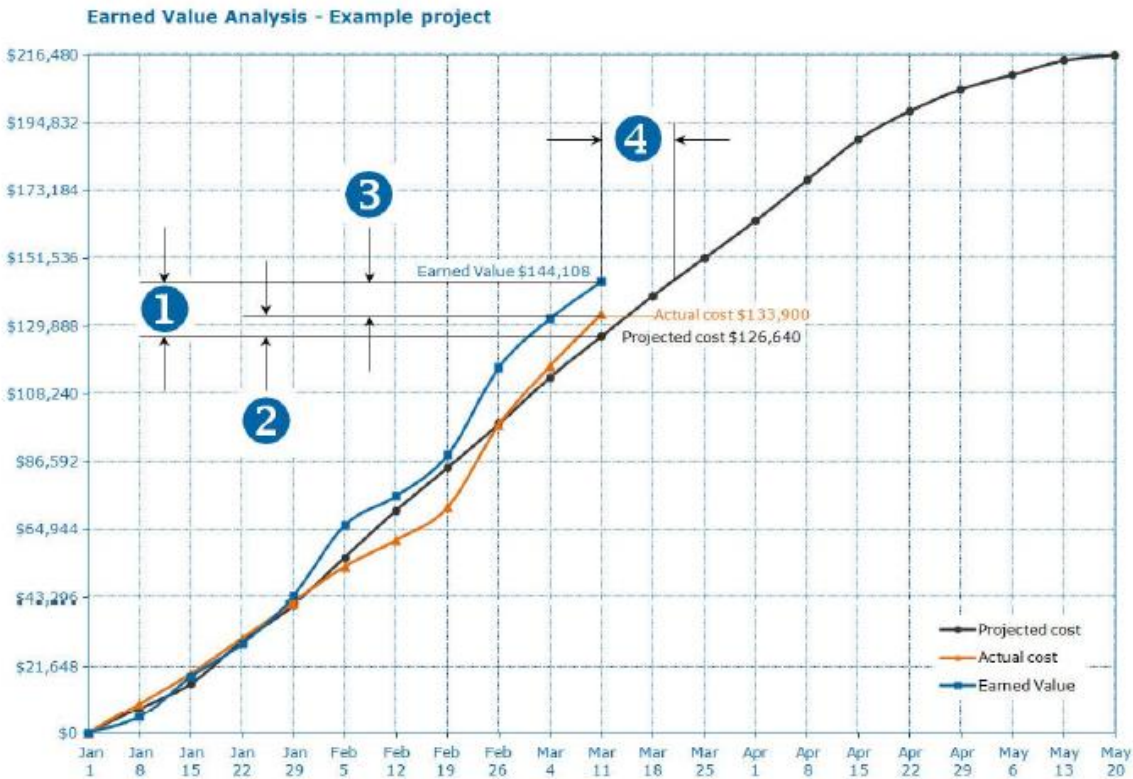


Figure 2-7 S. Curve for Earned value Analysis

Source: Pier Design [www. Pierdesign.ca](http://www.pierdesign.ca)

The figure 2.7 indicates the planned value, actual cost and earned value for a project. when planned spend curve is compared to the actual spent, it show a variance of 17, 468 USD which indicates to the project manager that the project will be completed at low cost compared to the planned value.

2.6. DELIVERY METHODS IN RWANDA ROAD CONSTRUCTION PROJECTS

With no doubt, the goal of every client in selecting a project delivery method must make certain that approach shall satisfy the project objective and allowing the project to be implemented and completed within the provided budget and on due time. The selection must take into consideration the safety and quality of the end product and client participation in both design and implementation phases. The capability of the contractor to execute the project activities can also be the parameter to consider in selecting project delivery method.

By exercising this in Rwanda, nevertheless, it seems that these parameters are not considered. Almost all construction projects are delivered through design bid build approach. The Literature reveals that many of the clients from public institutions do not even know the existence of the other alternative methods. However, recently some innovative methods have been introduced in the country and thus show that there are no exclusions of the applicability of the other alternative delivery methods in Rwanda!! For instance, Rwanda Transport development Agency (RTDA) tried the design-build and maintain method in unpaved road projects. The City of Kigali is also employing the design-build method to deliver one road project successfully. That is a change from the DBB approach.

2.6.1. Some project under DBB

1. Rehabilitation, Upgrading and Maintenance Works of Selected Feeder Roads in Rwamagana District (93Km)
2. Rehabilitation, Upgrading and Maintenance Works of Selected Feeder Roads in Gisagara District (71.8Km)
3. Rehabilitation, Upgrading and Maintenance Works of Selected Feeder Roads in Nyamasheke District (52.3Km)
4. Rehabilitation, Upgrading and Maintenance Works of Selected Feeder Roads in Karongi District (75Km)
5. Rehabilitation and periodic maintenance work of Giticyinyoni- Ruli – Rushashi - Gakenke road (68.7km),

6. Execution works for periodic maintenance works of Kaduha –Buhanda – Kirengeri (NR13) unpaved road (46Km733m) in Ruhango – Nyanza and Nyamagabe Districts
7. Rehabilitation of RUKALI – KABUGA (DR95) unpaved road (40.1 Km) with in Nyanza District, Southern Province.
8. Periodic maintenance works of Ruhango – Kinazi – Mukunguri, Kinazi – Rutabo road, 36.3 km (Access road to Cassava Factory) in Ruhango District.
9. Periodic maintenance works of Rwamagana – Zaza unpaved road (31 Km), located in Rwamagana & Ngoma Districts, Eastern Province

2.6.2. Some project under DBM

1. Rehabilitation, Upgrading and Multiyear Maintenance Works of Indicative Feeder Roads in Nyaruguru District-69km, Under Design, Build and Maintain (DBM) Following Output and Performance Based Output Road Contract (OPRC)
2. Rehabilitation, Upgrading and Multiyear Maintenance Works of Indicative Feeder Roads in Rutsiro District-79km, Under Design, Build and Maintain (DBM) Following Output and Performance Based Output Road Contract (OPRC)
3. Rehabilitation, Upgrading and Multiyear Maintenance Works of Indicative Feeder Roads in Nyagatare District-55km, Under Design, Build and Maintain (DBM) Following Output and Performance Based Output Road Contract (OPRC)
4. Rehabilitation, Upgrading and Multiyear Maintenance Works of Indicative Feeder Roads in Gatsibo District-83km, Under Design, Build and Maintain (DBM) Following Output and Performance Based Output Road Contract (OPRC)
5. Rehabilitation, Upgrading and Multiyear Maintenance Works of Indicative Feeder Roads in Nyabihu District-93km, Under Design, Build and Maintain (DBM) Following Output and Performance Based Output Road Contract (OPRC)
6. Rehabilitation, Upgrading and Multiyear Maintenance Works of Indicative Feeder Roads in Gakenke District-69km, Under Design, Build and Maintain (DBM) Following Output and Performance Based Output Road Contract (OPRC)
7. Construction works of Huye- Kibeho- Ngoma road (66km)

2.7. CHALLENGES OF THE DELIVERY METHODS ON ROAD PROJECT IN RWANDA

The majority of Projects in Rwanda if not all were/are not completed at contractual period; the related main challenges are the following:

- Deficiency of required expertise with the local contractors;
- Deficiency of well-established pre-agreement planning;
- Occasionally the underbid the works are observed,
- Financial incapability
- Insufficient equipment
- Delay in expropriation and relocation of public utilities within ROW

The problems related to the project management are main sources of the above mentioned challenges.

The local contractors should solve the issues related to the project management and avoid underbidding the works; furthermore they should analyze and allocate the projects risks properly.

The domestic companies meet with the challenges related to fulfill the necessities in DBM approach since all projects delivered through DBM are under financing with the international agencies where the technical and financial qualifications are so high, therefore they have to improve their financial and technical capacities.

CHAPTER 3 RESEARCH METHODOLOGY

3.1. INTRODUCTION

Chapter three defines the procedures used for evaluating applicability of DBM and DBB projects delivery methods to the roads construction industry in Rwanda. The methodology used by this research is structured into three parts namely source of data, data analysis and data collection. Every part explains the definition, decision and parameters used in the research data analysis.

Through this chapter, the methodology and research design to be used for achieving the main goal of the present research will be elaborated. Furthermore, this chapter presents the information and data sources, research instruments, sample size and method of analysis. The following paragraph explains an overview of the adopted research strategy and justification of the methodology used for this thesis.

The data analysis was started by identifying the data sources which have the consistent and reliable projects information for DBM and DBB methods. Rwanda Transport Development Agency, road construction firms and contractors are the main sources of the data for evaluating both roads delivery methods. RTDA trails a big amount of the project's information for managing both DBM and DBB delivery methods, furthermore originality of the data source help for the application and realistic representation for retrieving projects information for the present research.

3.2. RESEARCH DESIGN AND METHODOLOGY

The used approach to this research starts with the identification of the problem which was elaborated through discussions with the different stakeholders and literature review and then after formulates the research design.

The sources of data and information were selected basing to the already formulated research design. Basing to the data sources, the research instruments were decided. The available documents such as consultants' reports and books were reviewed; all those are in relation with the applicability of DBM and DBB delivery methods.

With a comprehensive literature review and desk study, case studies and questionnaires were designed. Questionnaires were distributed to the contractors, consultants, and RTDA staff and road construction experts for getting their views. After getting the anticipated data, the data have been checked and reviewed. They were then analyzed for double check their validity along the research work. Thus was followed by the comprehensive discussions for drawing conclusions and recommendations according to the findings of the research.

Expressive and investigative survey was used in the research. The aim was to collect data from pertinent population such as Rwanda Transport Development Agency, road construction firms, contractors and road construction experts to appraise the views of the different stakeholders about effectiveness of DBM and DBB delivery methods and their current practice in road construction projects in Rwanda.

3.3. DATA COLLECTION

3.3.1. Questionnaire

With the line of the research objectives, questionnaires were elaborated and sent to RTDA, Contractors, Consultants and road construction experts who were requested to read and give their answers and recommendations. The questionnaire was designed in order to help in giving the highlight related to the cost and schedule overrun in the road construction projects. It was assured that the feedback from questionnaires will be used for the research purpose and remain confidential.

3.3.2. Case Study

For getting an answer to the question related to which delivery method is better approach between DBM and DBB to road construction projects, the samples projects carried out by DBM as well as DBB methods were selected . The selection approach was non probability sampling and selected samples serve the purpose and objective of the research. Therefore six projects under implementation with DBM approach and nine projects implemented with DBB approach were chosen to determine if the efficiency of the project delivery method either DBM or DBB is related to these effects.

3.3.3. Desk Study

It is defined as the exploration of the accessible data or information to definite issues frequently earlier starting a comprehensive study. For that reason, it was selected by means of one instrument to measure the performs from similar studies, documents and reports.

3.4. RESEARCH INSTRUMENTS

To identify which delivery method is more appropriate to a certain condition, two research instruments were used which are desk and case studies.

The purpose behind for carrying out of the desk study was to get the data from the documents which included the schedule and cost variations and completion reports as well for having contextual facts on cost and schedule overruns in the roads construction projects. Furthermore, road construction experts were shared their views and other related data through questionnaires survey. By the literature review, it was tried to get awfully information and gaining knowledge and understand better the different project procurement methods and identified alternate project delivery methods as well. The respondents of the questionnaires were selected randomly from Rwanda Transport Development Agency, from Contractors, Consultants and from construction experts who have involved in the road construction industry.

3.5. SAMPLE SIZE/RESEARCH POPULATION

According to the research structure, both questionnaires and cases studies are prepared for analyzing and organizing the known data to deliver project performance. Thus study populations are from the main client for road construction in Rwanda which is RTDA, Experts in road construction industry, consultant firms and contractors who are carried out both DBM and DBB methods or one of them. It has been tried to have the representative samples from different populations as they are described in the above paragraph, table 3.1 represents the samples and their distribution including the responses percentages.

Table 3-1 Responses distribution

Population Category	Questionnaires Distributed	Questionnaires Collected	Responses (%)
RTDA Staff	8	7	87.50
Contractor	9	7	77.78
Consultant	7	5	71.43
Professional	11	10	90.9
Total	35	30	85.7

The total 35 questionnaires were distributed to different population from which 8 are from RTDA, 9 are from contractors, 7 are from consultant firms and 11 are the Experts in road construction industry and who have the willing to answer the questionnaire.

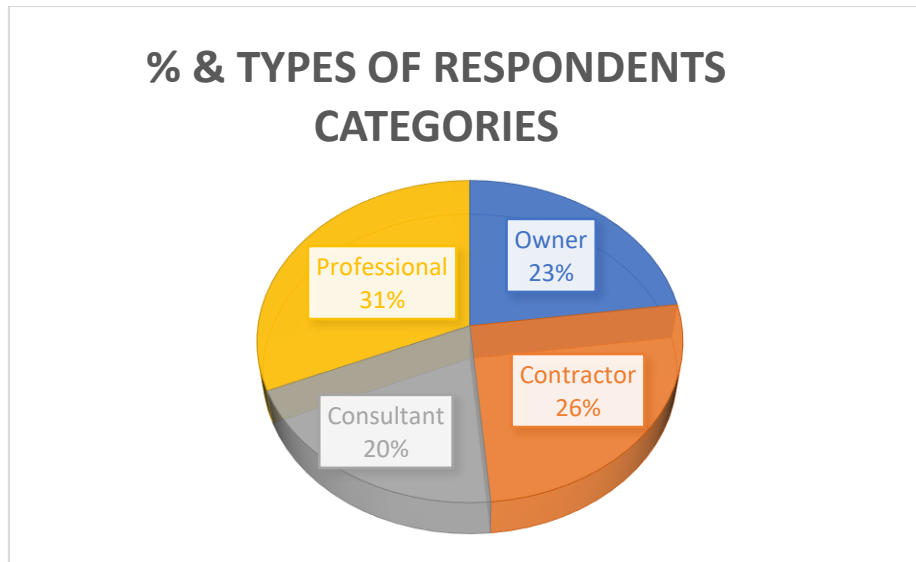


Figure 3-1 Percentage and respondent Categories

3.6. DATA ANALYSIS

Both case and desk studies are analyzed based to the theoretical knowledge and literature review. Statistical analysis (descriptive method) is used to analyze the responses from questionnaires. Such kinds of analysis help to evaluate the answers over the real facts. For that reason the records tabularized in categories then define the numbers of individuals belonging to every category, which are reviewed over the tabular form.

CHAPTER 4 .RESEARCH ANALYSIS AND DISCUSSION

4.1. OVERVIEW

The analysis tries to evaluate the applicability and efficiency of the DBM and DBB methods and research on which method is advantageous over the other in terms of cost and time. In Rwanda, the usual road construction method is DBB, but lately, DBM method has been used to deliver the feeder roads financed by World.

Accordingly, in this proposed study characterizes by assessment of the efficiency of the DBM over DBB construction methods by conserving projects performance criteria (construction cost and construction schedule).

The purpose of the research is to conduct the comparison(statistically) between DBM and DBB in Rwanda road construction industry, the collected data are evaluated with different ways through literature review.

4.2. CASE STUDIES ON BOTH PROJECT DELIVERY METHODS

According to the Rwandan road's industry, they are three main stakeholders in road constructions, such as Clients, Contractors and Consultants. For supporting the socio-economic development of the county, the clients are mandated to provide safe roads infrastructure. The mission includes to upgrade the exiting road's condition and development of the road's networks.

Many local contractors are not technically and financially qualified for tendering in the projects financed by external donors. Hence, foreigners' companies (Most of them are the Chinese companies), which encounter for the specifications win such kind of projects. Upon contract award, every contractor has a mandate to deliver an infrastructure as per specifications of the contract. Design and/or supervisions activities are the responsibilities of the consultant(s) who should have separate contract detailing his duties.

In both construction methods, there are always two distinct consultants, the first one for performing the design activities and the second performing the supervision works. In DBB delivery method, consultants are hired by the Client and they are, therefore, independent from Contractor.

But in DBM delivery method, the design Consultant is the sub consultant of the Contractor. Hence, at the bidding stage, a contractor should include in his offer, the capability of the consultant who will work as his sub consultant and he is an object of evaluation by the client.

He therefore works for the Contractor. For the supervision of the works, a separate consultant is deployed by the Client.

For the applicability evaluation in Rwandan Project purposes, we have considered 6 DBM projects and 9 DBB unpaved roads project. As DBM delivery method is the new approach in Rwanda, all 6 selected DBM projects are still ongoing but the selected DBB projects are all delivered(completed).

All projects have been carefully selected, to evaluate the efficiency of the both delivery methods to the Rwandan road's projects.

4.2.1. Case Study of DBB Road Projects

Meant for the study, projects are selected based on the cost and schedule performance. They are delivered through DBB method and are completed and also, they are all experienced cost and time overrun.

The Sampled design bid build Projects are listed below:

1. Rehabilitation, Upgrading and Maintenance Works of Selected Feeder Roads in Rwamagana District (93Km)
2. Rehabilitation, Upgrading and Maintenance Works of Selected Feeder Roads in Gisagara District (71.8Km)
3. Rehabilitation, Upgrading and Maintenance Works of Selected Feeder Roads in Nyamasheke District (52.3Km)
4. Rehabilitation, Upgrading and Maintenance Works of Selected Feeder Roads in Karongi District (75Km)

5. Rehabilitation and periodic maintenance work of Giticyinyoni- Ruli – Rushashi - Gakenke road (68.7km),
6. Execution works for periodic maintenance works of Kaduha –Buhanda – Kirengeri (NR13) unpaved road (46Km733m) in Ruhango – Nyanza and Nyamagabe Districts
7. Rehabilitation of RUKALI – KABUGA (DR95) unpaved road (40.1 Km) with in Nyanza District, Southern Province.
8. Periodic maintenance works of Ruhango – Kinazi – Mukunguri, Kinazi – Rutabo road, 36.3 km (Access road to Cassava Factory) in Ruhango District.
9. Periodic maintenance works of Rwamagana – Zaza unpaved road (31 Km), located in Rwamagana & Ngoma Districts, Eastern Province

4.2.1.1 Cost and Time overrun of Selected DBB Projects

The selected projects under DBB are tabulated below. The table 4.1 presents the cost and time variations as per selected projects

Table 4-1 Initial and revised contract cost and projects duration of the DBB selected contracts.

SN	Projects Title	Length In (km)	Initial project amount (Frw)	Revised project amount (Frw)	Initial project Period (months)	Revised project period (months)
1	Rwamagana Feeder Roads	93	3,271,955,783	3,860,651,035	12	15
2	Gisagara Feeder Roads	71.8	2,418,718,663	3,222,859,546.85	12	24
3	Karongi Feeder Roads	75	5,090,665,057	5,935,080,610.01	15	20.5
4	Nyamasheke Feeder roads	52.3	3,673,786,453.01	4,226,864,885.49	14	21

5	Giticyinyoni-Ruli-Gakenke	68.7	8,552,743,380	10,262,291,166	16	28
6	Kaduha-Buhanda-Ruhango	46.73	8,135,798,351.26	8,135,798,351.26	15	16
7	Rukari-Kabuga (in Nyanza)	40.1	5,171,158,070	5,171,158,070	12	14
8	Ruhango-Kinazi-Mukunguri	36.3	2,093,269,199	2,446,213,610	6	16
9	Rwamagana-Zaza	28	1,849,378,800	2,214,878,012	10	22

Source: Rwanda Transport Development Agency, RTDA

The proportion of contracts cost increase of the Design Bid Build project were calculated and organized in the below table for illustrating the implication of the contracts cost variation whose average value is +15.5%. contracts cost increase and related proportion (%) are shown in the table4.2.

Table 4-2 *Increments in Contracts cost of the Sampled DBB Contracts*

SN	Projects Title	Initial contracts amount (Frw)	Revised contracts amount (Frw)	Increment in Contracts cost	& Increase in Contracts cost
1	Rwamagana Feeder Roads	3,271,955,783	3,860,651,035	588,695,252	17.99%
2	Gisagara Feeder Roads	2,418,718,663	3,222,859,546.85	804,140,884	33.25%
3	Karongi Feeder Roads	5,090,665,057	5,935,080,610.01	844,415,553	16.59%
4	Nyamasheke Feeder roads	3,673,786,453.01	4,226,864,885.49	553,078,432	15.05%
5	Giticyinyoni-Ruli-Gakenke	8,552,743,380	10,262,291,166	1,709,547,786	19.99%

6	Kaduha-Buhanda-Ruhango	8,135,798,351.26	8,135,798,351.26	-	0.00%
7	Rukari-Kabuga (in Nyanza)	5,171,158,070	5,171,158,070	-	0.00%
8	Ruhango-Kinazi-Mukunguri	2,093,269,199	2,446,213,610	352,944,411	16.86%
9	Rwamagana-Zaza	1,849,378,800	2,214,878,012	365,499,212	19.76%
AVERAGE					15.50%

For easy comparison and visualization, the figure below (4.1) shows the contracts cost overrun which the sampled projects experienced. The average percentage increase is 15.5% the individual percentage of the revise contracts cost increase is momentous.

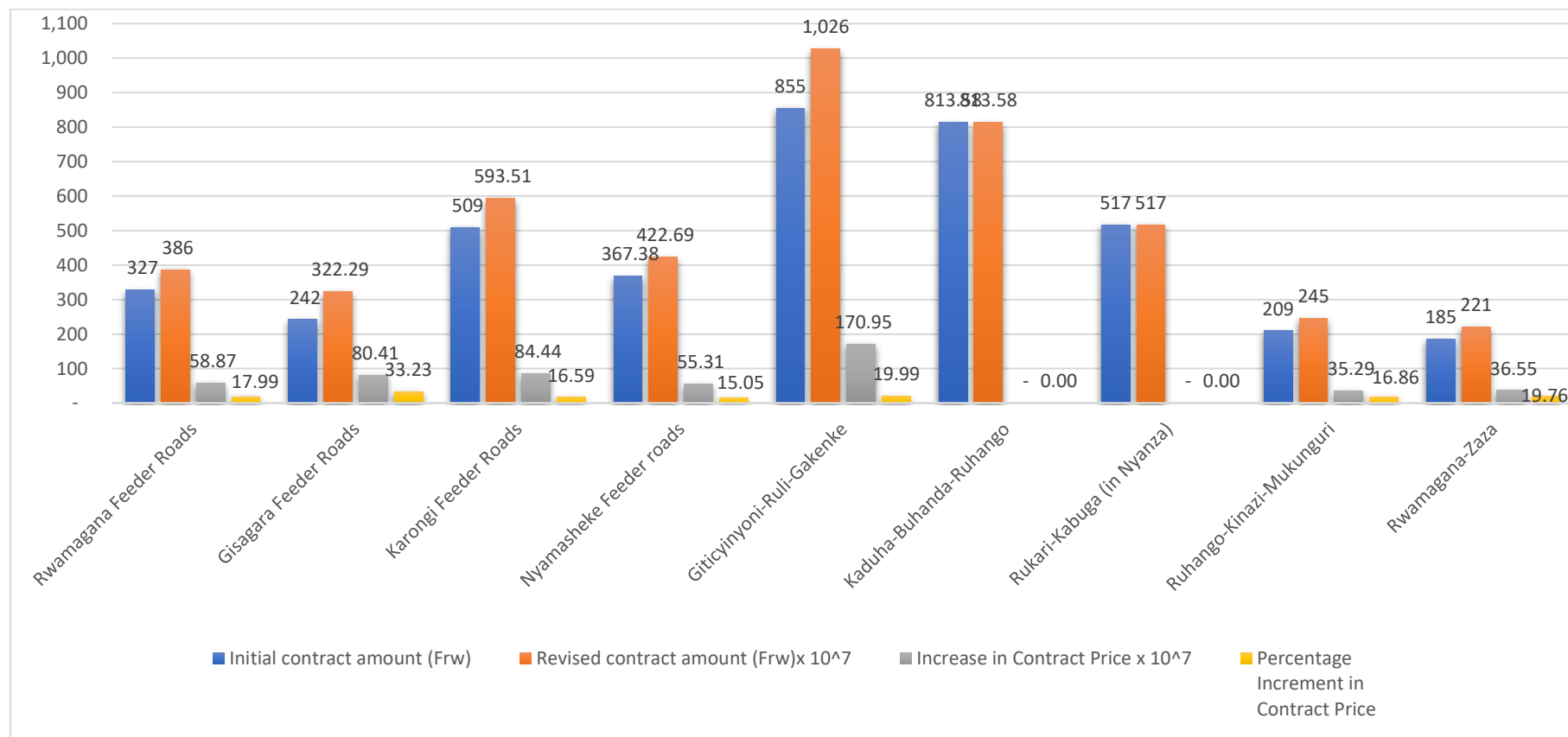


Figure 4-1 Percentages increase as well as initial and total contracts cost of the sampled DBB projects.

The increase months of the contractual time and related increase percentages of DBB projects are presented in the below table 4.3 for illustrating the importance of the contracts period variation.

Table 4-3 Increase in Contracts Period of the Sampled DBB Contracts

SN	Projects Title	Initial Contracts Period (MONTHS)	Revised contracts period (MONTHS)	Increase Contract Period (MONTHS)	% Increase in Contracts Period
1	Rwamagana Feeder Roads	12	15	3	25.00%
2	Gisagara Feeder Roads	12	24	12	100.00%
3	Karongi Feeder Roads	15	20.5	5.5	36.67%
4	Nyamasheke Feeder roads	14	21	7	50.00%
5	Giticyinyoni-Ruli- Gakenke	16	28	12	75.00%
6	Kaduha-Buhanda- Ruhango	15	16	1	6.67%
7	Rukari-Kabuga (in Nyanza)	12	14	2	16.67%
8	Ruhango-Kinazi- Mukunguri	6	16	10	166.67%
9	Rwamagana-Zaza	10	22	12	120.00%
AVERAGE					66.30%

The tables 4.2 and 4.3 indicates that the projects cost and contracts period overrun from 0% to 33.25% of initial contractual amount with average value of 15.5% and from 6.67% to 166.67 % with average value of 66.30% of the initial contractual period respectively.

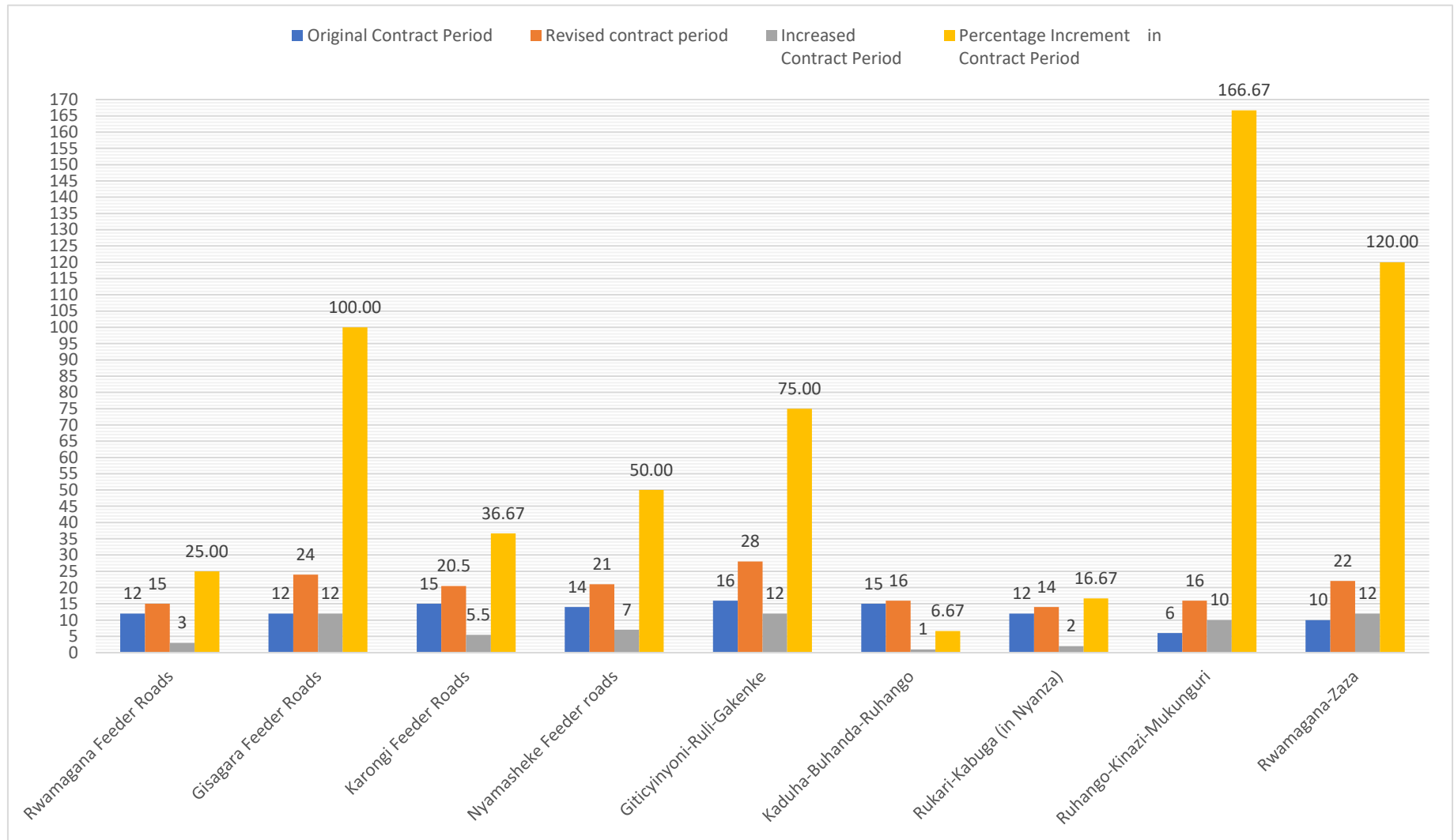


Figure 4-2 Percentages of time overrun of the sampled DBB projects

By the two above tables (4.2 & 4.3), we can conclude that the road construction projects in Rwanda are not running according to the period and cost initially estimated before actual works.

4.2.2. Causes of The Cost and Time Overruns in DBB Delivery Method

4.2.2.1. Causes of the Cost overrun

The main causes of the cost overruns in DBB are related to the additional works, variations, design changes and ROW which, frequently, happen in DBB projects.

Two main aspects behind the above are:

1. The terms of references of the Client may not be well prepared as per existing condition of the road. In that case the design consultant may not deliver enough information about the road which could lead to the additional works and variations subsequently to the cost overruns
2. The design Consultant may not perform a good study especially the geotechnical and geometric studies which could cause the design change during the project implementation.

Change in scope of the project can cause the cost overrun of the project. Client may change the scope during the project implementation. For example, the study may be done on 6m width of the road then later the client may change it to 7m width during the project implementation, which results in an increase of the project quantities and there by costs.

Furthermore, emergency works (unplanned works) caused by flooding; land sliding, etc can also contribute in cost overrun of the project

4.2.2.2. Causes of time overruns

Due to Client:

- Budget constraints is the main challenge which could increase the project period (delay in payment of the certificates from Contractors)
- Delay in reacting on the contractor's and consultant proposals, **poor communication**
- Delay in resolving ROW issues to the contractors (delay in expropriation and relocation of utilities, RAP, etc)

Due to Contractor:

- Poor management in planning and execution of works

- Poor resources allocation, etc
- The underestimation of the project cost can also delay the project
- Financial incapability (Liquidity) of the contractor for financing the project contributes a lot in project delay

Due to Consultant:

- Untimely response to issues both technical and managerial
- Delay in approving invoices
- Assigning inexperienced professionals on site

Unforeseen works

Contractor may spend much time to handle the unpredicted works caused due to, like flooding, landslide, etc.

4.2.3. Case Study of DBM Road Projects

Similar to the DBB delivery method, six Road projects were selected for DBM case study. As this delivery method is new in road construction industry in Rwanda, all selected roads are not completed.

The Sampled DBM Projects are listed below:

1. Rehabilitation, Upgrading and Multiyear Maintenance Works of Indicative Feeder Roads in Nyaruguru District-69km, Under Design, Build and Maintain (DBM) Following Output and Performance Based Output Road Contract (OPRC)
2. Rehabilitation, Upgrading and Multiyear Maintenance Works of Indicative Feeder Roads in Rutsiro District-79km, Under Design, Build and Maintain (DBM) Following Output and Performance Based Output Road Contract (OPRC)
3. Rehabilitation, Upgrading and Multiyear Maintenance Works of Indicative Feeder Roads in Nyagatare District-55km, Under Design, Build and Maintain (DBM) Following Output and Performance Based Output Road Contract (OPRC)
4. Rehabilitation, Upgrading and Multiyear Maintenance Works of Indicative Feeder Roads in Gatsibo District-83km, Under Design, Build and Maintain (DBM) Following Output and Performance Based Output Road Contract (OPRC)
5. Rehabilitation, Upgrading and Multiyear Maintenance Works of Indicative Feeder Roads in Nyabihu District-93km, Under Design, Build and Maintain (DBM) Following Output and Performance Based Output Road Contract (OPRC)
6. Rehabilitation, Upgrading and Multiyear Maintenance Works of Indicative Feeder Roads in Gakenke District-69km, Under Design, Build and Maintain (DBM) Following Output and Performance Based Output Road Contract (OPRC)

4.2.3.1 Time and Cost overrun of sampled DBM Projects

The Selected DBM Projects presented in Table 4.4 were sampled from the unpaved roads under implemented through DBM delivery method in Rwanda. The below table presents the cost and time variations as per selected projects

Table 4-4. Initial and revised contract cost and projects duration of the DBM selected contracts.

SN	Projects Name	Length in (Km)	Initial Projects Amount FRW	Revised projects Amount [FRW]	Initial contracts Period Months]	Revised contracts Period Months
1	Nyaruguru feeder roads	69	11,690,479,498	NA	42	NA
2	Rutsiro feeder roads	79	11,148,385,147	NA	42	NA
3	Nyagatare feeder roads	55	5,455,285,633	NA	48	NA
4	Gatsibo feeder roads	83	10,446,089,042	NA	48	NA
5	Nyabihu feeder roads	93	16,629,780,620	NA	40	NA
6	Gakenke feeder roads	69	10,789,587,634	NA	42	NA

Source: Rwanda Transport Development Agency, RTDA

As per the contract terms and confirmed by the client, the revised contract amount is not applicable. It is the same with the contract period where construction period will not be revised unless in case of force majeure such as war, pandemic, flooding, etc. Therefore, the initial contract amount and initial contract period are to be kept unchanged.

Table 4-5 Initial and Revised Contract cost and Period of the Sampled DBM Contracts

SN	Project Name	Length in Km	Initial Contract Amount FRW	Revised Contract Amount [FRW]	Original contract Period Months]	Revised contract Period Months
1	Nyaruguru feeder roads	69	11,690,479,498	11,690,479,498	42	42
2	Rutsiro feeder roads	79	11,148,385,147	11,148,385,147	42	42
3	Nyagatare feeder roads	55	5,455,285,633	5,455,285,633	48	48
4	Gatsibo feeder roads	83	10,446,089,042	10,446,089,042	48	48
5	Nyabihu feeder roads	93	16,629,780,620	16,629,780,620	40	40
6	Gakenke feeder roads	69	10,789,587,634	10,789,587,634	42	42

Data from DBM projects are presented and analyzed in the below tables to illustrate the significance of the issues, percentages of costs overrun are calculated in table 4.6

Table 4-6 Increase in Contracts amounts of selected DBM Projects

SN	Road	Initial Contract Amount FRW	revised contracts Amount	Increment in Contracts Price	Percentages increase in contracts cost
1	Nyaruguru feeder roads	11,690,479,498	11,690,479,498	0	0%
2	Rutsiro feeder roads	11,148,385,147	11,148,385,147	0	0%
3	Nyagatare feeder roads	5,455,285,633	5,455,285,633	0	0%
4	Gatsibo feeder roads	10,446,089,042	10,446,089,042	0	0%
5	Nyabihu feeder roads	16,629,780,620	16,629,780,620	0	0%
6	Gakenke feeder roads	10,789,587,634	10,789,587,634	0	0%

As per the terms of the contracts of the above projects, Client pay 80% of the lumpsum amount for the completed constructed Km other 20% will be paid during the maintenance period (**source:** Contracts of the Contractors), for getting the lumpsum to be paid per one completed

Km, you take the contract amount divided the total length in terms of Km of the project. So, it is understandable that the projects will not face with the challenges of the cost variation. Therefore, as per the terms of the contracts and as per shown in the Table 4.7 and the below figure 4.3, we are sure that the cost increment in the above projects is 0%, unless Client want to increase the number of the Kms to be constructed.

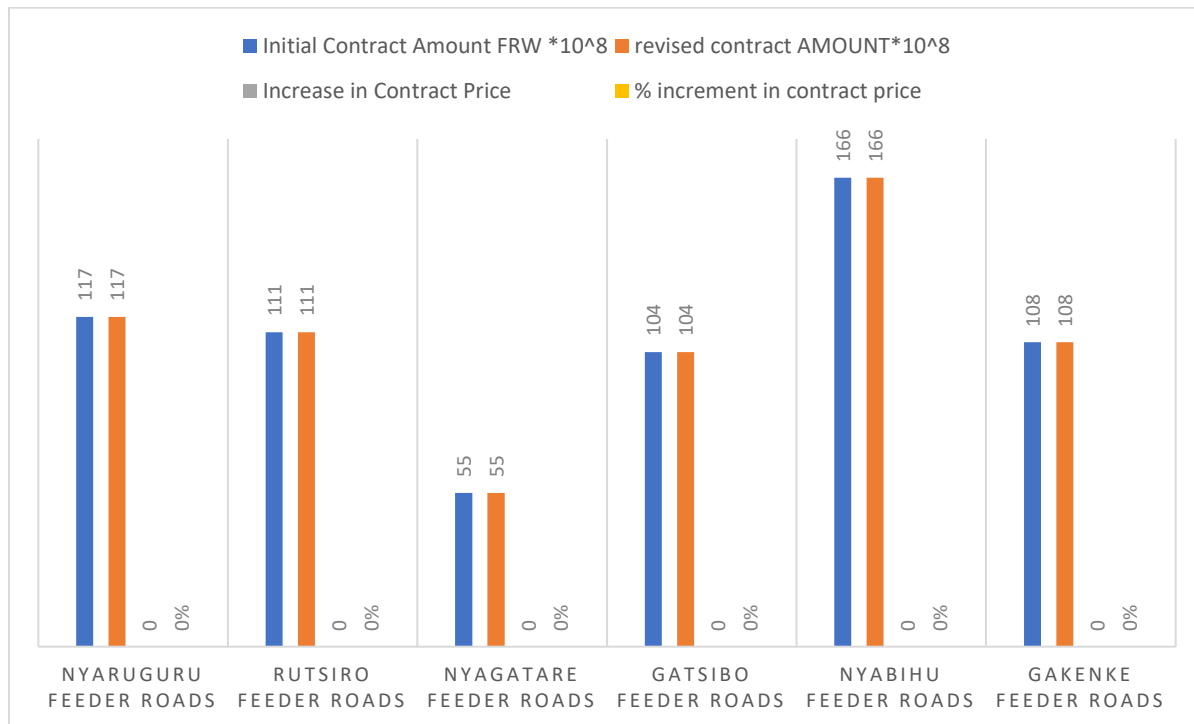


Figure 4-3 Percentages increments as well as initial and revised contracts costs of selected DBM projects

As the total financial commitment is known at the beginning of the projects, contractors or Client do not have any room to make/introduce changes during the project's implementation, because there is no provision to make changes in the scope of work and specification.

From that perspective the time variation is expected to be fixed as well, unless handing over of site by the client is delayed.

Any other delay of the project is the accountability of the Contractor and it is supposed to be an issue of claim by the client.

4.3. COMPARISON ON DBB AND DBM

The following tables 4.7 and 4.8 show the construction cost per Km for the sampled projects

Table 4-7 Average cost per Km of Sampled DBM Projects

Project Name	Length_km	Contract Amount	Cost per Km
Nyaruguru Feeder Roads	69	11,690,479,498	169,427,239.10
Rutsiro Feeder Roads	79	11,148,385,147	141,118,799.33
Nyagatare Feeder Roads	55	5,455,285,633	99,187,011.51
Gatsibo Feeder Roads	83	10,446,089,042	125,856,494.48
Nyabihu Feeder Roads	93	16,629,780,621	178,814,845.39
Gakenke Feeder Roads	69	10,789,587,634	156,370,835.28
Average			145,129,204.18

Table 4-8 Average cost per Km of Sampled DBB Projects

	Project Title	Length_km	Revised contract amount	Cost per Km
1	Rwamagana Feeder Roads	93	3,860,651,035	41,512,376.72
2	Gisagara Feeder Roads	71.8	3,222,859,546.85	44,886,623.22
3	Karongi Feeder Roads	75	5,935,080,610.01	79,134,408.13
4	Nyamasheke Feeder roads	52.3	4,226,864,885.49	80,819,596.28
5	Giticyinyoni-Ruli-Gakenke	68.7	10,262,291,166	149,378,328.47

6	Kaduha-Buhanda-Ruhango	46.73	8,135,798,351.26	174,102,254.47
7	Rukari-Kabuga (in Nyanza)	40.1	5,171,158,070	128,956,560.35
8	Ruhango-Kinazi-Mukunguri	36.3	2,446,213,610	67,388,804.68
9	Rwamagana-Zaza	28	2,214,878,012	79,102,786.14
AVERAGE				93,920,193.16

From the above tables, the situation might be observed that the construction cost per Kilometer is lesser in DBB projects than DBM. Thus, justify why DBM projects are costlier but the project cost is known and fixed before the project starts and the likelihood of variations and additional works is low.

The uncertainties, single point of responsibility and long maintenance period (two years compared to one year for DBB) remain completely the responsibilities of the DBM contractors, so the high cost of the DBM projects aimed to compensate all those uncertainties. In general, DBM project are better in terms of projects cost completion with comparing to the contract amount.

The main sources of the delay for DBM projects are related to the delay of submission and approval of design studies, issues related to the right of way (ROW), delay in mobilization and starting of the works and poor management of the project on the contractor's side.

4.4. QUESTIONNAIRE SURVEY RESULT

The majority of the respondents (60%) do agree to shift from DBB to DBM. Most the respondents from Both contractors and consultant have no objections to shift from the traditional to the new innovative project delivery despite the difficulties mainly related to the financial qualification of the local contractors in DBM projects.

4.4.1. Respondent's View Regarding the Project Schedule

From the responses got during the survey, 57% confirm that DBM delivery method is more effective meet the project construction schedules due to that Contractors assume all duties from design phase to the concession period. He can purposely reduce planned time schedules for processing the activities. 30% of the respondents confirm that DBB meet with construction schedule whereas 13 % responded that they don't know which method is more advantageous in terms of construction schedule.

Table 4-9 Responses in favor of both project delivery method about project schedules

perception in favor with respect to project schedules	Number of Respondents	Response Rate (%)
DBM	17	57
DBB	9	30
Have no idea	4	13
Total	30	100

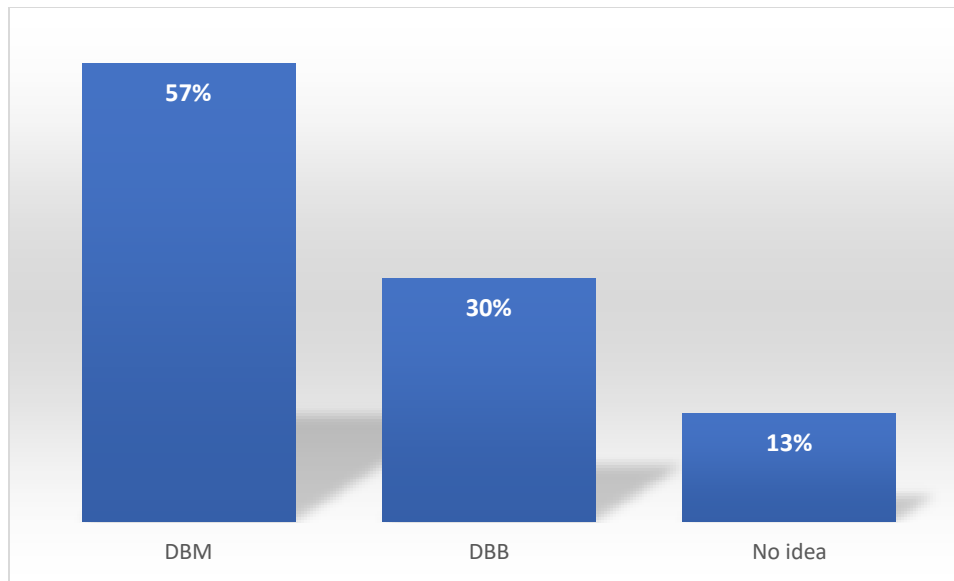


Figure 4-4 % of Responses of both project delivery method about project schedules

4.4.2. Respondent's View Regarding the Project Cost

The survey shows that 60% of the responses, agreed to shift from DBB to DBM, among them only 26.67% are intended to shift for cost reduction purpose.

Table 4-10 Responses in favor of both Project Delivery Method about project cost

perception in favor with respect to project cost	Number of Respondents	Response Rate (%)
DBM	8	26.67
DBB	22	73.33
Total	30	100

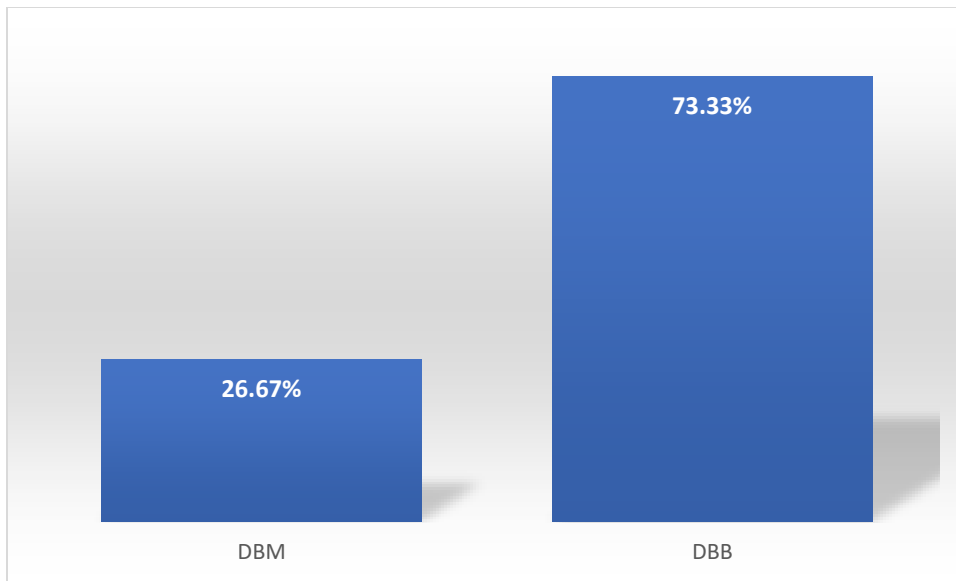


Figure 4-5 % of Responses in favor of both Project Delivery Method about project cost

There are several reasons behind the respondent's views. Some of them are the consideration of the design cost. Contractor is obliged to hire a design consultant who have to work as sub consultant at the design stage. According to the one design consultant whom I have discussed about the cost of the design, he has releveled that their cost is 3% of the contractor's contract amount. The projects under DBM methods are subject of maintenance period of three years, all these are contributing in high construction/rehabilitation cost of the BDM Project. Furthermore due experience/Technical reference and annual turnover varying from 4 to 7 Million United States Dollars required to all contractors who will participate in tendering, limits almost local contractors in tendering process , hence the big foreign companies win the tenders as sole or in joint venture with the best local contractors, the cost of the foreign companies/big companies are always high compared to cost of the local companies/small companies.

4.4.3. Overall Evaluation of the Respondents

The Majority of respondents prefer DBM as the better approach mainly for the two reasons, single point of responsibility and reduction of life-cycle cost (cost that is associated with the project from the beginning of the project to the end of its useful life and beyond). Here they explain that after the project construction with DBB approach, there is no clear maintenance strategy of the completed projects, especially unpaved roads constructed under the Government of Rwanda financing. But they recommend the projects owners to estimate the realistic time for the design stage and to pay attention in selecting the contractors to implement the DBM Projects for being sure that the project will be implemented as per expected and in mutual understanding.

The responses supporting the DBB delivery method are based on the its advantages over DBM, they have mentioned some of them as described in Chapter two.

Since the process is sequence and linear in DBB method, it is challenging to reduce both construction and design period, that is why many of the respondents confirm that DBM delivery method decreases projects schedule and cost in terms of life cycle better than DBB methods.

It is mentioned that the DBB Projects suffer from additional works, variations, design changes, and issues related ROW during the project implementation but the quality of the end product can be assured While in the DBM the executed contract quantities are always higher than the contracted ones and thus may contribute in compromising the quality of the end product

It was also mentioned that the Project Owners do not have the trust to the local consultants for control and supervision of DBM Projects.

But the Consultants have full confidence to implement the projects, as they claim to have the experienced staff with enough construction management skills. But on side of the local contractors, they accept that there is a long journey to go for implementing the DBM Projects since their technical and financial capabilities are still low compared to the requirements of the DBM Projects.

CHAPTER 5 .CONCLUSION AND RECOMMENDATION

The intention and purpose of the research is to conduct comparative analysis between DBB and DBM delivery methods to the industry of road construction in Rwanda in terms of construction cost and construction schedule, for advising the clients which is the best delivery method in Rwanda's road construction industry.

5.1. CONCLUSIONS

Each project is constrained by budget and time, for meeting its purpose, every infrastructure needs to be delivered within the budget, contractual period, as per specification and safely.

Infrastructure has to serve its intended service at the right time. Country like Rwanda that invests its scarce capital on constructions, completing a project within planned time and budget is a main concern and many of the projects in Rwanda are facing cost and time overruns.

However, there are many causes of the projects delays and cost overruns, the present research aim to advise the better delivery method which could abate those issues between DBB and DBM and identify possible difficulties those delivery methods can face and propose the preventions measures for their better applicability.

1. DBM projects got higher cost compared to the projects carried out under DBB delivery method, but the maintenance responsibility balances this cost.
2. Cost and Time and overruns are higher in DBB projects compared with DBM. But client's burden of work is highly reduced in DBM than DBB,
3. If Design Build and Maintain delivery method is used, there is more chance to complete a project within provided budget and time. Therefore, with a need to abate the risks, it is better to adopt DBM delivery method for the projects of the defined budget, complex and shorter period.
4. The causes of the cost and time overruns in the projects delivered with Design Bid and Build method are mainly due to the additional works, variations, design changes and ROW. DBM

projects may face with delay because of delay of the design stage and related approvals, ROW and incapability of the contractor

5. Design Bid Build method has Some advantages like well-known delivery approach, simple procurements processes, lowest price accepted, but It has also some disadvantages like long schedule for linear processes, no inputs from contractor during the design stage and is not suitable for complexity projects
6. Fast track delivery, Single point of responsibility for design, construction and maintenance, and early definition of project cost in the process and reduced life-cycle cost are some advantages of DBM delivery method.

Nevertheless, it has some disadvantages too, like issues related to the quality, higher cost, requirement of good professional skills to explicitly develop the project's scope and client's requirements for eliminating the changes which could be raised after starting the project.

7. The questionnaire survey and desk study outcomes showed that DBM delivery method in the road construction projects has considerably lower cost growth. The outcomes also revealed that the projects delivered through DBM have the schedule growth lower than the project delivered through DBB. Hence DBM delivery method is more advantageous than DBB delivery method, therefore can be adopted by RTDA in roads construction procurement process not only in the projects financed by World Bank but also the projects financed by the Government of Rwanda and other financing agencies.

5.2. RECOMMENDATIONS

Depending to the research results that the project delivered through DBB are facing with cost and time overruns, the corrective measures have to be proposed for both time and cost savings. The project stakeholders have to work as a team for having good project performance.

For having a good projects performance, the followings factors need to be given due consideration:

1. Selection of project delivery method would match project objectives, for a better result
2. One shall make sure that the selected delivery method minimizes risk

3. Continuous training needs to be conducted to upgrade the level of professional of parties involved in the construction industry.
4. Projects owners need to further evaluate the effectiveness of the DBM as another choice to deliver the projects rather than piling on DBB
5. Projects Owners should set off the issues related to the ROW before issuing service orders to the Contractors, those issues contribute a lot in projects delay, in any delivery method

Particularly, the following factors need to be considered for getting the better results from DBM:

- ✓ Clients must be capable to certainly and explicitly define his expectations, definition of the requirement, the users need and priorities of the projects to the bidders
 - ✓ Would be strong sympathetic on DMB process and completely understand the sharing out of the risks between Client and Contractor
 - ✓ Conclusions would retain effective fast-tracking on the design documents and construction.
 - ✓ For preventing the quality issues over DBM, the approval of the design documents should be strict.
6. Contractors would pay attention in estimating the project cost and risks allocation during tendering process. They must evade effect of wrong proffering procedures caused by high determination of tender winning. Consequently, before submitting their bids, DBM Contractors must visit and study careful the sites for getting the require data which will allow them to proper pricing and risks allocation in tendering.
 7. Competition level in DBM projects in Rwanda is limited mainly due to that it is the new approach for road delivery in Rwanda, therefore RTDA would motivate consultants and contractors through trainings for increasing the number of the firms and contractors tendering in DBM projects.
 8. The scope of this research did not consider the quality of the works on site for both delivery methods, so another study related to the quality of the end product could be suggested for evaluating the results of the probability of quality linked to both methods.

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APPENDIX

1. QUESTIONNAIRE

1. General Profile of the Respondent

1.1 Name: (Optional) _____

1.2 Position: _____

1.3 Organization: _____

1.4 Address: (Optional) _____

1.5 How long have you worked in the road sector

0-5 Year

11-15 Year

6-10 Year

Above 10 Year

1.6 Contact Person's Phone: (Optional) _____

1.7 Contact Person's Email Address: (Optional) _____

1.8 Did you have past work experience with the selected design-build and Maintain project delivery?

Yes

No

2. Project Characteristics

2.1 How many D-B-M projects have you executed before?

One

Two

Three

More than Three

2.2 What was the stage of the design of the project when construction contract was awarded?

At Feasibility study

At detailed design

2.3 To what extent were you able to minimize design risks by involving personnel with design and construction experience?

Less than 25%

25%-50%

50%-75%

75%-100%

2.4 What were the major challenges you faced during the implementation of the construction of Design-Build Maintain the project?

2.5 How did you manage the design activity?

By using in house design staff

By outsourcing the design work

2.6 Please describe any major causes of delays related to delivery method that occurred in the construction of the project?

2.7 In which of project delivery methods do you think that speed of delivery was better and Why or how:

- Design-Bid-Build
- Design-Build-Maintain
- I do not know

2.8 In which type of project delivery system do you believe that project schedule is efficiently utilized?

- Design-Bid-Build
- Design-Build-Maintain
- I do not know

2.9 If you have been always deploying the Design-Bid-Build so far, do you intend to shift to the DBM

Yes No

2.10 If yes what is/are the reasons behind your decision

To reduce project cost

To reduce project time

To reduce administrative burden to owner

Other(please specify) _____

2.11 In relation to the newness of DBM to Rwanda, what is your recommendation for the application of DBB versus DBM

2.12 Did the delivery system enhance or hinder your ability to perform? How?

- Yes, it enhances
- Yes, it hinders
- I do not know

Not Applicable (for consultants)

If it hinders what is your proposal to improve?

2.13 Experience for key-design personnel is one of the Employers (RTDA) Requirements.

How frequent can you get personnel that meet the requirements of DBB, DBM experience?

- Always
- In most cases
- Sometimes

- Rarely

2.14 How do you define the complexity of a project using DBB versus DBM

2.15 How are the owners affected in introducing innovation and flexibility during the implementation of DBM?

- The owner insists on absolute design control
- It allows flexibility and innovation
- The owners' program is somewhat tight in allowing flexibility and innovation

2.16 What are your Organization practices to reduce/minimize design errors in DBB versus DBM?

2.17 From your experience, in what type of project delivery method design risks are better minimized?

- Design-Bid-Build
- Design-Build -Maintain
- I do not know

2.18 your comments on the applicability and preference between DBB and