ADDIS ABABA UNIVERSITY
ADDIS ABABA INSTITUTE OF TECHNOLOGY (AAIT)
SCHOOL OF GRADUATE STUDIES
SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING

Cause and Impact of Departure from Standards in Road Design and Construction Projects (The Case of Ethiopian Roads Authority)

BY:
Wubrst Tadesse

A Thesis Submitted to the School of Graduate Studies of Addis Ababa University in Partial Fulfillment of the requirement for the degree of Master Science in Civil Engineering (Road and Transport Engineering)

Advisor

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School of Graduate Studies School of Civil and Environmental Engineering

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Approval by Board of Examiners

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Advisor	Signature	Date
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External Examiner	Signature	Date
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Chairperson	Signature	Date

UNDERTAKING

I certify that research work titled "CAUSE AND IMPACT OF DEPARTURE FROM STANDARDS IN ROAD DESIGN AND CONSTRUCTION PROJECTS (THE CASE OF ETHIOPIAN ROADS AUTHORITY)" is my own work. The work has not been presented elsewhere for assessment. Materials which have been used from other source have been properly referred.

Wubrst Tadesse ________
Name Signature

Place: Addis Ababa

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ABSTRACT

This thesis assesses, review, analyze and recommend on cause, mitigation measures and impact of departure from standard on VOC of Ethiopian road projects in the case of Ethiopian Roads Authority. To address the problems, a questionnaire was designed and distributed to Contractor, Consultant and Employer participating in road construction sector. A total of 48 questionnaires from Contractor, Consultant and Employer were collected. To supplement questionnaire a desk study of randomly selected 5 ongoing road projects that administered by ERA which have departure from standard issue from these projects 4 AC road projects are used to investigate the impact of departure from standard on VOC.

Based on the analysis of questionnaire and desk study the result reveled that limit construction costs, avoid land acquisitions, avoid adversely impacting the natural environment and preserve right-of-ways and historical or cultural resources are the most frequent causes of departure from standard and the most predominant type of design exception is pre-existing design exception and the type of roadway mostly affected by departure from standard is new construction and departure from standard mostly occurred on escarpment and mountainous terrain and based on HDM-4 Vehicle Operating Costs Module the total VOC for 20 year analysis period for Dabat – Kirakir – Ketema- Neguse Design –Build road project Contract 1: Dabat – Ajire is ETB: 1,876,295.62 and ETB: 1,885,461.60 with design standard and departure from the standard respectively, for Robe–Gasera–Km 60 is ETB: 2,047,253.21 and ETB: 2,214,319.65with design standard and departures from the standard respectively and for Adi Arkay-Telemt road project is ETB: 1,333,987.12and ETB: 2,908,865.69 with design standard and departures from the standard respectively. However, for Alaba -Angcaha -Wato Road project ETB: 2,294,339.36 and ETB: 2,443,648.60 with design standard and departures from the standard respectively, Hence, from the result effect of departure from standard of design criteria have direct relationship with VOC.

Thus, Contractor should submit his departure from standard report for employer approval by considering and incorporating the comparison of VOC for both with design standard and departure from standard, ERA Geometric Design Manual should include design guideline to reduce VOC of departure from standard and put it as one of the criteria to submit the departure from standard request, establishment of an independent organization to follow up the proper implementation of mitigation measures, cost comparison should be made between the cost which is reduced by providing departure and road user cost due to departure from standard are some of the recommendation made under this study.

Key words: Cause, Mitigation Measure, Design Criteria, Standard, Departure from the Standard, Vehicle Operating Cost

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ABBREVIATIONS

AASHTO: American Association of State Highway and Transportation

AC: Asphalt Concrete

CSDEs: Controlling Substandard Design Elements

DMRB: Design Manual for Road and Bridges

ERA: Ethiopian Roads Authority

FDOT: Florida Department of Transportation

GC 1: General Contractor 1

HDM: Highway Development and Management

HMA: Hot Mix Asphalt

MCHW: Manual of Contract Document for Highway Works

NCHRP: National Highway Research Program

PCC: Portland cement Concert

PE: Project Engineer

ROW: Right of Way

STAs: All State Transportation Agencies

TL: Team Leader

UNEP: United Nation Environmental Program

VOC: Vehicle Operating Cost

CHAPTER ONE

1.1.INTRODUCTION

This introduction presented a context of departure from standards and designers preparing submissions. It has also been prepared to make ERA that is developing Departure from Standards policies and procedures. To do so, the discussion starts with the background and purpose of the research project, and then it explains the research focus and gives a brief overview of the project's approach towards literature research. The introductory section ends with a mission statement and an overview of the proposed research method.

Construction industry makes significant contribution to the socio economic development process of a country. Its importance originates largely from the direct and indirect effect it has on all economic activities. It contributes to the national output and stimulates the growth of other sector through a complex system of linkage (United Nation Environmental Program, 1996); UNEP further observes that the industry consumes one-six to one half of world's wood, mineral, water and energy. It contributes to employment and creates income for population and has multiplier effects on the economy.

Road construction projects usually face Departure from Standards and problems during the design and construction stage. These problems are a customary phenomenon in which clients and contractors lose their interests while executing most contracts in the country. It is also important for the studies to be conducted related to the effects of departure from the standard of design practices that need to be taught at research institutions and universities to search for sound solutions to the existing/ challenging situations for the upcoming projects in the country. Provided that the significant impact of construction segment on the Ethiopian economy and the interest of international and local construction companies in that construction market, this study attempted to assess the assessment of departures on cause, mitigation measure and VOC implication of road projects in the country that will play a role in minimizing negative impacts at a considerable level in the industry and identifying the common causes and different mitigation measures of the declared departure from the standard.

1.2.STATEMENT OF THE PROBLEM

Departures from Standard in road design and construction project have practiced in Federal road projects of Ethiopia, which results in costs implication VOC which includes Fuel, lubricating oil, tires, spare parts, maintenance labor, capital, crew, overhead and safety problem.

This research paper identified the type of design criteria, cause, impact on VOC and mitigation measures of departure from Standards in road design and construction projects in Ethiopian Roads Authority. The above-mentioned research problem has been taken into account for the identification of the study topic. Hence, this paper conducted an in-depth study with both primary and secondary data gathering devices to obtain the required responses of the study area for the identified problems and then the findings will attempt to make a conclusion and proper recommendation while presenting this research report. The identified real problems also provide an important benchmark for future research to study the assessment of departures of design practices of road projects in Ethiopia.

Often attention is not given to problems that arise due to departure from standards problems of design outputs that usually become resulting in undue VOC and safety problems to most contracts administered by Ethiopian Roads Authority. To minimize such impacts I have motivated to assess cause of the departure practices and its impact on VOC to get proper justifications for sustainable solutions in this regard and making recommendations on how to improve the ERAs Procedure to approve departures of road projects and also enable ERA to establish a policy and procedures for Departures from Standard.

1.3.RESEARCH QUESTIONS

The research questions of this study can be summarized as follows:

- What is the type of design criteria affected by departure from standard?
- What are the causes of departure from the standard in Federal Road Projects of Ethiopia in case of Ethiopian Roads Authority?
- What is the impact of departure from the standard on VOC in Federal Road Projects of Ethiopian Roads Authority?
- What is the mitigation measures used for departure from standard?

1.4. OBJECTIVE OF THE STUDY

1.4.1. General Objective

The main objective of the research is to assess the cause and mitigation measure of departure from the Standard of road projects in Ethiopian conditions. In other words, the objective of this research is to assess the departures of various road projects in Ethiopia Roads Authority and to carry out its descriptive statistical analysis in order to get the results of the study.

1.4.2. Specific Objective

The specific objectives of this research project are:-

- To identify the type of departure from standard during the design and construction in federal road projects of Ethiopia in the case of Ethiopian Roads Authority.
- To identify the cause of departures in the national road projects of Ethiopian Roads Authority.
- Investigate different mitigation measures.
- Indicate the impact of departure from standard on VOC by using (HDM-4) Vehicle Operating Costs Module of selected road projects.

Often attention is not given to problems that arise due to departure from standards problems of design outputs that usually become resulting in undue cost and safety problems to most contracts. To minimize such impacts one has to assess the departure practices and its impact to get proper justifications for sustainable solutions in this regard. The identified real problems also provide an important benchmark for future research to study the assessment of departures of design and construction practices of road projects in Ethiopia.

1.5.SCOPE AND LIMITATIONS OF THE STUDY

The scope of this research project is limited on-going road projects in Ethiopia. This is made, due to the fact that the necessary and relevant information can be easily obtained from currently undergoing road projects to achieve the desired result of the study. The departure from standard assessment of road design projects in Ethiopia indicates that the results obtained in this research do not necessarily govern all projects in the country but it can be taken or considered as a representative sample for the existing situations. Thus, independent study/research should be made on different project types to investigate in detail the departure practices. The data for this study was gathered through primary and secondary data survey from questionnaires and written documents. Project information/ data of only 5 road projects were obtained from ERA and the projects are constructed in different areas of the country and only impact of departure from standard on VOC analyzed from other impacts. The organizations are Employers, Contractor and Designers/Consultant. The sample projects were commenced from 2017 to 2020. The projects were constructed by different contractors either local or foreign origin. The study population will try to encompass the different road projects that have been under construction and the theoretical contribution of this thesis is investigation of the safety impact of departure from standard and practical contribution is to identify different causes, mitigation measures and analysis of VOC impacts of departure from standard.

1.6.ORGANIZATION OF THE RESEARCH

This research will have the following broad categories.

Chapter I: Introduction/ Research /Overview
Chapter II: Literature review
Chapter III: The research design and methodology
Chapter IV: the research result and discussions
Chapter V: The research conclusions and recommendations

Each of the above chapter contains the following contents as stipulated bellow.

- Chapter I: describes background, the objective of the study, scope and limitation of the research.
- Chapter II: contains the literature review part that encompasses related manuals, papers, and relevant manuals that included general information about causes, effects, and origin agent and mitigation measures of departure from standard/design exception.
- Chapter III: covers the research methodology. The methodological approach consists of The overall research strategy; the study approach, data source and collection, method of analysis and writing of research paper.
- Chapter IV: describes the analysis, result and discussion of the research. It contains the findings on the cause, effects and possible mitigation measures of departure from standard/design exceptions.

- Chapter V: in this part based on the findings of the study, conclusions and recommendations are presented.

CHAPTER TWO

2.1. LITERATURE REVIEW

2.1.1. Introduction

In this chapter a comprehensive literature review has been made focusing on the possible causes of departure from standard, their impacts and remedial measures of departure from standard/design exception on road design and construction projects.

(Eireann et al., October 2016); Describes Departure from Standard shall mean any of the following:

a) A Departure from any of the mandatory requirements of TII Publications (Standards) the use of technical design standards and/or specifications other than those in TII Publications (Standards);
b) The use of a set of requirements or additional criteria for any aspect of the works for which requirements are not defined in the Contract;
c) The use of a technical design standard or technical specification in a manner or circumstance which is not permitted or provided for in such directive or specification;
d) A combination of any of the criteria specified above.

As (Mason et al., 2003); described nearly all highway and street construction and improvement projects are designed to con-form to agency-adopted geometric design criteria. In some situation achieving conformance with all design criteria is not practical or reasonable. A “design exception” is the process and associated documentation of creating or perpetuating a geometric feature that does not meet relevant criteria. Because design features that do not meet criteria should be deliberative, documented and approved by an authorized official. All state transportation agencies (STAs) prepare design exceptions. However, the volume of design exceptions, project conditions requiring their preparation, technical processes employed, and approval roles vary substantially among states. Although, cognizant of the benefits associated with preparing design exceptions, some states are concerned about the level of resources (i.e. agency personnel, funds and time) used in the process. This report describes the range of design exception practice among STAs and the problem and suggested improvement based on the experience of state agency personnel.

(The State of New Jersey Department of Transportation, 2012); indicated that when conditions warrant, design exceptions may be granted for a project design that proposes one or more controlling substandard design elements (CSDEs). Design exception may be approved when it can be documented that a lesser design value is the best practical alternative. The factor may be considered when determining if a lesser design value should be selected shall include social, economic and environmental impacts together with safe and efficient traffic operations.

Design exception is the process and resulting documentation associated with a geometric features created or perpetuated by a highway construction project that does not conform to the minimum criteria set forth in standards and requirements. This includes what some may refer to as design exceptions. (Mason et al., 2003)

There was an average of 39 design exceptions per year from 1993 through 1998. The majority of the project involved bridge replacement with the next frequent being roadway widening reconstruction projects and construction of turning lanes. The most common design exception was a design speed lower than the posted speed limit following by a reduction in sight distance, curve radius, or shoulder width. The most common reason for the request referred to the existing conditions on the road followed by the right-of-way issue and project cost. The crash analysis showed that, with a very few exceptions, use of the design exception process did not result in either construction of projects with high crash rates when compared with average state wide rate or an increase in crash after construction compared to before construction. (Kenneth R. Agent. et al., March 2002).

On occasion, designers encounter situations in which the appropriate solution may suggest that using a design value or dimension outside the normal range of practice is necessary. Arriving at this conclusion requires the designer to understand how design criteria affect safety and operations. For many situations, there is sufficient flexibility within design criteria to achieve a balance design and still meet minimum values. However, when this not possible, that is when exception may be considered. (U.S. Department of Transportation Fedral Highway Administration, July 2007).

This chapter explained some of the earlier studies, practices and manuals related to the departure of highway design elements from that take part in under taking this research. Few studies have attempted to assess the design associated issues and look into different features that lead to improving departure of highway design outputs and reviewing the procedures for approving departures from standards/design exceptions. Therefore, this paper investigated in detail by concentrating on the current situations in Ethiopia for the departure of the design elements that required to be updated for highway projects. The literature review divided into eight major sections: Introduction, description of design manual, types of design exceptions and project types requiring a design exception, submission requirements and application process of departure from the standard, mitigation measures of a design exception, cost implicitly (VOC) of departures and cause of departure from the standard.

2.1.2. Description of Geometric Design Manual

The part of the literature discusses the design manual components in the design development of a highway project. The following four elaborations that used indifferent countries discussed design manual situations adopted and mainly focused on geometric design manual for highway designs are addressed. The geometric design aspect is selected for this particular study. This part of the design has been selected because of the fact that this has been usually affecting project’s cost, comfort and safety from the practical point of view. Thus, the geometry of the roadway has been mainly contributing to the determination of different features of earthworks, pavement layers and crossing structures. Hence, other country's experiences in this aspect are important features that will help in updating design manuals for the conditions based on its applicability for the Ethiopian environment.

According to (Ethiopian Roads Authority, 2002) & (The United Republic Of Tanzania Ministry of Works, 2011) there may be circumstances where the designer will be obliged to deviate from the standards. For instance, the inclusion of a switchback and the use of a gradient greater than the desired value are considered as departures from the standard. In such cases and other departures, the designer requires obtaining written approval from ERA. The following information to ERA:

- the number, name, description of the road,
- The facet of design for which departure from standard is desired.
- A description of the standard, including normal value, and the value of departure from the standards.
- The reason for the departure from standards, and
- Any mitigation to be applied in the interest of safety.

The designer must submit all major and minor departures from standards to respective ERA regional directorates for evaluation. If the proposed departures from the Standards area acceptable, the departures from standards will be submitted to the quality assurance, road inspection and safety directorate for final approval.

Design criteria and policies in the manual provide a guide for the designer to exercise sound engineering judgment in applying standards in the design process. This guidance allows for flexibility in Appling design standard and approving design exceptions that take the context of the project location into consideration; which enables the designer to toiler the design, as appropriate, for the specific circumstance while maintaining safety. (The United Republic Of Tanzania Ministry of Works, 2011).

Kentucky has a formal procedure to document the request and approval of a design exception. The documentation materials include: a description of the project, the design criteria, a description of the exception requested, and the reason for requesting the exception. (Kenneth R. Agent. et al., March 2002).

As (New Work State of Opportunity Department of Transportation, 2020); described that nonstandard feature is created when the established design criteria for a critical design element is not met. All nonstandard features to be retained must be listed, justified, and approved. Since many of the values for the critical design elements are dependent on the design speed, the selection and justification of a nonstandard design speed are not permitted. Any nonstandard critical design elements individually justified. In addition to the critical design element covered in this chapter, there are other design elements with established values or parameters that must be considered. These elements are important and can have a considerable effect on the project's magnitude. Any decisions to vary from recommended values or accepted practices need to be explained and documented as nonconforming features in the scoping/ design approval documents. If it is found that a pedestrian facility cannot fully comply with standards, the facility must be made accessible to the extent practicable within the scope of the project.

According to (Eireann et al., October 2016) a Departure from Standard shall mean any of the following:

a. A Departure from any of the mandatory requirements of TII Publications (Standards) the use of technical design standards and/or specifications other than those in TII Publications (Standards);
b. The use of a set of requirements or additional criteria for any aspect of the works for which requirements are not defined in the Contract;

c. The use of a technical design standard or technical specification in a manner or circumstance which is not permitted or provided for in such directive or specification;
d. A combination of any of the criteria specified above.

As (Ruyters H.G.J.C.M. et.al., 1994) described that most countries, geometric road design standards have been set to help engineers design sound roads. Freely rendered from (MeLean, 1980), geometry design standards are generally supported on three main grounds:

- to ensure uniformity among different designs, particularly across administrative boundaries; Wlifomlity makes traffic situations and road user behavior more predictable, which is believed to be good for safety;
- to enable the existing expertise in geometric design, which tends to be centered in the major road authorities, to be more broadly applied; and
- To ensure that road funds are not misspent through inappropriate design, making inadequate provision for future traffic growth and current safe operation.

2.1.2. Types of Design Exceptions and Project Type Requiring a Design Exception

(The State of New Jersey Department of Transportation, 2012) & (U.S. Department of Transportation Fedral Highway Administration, July 2007) mention the type of construction requires design exception are:-

- Anew highway construction
- Existing highway reconstruction (lane addition including auxiliary, acceleration and declaration lane, and a change in the horizontal and/or vertical alignment, including an increase in exciting pavement surface elevations).
- Total bridge replacement on an NHS roadway
- Bridge widening
- 3R (resurfacing, restoration, and rehabilitation projects)

And (The Goverment of Western Australia, March, 2020) mentioned three types of Design Exceptions;

- A pre-existing Design Exception:-This typically occurs on an upgrade project when it is proposed to retain an existing substandard design element. For example a vertical crest curves not meeting sight distance requirements on a section of road to be resurfaced or widened of the exciting formation.

- ❖ A Design Exception based on similar designs elsewhere on the road network:-While not meeting desirable design criteria, similar designs have been implemented elsewhere that perform to an acceptable level of safety and performance for example a short merge on the exit to a roundabout that has been converted from one to two lanes and a vertical crest not meeting sight-distance criteria in a constrained location but with mitigating treatments similar to nearby locations on the same road.
- ❖ A new Design Exception:-This situation might arise when an innovative design concept is proposed, or when constraints force designers to develop a design that has not previously been applied on the network. These projects are to be assessed as Pilot Projects or trials. Due to lack of supporting data, these design exceptions present unknown levels of risk to road users. Therefore they require a much more rigorous level of assessment and post-implementation monitoring to ensure that risks are managed appropriately. example of this on rural restoration and urban projects in very constrained situations where: a disproportionate amount of funding is required to improve a particular geometric element (for example, cost to relocate major services or excavate hard rock)
    - land acquisition is not permissible, or
    - there are prohibitive environmental or heritage constraints

2.1.5. Submission Requirements and Application Process of Departure from the Standard

As (Alba Comhdhail Departure from Standared Advise and Procedures Guide, March, 2016) described the responsibility of the Design Organization to identify all Departures from Standard and to submit these to Transport Scotland for approval. Before incorporating a Departure from Standard in to the works, the Design Organization must seek the approval of Transport Scotland’s Standards Branch who is responsible for approval or rejection of applications from DMRB and MCHW Departures from Standard. Transport Scotland Standards branch should be consulted as early as possible in the design process and at key stages during the design development. Once the Transport Scotland Standards Branch Official has determined each departure (s) he gives a decision of either (i) Approved, (ii) Rejected, or (iii) Not Determined.

(i) **Approved** – An approved Departure shall be considered as meeting Transport Scotland Standards Branch's requirements for that element of the works, provided that any mitigation measures proposed by the designer or provisional to that approval are also included into the design and works.

(ii) **Rejected** – Departure has not met with Transport Scotland Standards Branch's requirements for that element of the works.

(iii) **Not Determined** – Departure from Standard has been applied for incorrectly and is not considered by Transport Scotland Standards Branch to be a deviation from the standards and guidance laid down in the DMRB or MCHW. Once the Design Organisation has identified a Departure from Standard, the Departure from Standard Application Process must be followed

(UK Roads Liaison Group Department for Transport, October 2011) Generally recommended that detailed reports, normally prepared for other purposes, are not attached to departure applications. It is not the intention of the departure process to capture all aspects of the design process, but it is the intention to summaries the salient facts and assumptions. When summarizing information it is good practice to reference the source documents sufficiently so that documents can be retrieved in future. Attachment to the departure application should be clearly identified and listed (e.g. drawing numbers) so that the reader can ascertain the scope of the submission and the information he is expected to read.

(U.S. Department of Transportation, June, 2001) States that all countries visited utilize design guidelines for roadway design that are considered central to their design philosophy. These guidelines are typically stricter for motorways and are applied more as standards and with greater all countries visited have a design exception process through which to address departures from design guidelines. This process is more frequently applied to non-motorways. It was also noted that, in general, the public more easily accepts the lack of flexibility in motorway design because the purpose of this road mobility is gained at the expense of aesthetic treatment. Greater design flexibility was observed for urban and rural non-motorway that typically is responsive to site-specific limitations. Thus, the wider acceptability of such design departures may be due to the fact that each problem area is addressed within its context and constraints.

As (U.S. Department of Transportation Fedral Highway Administration, July 2007) mentioned that effective documentation of design exceptions is important for several reasons.

First, requiring complete documentation using prescribed formats and technical references is an effective means of maintaining quality control over decisions and outcomes

Second, documentation offers an historical advantage for upcoming designers. If safety or operational problem arises or if the location is being reconstructed, understanding the thought process and reasons for the decisions that were made in earlier projects can be important information for designers, predominantly where design exceptions were used. For this to be useful, an archive system is needed that allows designer to quickly and easily find historical documentation for decision made at their project locations.

Third, if a designer is questioned in a lawsuit and design carelessness is suspected, design exception documentation provides proof that the decision was made in deliberative, thorough approach after fully evaluating the impacts and alternatives.

And (The Highways Agency et al., May, 2008); also describes the justification for a Relaxation or Departure must include an assessment of the benefits, adverse impacts (i.e. 'disbenefits'), hazards and risks associated with the design incorporating the Relaxation or Departure when compared with a design fully in accordance with standards.

Application

(Tasmanian Government Department of State Growth, September 2020); Also describes the application shall provide as a minimum the following information:

- explanation of the project as well as total budget distribution and road class
- current and projected traffic volumes
- recent accident history if it is for an existing road (if known)
- reference to the particular guideline, standards or planning scheme criteria from which the design element would depart
- any impact on safety, environment, cultural heritage, community, access and the adjoining road network

- justification for departing from the normal standard/guideline, including the implications and additional cost of meeting the normal standard/guideline and demonstrating that adoption of different value for the criteria is in the overall community interest, particularly with respect to cost and safety
- proposed mitigation measures and assessment of risk, where the departure has safety implications
- Any other relevant information.

Approval or Rejection

The Client will consider the application and may decide to: refuse the design as presented request further information before a recommendation can be made to approve the application with some modification approve the design as presented. On the acceptance or rejection of the application, the Client will advise the Consultant of the decision, outlining reasons if the application has been rejected.

Acceptance of an application for departure from a guideline or standard shall be project-specific. It shall not set a precedent for any other project.

The Design Exception Process

(U.S. Department of Transportation Fedral Highway Administration, July 2007) Described that the process to evaluate and document a decision to deviate from the adopted design criteria must be deliberative and thorough. Design exception procedures vary to some extent from state to state, but the activities described in this chapter are fundamental to a good design exception process.

Steps for design exception

1. Determine the cost and impacts of meeting design criteria
2. Develop and evaluate multiple alternatives
3. Evaluate risk
4. Evaluate mitigation measures
5. Document review and approve
6. Monitor and evaluate in-service performance

(Ethiopian Roads Authority Construction Projects Management Stream 6, December 2020); Clearly shows the following process flow chart and process description for departure issues management.

Input	Process	Output	Responsibility
Contract Agreement Works Program	Submission of Departure Proposal	Contractor Proposal	Contractor
Contractor Proposal	Review of Departure Proposal and forward to the Employer for an approval	Comments on Departure Proposal or Request for an Approval	ERA PE/TL
	Check for the fulfilments of criteria's shown on the process description		
Works Contract Document Legal Standards	Is Departure Proposal acceptable? No Yes		ERA PE/TL
Contract Document	Write an approval letter to the Engineer from the Employer which is to be signed by the DDG	Approval Letter	ERA PE/TL/Director
Contract Document	Forward an approval to the Contractor	Approval Letter	Consultant

Figure 1: process flow chart for approval of departure requests

Table 1: process description of departure request management

No.	Process Description
1	The Contractor will submit his Departure proposal to the Engineer. (*Departure is the case in which the designer is enforced to deviate from the standards*)
2	The Engineer will review his submittal and review as per the Contract. Then, if the Engineer found it acceptable, it will be forwarded to the Employer for an approval
3	The Employer will the check for the following criteria as per the contract and other pertinent documents: • Departure report format is as per standard, • Identify the reason for the Departure from Standards • Check the impact of the proposed departure • Identify the cost and time implication, if any? • Check the soundness of the proposed departure in terms of technical, environmental, social and economic aspects, • Sufficient Conditions to Regard Design as Needing Design Departure are fulfilled, • The Extent to which the Design Shall Depart from Geometric Design Parameters is as per the Contract. • In case of Extra-Contractual Departure, make sure that the Earthwork quantity deduction is toward the Employer's benefit assessed thoroughly**. (**N.B. this only applied if the Contract specifically allows Extra-contractual departure**)**
4	If the Employer founds drawbacks on the submittal, he will forward his comments for resubmission of the proposal. On the other hand, if the Employer found it acceptable, the Employer will write an approval letter to the Engineer for the commencement of work.
5	Then the Engineer will forward an approval to the Contractor and instruct to commence the subcontracting work

2.1.4. Mitigation Measures of a Design Exception

(Florida Department of Transportaion, 2020) and (U.S. Department of Transportation Fedral Highway Administration, July 2007) put different mitigation measures for design exceptions for different design criteria:

Potential mitigation strategies for horizontal curve radius are:

(1) To provide advanced warning:

a) Signing

b) Pavement marking messages

c) Dynamic curve warning systems

(2) To provide delineation:

a) Chevrons
b) Post-mounted delineators
c) Reflectors on barrier

(3) To improve the ability to stay within the lane:

a) Widen the roadway
b) Skid-resistant pavement
c) Enhanced pavement markings
d) Lighting;
e) Audible and vibratory treatment

(4)To improve the ability to recover if driver leaves the lane:

a) Paved or partially paved shoulders
b) Safety edge

(5) To reduce the crash severity if driver leaves the roadway

a) Remove or relocate fixed objects
b) Traversable slopes
c) Breakaway safety hardware
d) Shield fixed objects and steep slopes

Potential mitigation strategies for shoulder widths are

(1) Choose best arrangement of lane and shoulder width based on site characteristics to optimize safety and operations by distributing available cross-sectional width.
(2) Signing to provide advanced warning lane width reduction.
(3) To improve the ability to stay within the lane:
    a) Wide, recessed or raised pavement markings
    b) Delineators
    c) Lighting

d) Audible and vibratory treatment

(4)To improve the ability to recover if the driver leaves the lane:

a) Paved or partially-paved shoulders

b) Safety edge treatment

(5)To reduce crash severity if driver leaves the roadway

a) Remove or relocate fixed objects
b) Traversable slopes
c) Breakaway safety hardware
d) Shield fixed objects and steep slopes

Potential mitigation strategies for deficient cross slope are:

(1) Signing to provide warning of slick pavement

(2)To improve surface friction:

a) Pavement grooving (PCC Pavement)
b) Open-graded friction courses (HMA pavement)

(3)To improve drainage:

a) Transverse pavement grooving (PCC Pavement)
b) Open -graded friction courses (HMA pavement)
c) Pavement edge drains
d) Modified shoulder cross slope to mitigate cross-slope break on the high side of super elevated curves.

Potential mitigation strategies for vertical clearance are:

1. Signing to provide advance warning;
2. To prevent impacts with low structures:
    a) Alternate routes
    b) Large vehicle restrictions.
    c) Bridge Jacking may be a consideration to address bridges with minor deficiencies

2.1.6. Relationship between Safety and Departure from the Standard

(Hauer Ezra, December 15, 1999) Conclude that designers of roads believe that roads built to standards are safe. Lawyer and judges assume that roads designed to standards are appropriately safe. Beliefs, no matter how passionately held, and assumptions, no matter how repeatedly applied, are fallible guides to the truth. The truth is not that roads designed to standard are not safe, not unsafe nor are they appropriately safe; roads designed to standards have an unpremeditated level of safety. This is the claim to be substantiated.

(Stamatiadis and Nikiforos, 2017); Crash investigation showed that, with a very few exceptions, use of the design exception procedure did not have any negative effects on highway safety. The analysis showed that the design exception projects resulted in an enhancement over the prior condition although some aspect of the design may not be typical.

(D. O'Cinneide, 1995); Indicates the safety consequences of reducing the design speed from 100 km/h to 80 km/h. the design parameter values for European design standards (I) while the predicted increases in accidents are based on a synthesis of the information contained in his chapter. The majority design parameters show strong associations to safety except for gradients, vertical curvature, and overtaking sight distance. Decreasing the horizontal curvature by the specified design step results in the greatest effect on the accident rate. A decreasing in design speed from 120 km/h to 100km/h would show significantly smaller increases in accidents.

(Richard J. Porter, August 2012); Conclude that road segments with one or more design exceptions had the same expected frequency of total crashes (all types and severities), fatal-plus-injury crashes, and property-damage-only crashes as road segments without design exceptions and there were no differences in the severity distributions of crashes occurring on roads with one or more design exception when compared to crashes occurring on roads without any design exceptions.

(Stamatiadis and Nikiforos, 2017); describes Potential impacts of selected design parameters

Design speed

When design speed Increase the following impacts are occurred

- Shorter travel time (depends on LOS)
- Reduced opportunity to view futures and service adjacent to the road way
- Decrease in safety

And when the design speed decreased the following potential impacts are occurred

- Increase opportunity to view futures and service adjacent to the road way
- Increase in safety

- Improve pedestrian/bicyclist environment

The Lane width Increase the following potential impacts are occurred

- Additional space for vehicles to manoeuvre
- Higher operating speed
- Increased impervious surface
- Increased capacity
- Longer pedestrian crossing distance greater risk
- Can provide room for turning movement at intersection
- Can provide room for additional lane
- More room for bicyclist

And the Lane width decrease the following potential impacts are occurred

- Reduced space to vehicle manoeuvre
- Reduced capacity
- Reduced vehicle speed
- Shorter pedestrian crossing distance
- Decrease in safety for pedestrian

When shoulder width increase

- Increased space for errant and disabled vehicle
- Increased space for bicycles
- Increase for impervious surface
- Increase for impervious area to be mitigated
- Longer pedestrian crossing distance

And decrease

- reduced space for errant and disabled vehicle
- reduced area for pedestrian and bicycle
- reduced for impervious surface to be mitigated
- shorter pedestrian crossing distance

The most common design exception involved a reduced design speed at a bridge replacement project. The typical reason for the exception was that the design conformed to the existing conditions on the roadway adjacent to the project and thus, there is no need to construct a bridge that would conflict with the context of the roadway. Roadway widening and shoulder addition were the next types of projects most commonly requested. For these projects the use of a decreased design speed was most commonly noted. These data indicate that there may be a need to revise the method by which design speeds are determined and used in roadway design. Moreover, these data may be indicative of the need for using a different type of speed that would reflect the operating conditions of the roadway rather than an abstract design speed. This was also noted in the Mason and Mahoney state policy review. NCHRP Report also recommends the treatment of the design speed differently than other criteria and recommends discouraging or even prohibiting its use as a design exception.

2.1.8. Cost Implicitly of Departures

(UK Roads Liaison Group Department for Transport, October 2011); States that the decision about whether or not a departure is justified will often be based in part on economic grounds. One of the main justifications for applying for a Departure from Standard is that significant financial cost would be involved in fully conforming to a standard. If the cost to the community of any potential increased accident risk stemming from a departure can be estimated, then this can be compared with the construction cost in compliance to a standard thus allowing a more informed decision to be reached. The costs to the community will accrue over time whilst the cost saving of conforming to a standard will occur close to the time of opening the scheme and will generally be a 'one-off' saving. The Cost Benefit Tool is an order-of-magnitude technique that provides a simplified methodology to allow designers to consider, on comparable terms, the construction cost savings obtained from a proposed Departure from Standard against a judgment of the maximum likely change in annual road user accidents arising from the Departure.

(UK Roads Liaison Group Department for Transport, October 2011); Also provided the method of appraisal focuses on comparing potential increases in the number of accidents (the impacts) against whole life cost savings from the infrastructure (the benefits). The analysis concentrates on safety effects, without considering vehicle operating and time costs, as the safety costs are generally the most important decision factor. However, where delays are likely to be caused over a long stretch of carriageway, then time costs and vehicle operating costs should also be considered separately as their impact may be significant.

The appraisal has the following steps:

Step 1: obtain the saving in whole life costs (Δ). These are derived using the following expression:

$CCC = \Delta C$

Where C-Represents the whole life cost of designing fully in accordance with standards, while C represents the whole life cost with the Departure from standard incorporated.

Step 2: Obtain the typical cost of an average accident (A) for the relevant road type using the information published in the latest version of "Reported road casualties Great Britain" which is published annually.

Step 3: Obtain the total number of accidents equivalent to the savings in whole life cost (N1)

$N1 = A/C\Delta$

To obtain an equivalent annual accident figure (N2), it is suggested that N1 is divided by the scheme design life. Typically imagine a 30 year design life unless there is a reason to choose a lesser figure.

Step 4: Compare the annual number of accidents equivalent to the savings in whole life cost (N^2) against the designer's judgment of the maximum increase in annual accident numbers likely to be caused by the departure from the design constraint required by the standard. **Note: This can only be an order of magnitude assessment not a detailed calculation.**

The impacts of the road condition, as well the road design standards, on road users are measured in terms of road user costs, and other social and environmental effects. A Road user cost comprises;

- Vehicle Operation Cost (Fuel, tyres, oil, spare parts consumption; vehicle depreciation and utilization, etc.)
- Cost of travel time: for both passengers and cargo, and
- Costs to the economy of road accidents (that is, loss of life, injury to road users, damage to vehicle and other road side objects).

It should be noted that in HDM-4, road user effects can be calculated for both motorized transport (motorcycle, cars, buses, trucks, etc.) and non-motorized transport (bicycles, human powered tricycles, animals pulled carts, etc.). (Kerali Henry G. R., 2000)

(Transport Sector Board, 2010) states that road user cost model is used to determine the road using different relation for the speed, travel time, vehicle operating cost and emission. (Odoki, 2016) also describes that one of the components of road user costs, the vehicle operating cost, is determined by multiplying the vehicle resource by unit cost. As (Odoki, 2000) and (Kerali Henry G. R., 2000), 2000 states that the road user cost is determined on per annum basis for each vehicle types and for each traffic flow period. The annual Road user cost for each vehicle type is the result of the multiplication of the cost per vehicle type of the vehicle by the total traffic volume of the corresponding vehicle (Kerali Henry G. R., 2000) also describes that road user costs are computed by multiplying the unit costs with predicted physical quantity of resource consumption.

2.1.8. Cause of Departure from Standard

(The Highways Agency et al., May, 2008) Also mention different situations to which departures are appropriate this are;

- where it can be justified that a requirement of a standard is in appropriate in a particular situation;
- where the application of the a standard would have un intended adverse consequences;
- Where innovative methods or materials are to be used; where an “Aspect not covered by Standards”.

(The Goverment of Western Australia, March, 2020), (U.S. Department of Transportation Fedral Highway Administration, July 2007) and (Department of Transportation Fedral Highway Administration Oklahoma, 2012) mentioned common reasons for considering a design exception include the need to, or desire to:

- avoid adversely impacting the natural environment
- improve the natural environment
- avoid adverse social effects
- avoid land acquisitions
- preserve right-of-ways
- preserve historical or cultural resources or scenic value
- accommodate the context of the site (such as community values related to the site)
- limit construction costs or avoid Excessive construction cost or cost/benefit
- Compatibility with adjacent sections

- No plans for improvement of adjacent sections in the foreseeable future
- Proposed improvements or changes in standards for the highway corridor
- Low crash history and/or crash potential
- Low traffic volumes

The most common reason for the request referred to the existing conditions on the road 66 percent followed by the right-of-way issue (33 percent) and project cost (25 percent). The usual comments made concern in right of way was that the exception would limit the amount of right of way needed for the project. The reason related to cost was that the cost to meet typical criteria would be excessive. (Kenneth R. Agent. et al., March 2002).

The most common design exception has involved a reduced design speed at a bride replacement project. The typical reason for the exception was that the design conformed to the existing conditions on the roadway adjacent to the project. The analysis shows that use of the design exception procedure has not resulted in construction of projects with high crash rates. The reasons for design exceptions have been well recognized and there is no confirmation that construction of projects with a design exception had an adverse effect on highway safety.

Finally, the literature review describes submission requirements and application process of departure from the standard, types of design exceptions and project type requiring a design exception, description of geometric design manual, steps for design exception, mitigation measures of a design exception, relationship between safety and departure from the standard, cost implicitly of departures, cause of departure from standard by different authors were described.

CHAPTER THREE

3.1. METHODOLOGY

3.1.1. Introduction

This chapter discusses method adopted in carrying out the data collected for the survey. Specific areas covered, study approach, instruments for data collection, research scope and limitations, sample and sampling procedure, and the procedure for analyzing the data. In order to obtain the applicable data both primary and secondary data were used to address the specific details under the study.

The primary data for the study was obtained through distribution of questionnaires from professionals involved in road construction projects of Ethiopia. In order to enrich the questionnaire for the research, a review of text books and journals were used to identify the various efforts that have been made in the past to evaluate and examine the effects of departure from standard on road construction projects. Secondary source of data were obtained from relevant literature research and publication on the subject matter.

3.1.2. Data Source and Sampling

Distribution of questionnaire survey focused on Client, Consultant and those Contractors only GC1 of high caliber status of contract they handle and mostly GC 1are contracted ERA’s project. The study samples are going to be selected using stratified sampling to include equal percentage ratios of Client, Consultant and all Grade 1 general construction companies.

According to the “Ministry of Urban Development and Construction Coordination Bureau” the numbers of construction companies, consultant and client in Ethiopia are;

Grade 1 General Contractors= 46

Consultant Company =82

Client= 1

Total number =129

Hypergeometric formula is used to calculate the sample size from the total population size and margin of error.

$$n=\frac{NZ^2pq}{(E^2(N-1)+Z^2pq)}$$

Where

n= No. of samples

N= total population

E= error of margin/margin of error

P & q= the population proportions (if the value are not known set them each to 0.5)

Z = the value that specifies the level of confidence in confidence interval for analysis of data and for confidence interval 90%, Z= 1.645.

Using a total population size of 129 and margin of error 10% yields a sample size of 44. Once the sample size has been decided, then convenience sampling was used to handout questionnaire and collect responses and Data collection was done by means of questionnaires which were completed by a selected group of 48 professionals.

3.1.3. Description of the Study Area

Data collection was done by means of questionnaires from the Client, Consultant and Contractors participating in the Ethiopian road projects. The questionnaires tested respondent's views and knowledge regarding issues relating to design exceptions in road design and construction projects of Ethiopia and the secondary data obtained from desk study of randomly selected 5 ongoing road projects that have departure from standard issue and form this 4 are used for Vehicle Operating Costs analysis by using Highway Development and Management (HDM-4) Vehicle Operating Costs Module. The selected road projects have high departure from standard issue because of this they can be representative for those projects with departure from standard these projects are Dabat -Keraker-Ketemanigus Design and Build Road Project, Contract 1: Dabat – Ajire, Robe - Gasera - Km 60 Design and Build road project, Alaba -Angcaha -Wato road project, AdiArkay-Telemt road project.

3.1.4. The Study Approach

The research was initiated from the prevailing practical problems and discovers whether there is a type, cause and effect of departure from standard in the road construction and design projects of Ethiopia. Once research problem is identified an in-depth literature review has been done to have an understanding on the type, causes, and cost impact (VOC) and mitigation measures of design exception. The review includes books, journals, Contractor's request for departure from standard internet sources and archival documents such as progress reports, contract documents of Ethiopian Roads Authority. After an in depth review of the literature a questionnaire was designed and distributed to contractors, consultants and client (ERA) staffs to obtain their professional opinion out of their experience.

After the required data are collected, checked and sorted analysis of data will follow to get the results and based on that discussions are made to draw conclusions and forward recommendations.

3.1.5. Data Source and Collection

Once the population size or the study area is identified, questionnaire format is prepared and distributed to selected professionals involved in road design and construction projects of Ethiopia in order to obtain the required information. The questionnaires will series of structured questions which related to the research work and directed to respondents of stockholders from the client, the contractor and the consultant who are the major participants of the federal road projects. The questionnaire will be divided in to two sections namely respondents profile and prevalence of departure from standard and consisted both open ended and close-ended questions. Thus, in some cases, respondents were to choose the option that best reflected their options. The respondents were asked to respond fifteen (15) questions.

The secondary data will mostly obtained from such sources as published and unpublished documents collected from different relevant research papers and from books, journals, internet sources and archival documents such as design review, progress reports, contract documents, final feasibilities and engineering design reports and supplementary agreements of randomly selected undergoing Road projects of the Ethiopian Roads Authority.

The answers for the structured part of the questionnaire are based on Likert's-scale of ordinal measures of agreement towards each statement as shown in the following sections. The reasons for adopting this simple scale are:

- To provide simplicity for the respondent to answer, and
- To make evaluation of collected data easier

Likert's-scale is important to know respondents' feelings or attitudes about something and is utilized for the data analysis. The respondents must indicate how closely their feelings match with the question or state mention a rating scale. After the possible causes, effects and controls of departure from standard are identified; respondents are asked the frequency of occurrence for each variable. Accordingly, the respondents choose one of the following based on their opinion and experience.

1-Never
2-Seldom
3-Sometimes
4-Always

3.1.6. Data Presentation and Analysis

This Chapter examines and analyses the results of data gathered from desk study and questionnaire survey which was distributed among professionals working in the national works of road projects administered by Ethiopian Roads Authority. Simple statistical analysis involving tables, rankings and percentages used in analyzing the results from the questionnaire. Descriptive explanations also employed in making the analysis more meaningful.

In order to analysis the cost implicitly of departure from standard which is vehicle operating cost of departure from standard use the Highway Development and Management (HDM-4) Vehicle Operating Costs Module. The input elements for HDM-4 Vehicle Operating Costs Module software includes: traffic data, type and geometry of the road section and vehicle fleet configuration.

This section consists of two major parts. The first part describes and analyses the data related to the respondents' experience and response rate. The second part focuses on the main objectives of this survey, ranks and discusses the major type and causes of departure from standard and proposed mitigation measures of departure from standard based on the opinions of the professional respondents from the Contracting parties i.e. the Consultant, Contractor and Client. Each ranking is made using mean score data analysis method based on the importance of frequencies of occurrence for the type of design criteria, causes, proposed mitigation measure of departure from standard and terrain type mostly affected by departure from standard identified. A desk study survey also conducted to evaluate the existence and extent of departure from standard form randomly selected undergoing projects of the Ethiopian Roads.

Documents surveyed include Contractor's request for departure from standard, Contract documents, design review, correspondence letters, final feasibilities and engineering design reports and other complementary documents. Based on the data collected, cause/reasons for departure from standard, mitigation measures for departure from standard, analyzing the vehicle operating cost by using the Highway Development and Management (HDM-4) and the most affected design criteria/element identified with their corresponding reasons.

3.1.7. Method of Analysis

Both descriptive and inferential statistics are employed in the data analysis. In the analysis the "Mean Score" method is adopted to establish the relative importance of the causes, effects and controls of departure from standard in road projects in Ethiopia. As discussed earlier Likert's scale of three to five ordinal measures of agreement towards each statement is used to calculate the mean score for each factor that is used to determine the relative ranking. The mean score (MS) for each variables of departure from standard is computed by using the following formula;

$$MS=\frac{\sum(F*S)}{N} \quad \text{[3.1]}$$

MS- Mean Score

F– Frequency of responses for each score

S – Scores given to each factor (from 1to 4)

N-Total number of responses concerning each factor

3.1.8. HDM 4 Input Data

Most of the HDM-4 data were obtained through examining available final feasibilities and engineering design reports which were acquired from the planning section of the Ethiopian Roads Authority (ERA). The Road Networks data mainly includes: speed flow pattern, climatic zone, existing geometry and condition of the road that is length, width, curvature, rise and fall, existing pavement type and thickness, roughness and traffic levels. The collected road network data for all road sections are presented in table1 below.

3.1.8.1. The Road Networks

The network data mainly includes: speed flow pattern, climatic zone, existing geometry and condition of the road that is length, width, curvature, rise and fall, existing pavement type and thickness, roughness and traffic levels. The collected road network data for all road sections are presented in table1 below.

Table 2:Dabat – Kirakir – Ketema- NeguseDesign –Build road project Contract 1: Dabat – Ajire with standard and with departure from standard

	Data Description	Dabat – Kirakir – Ketema- Neguse with design standard	Dabat – Kirakir – Ketema- Neguse Road Project with departure from standard
Definition	Road Class	Link road/secondary	Link road/ secondary
	Speed flow Type	Two lane standard	Two lane standard
	Traffic flow Pattern	Inter-urban	Inter-urban
	AADT-2020	309	309
	Pavement Type	DBST	DBST
	Length (Km)	43.2	43.2
	Width of carriage way (m)	6.5	6.5
	Shoulder (m)	1.25	1.25
	No. of Lane	2	2
	Surface Class	Sealed	Sealed
	Climate Zone	Humid/Tropical	Humid/Tropical
	Flow Pattern	Two way	Two way
Geometry	Super elevation	4	4
	Average Horizontal Curvature (degree/km)	110	50
	Vertical rise + fall (m/km)	16	24
	Vertical rise + fall (no/km)	1	1
	Speed limit (km/hr)	51	51
	Altitude (m)	2660	2660
Condition of road	Ride Quality (default value)	Good	Good
	Surface texture (default value)	New	New
	Structure adequacy(good, fair and poor)	Good	Good
	Condition at the end of the year	2020	2020
	Roughness (IRI-m/km)	2.5	2.5
	Surface Material	Bituminous	Bituminous
	Analysis start period	2020	2020
	Analysis period	20	20

	Compaction method	Mechanical	Mechanical
	Last re gravel year	2020	2020

Source: Final Engineering design report and departure from standard requests for approval of dabat -keraker-ketema nigus design and build road project, contract 1: dabat–ajire (2017)

Table 3: Alaba -Angcaha -Wato Road Project with design standard with standard and with departure from standard

	Data Description	Alaba -Angcaha -Wato Road Project with design standard	Alaba -Angcaha -Wato Road Project with departure from standard
Definition	Road Class	main access	main access
	Speed flow Type	Two lane standard	Two lane standard
	Traffic flow Pattern	Inter-urban	Inter-urban
	AADT-2023	1492	1492
	Pavement Type	AC	AC
	Length (Km)	79.64	79.64
	Width of carriage way (m)	7	7
	Shoulder (m)	1.25	1.25
	No. of Lane	2	2
	Surface Class	Sealed	Sealed
	Climate Zone	Tropical/sub-tropical/cool zone	Tropical/sub-tropical/cool zone
	Flow Pattern	Two way	Two way
Geometry	Super elevation	8	8
	Average Horizontal Curvature (degree/km)	175	32
	Vertical rise + fall (m/km)	14	20
	Vertical rise + fall (no/km)	2	2
	Speed limit (km/hr)	70	30
	Altitude (m)	3320	3320
Condition of road	Ride Quality (default value)	Good	Good
	Surface texture (default value)	New	New

	Structure adequacy(good, fair and poor)	Good	Good
	Condition at the end of the year	2023	2023
	Roughness (IRI-m/km)	2.5	2.5
	Surface Material	Bituminous	Bituminous
	Analysis start period	2023	2023
	Analysis period	15	15
	Compaction method	Mechanical	Mechanical
	Last re gravel year	2023	2023

Table 4: Robe–Gasera–Km 60 Design and Build Road Project with standard and with departure from standard

	Data Description	**Robe–Gasera–Km 60 Design and Build Road Project with design standard**	**Robe–Gasera–Km 60 Design and Build Road Projectwith departure from standard**
Definition	Road Class	Link road/secondary	Link road/ secondary
	Speed flow Type	Two lane standard	Two lane standard
	Traffic flow Pattern	Inter-urban	Inter-urban
	AADT-2020	768	768
	Pavement Type	AC	AC
	Length (Km)	60	60
	Width of carriage way (m)	7	7
	Shoulder (m)	1.5	1.5
	No. of Lane	2	2
	Surface Class	Sealed	Sealed
	Climate Zone	Sub-tropical	Sub-tropical
	Flow Pattern	Two way	Two way
Geometry	Super elevation	8	8
	Average Horizontal Curvature (degree/km)	410	75
	Vertical rise + fall (m/km)	14	14
	Vertical rise + fall (no/km)	1	1
	Speed limit (km/hr)	100	50
	Altitude (m)	2460	2460

Condition of road	Ride Quality (default value)	Good	Good
	Surface texture (default value)	New	New
	Structure adequacy(good, fair and poor)	Good	Good
	Condition at the end of the year	2020	2020
	Roughness (IRI-m/km)	2.5	2.5
	Surface Material	Bituminous	Bituminous
	Analysis start period	2020	2020
	Analysis period	20	20
	Compaction method	Mechanical	Mechanical
	Last re gravel year	2020	2020

Table 5: Adi Arkay-Telemt Road Project with standard and with departure from standard

	Data Description	**AdiArkay-Telemt Road Projectwith design standard**	**AdiArkay-Telemt Road Projectwith departure from standard**
Definition	Road Class	Link road/secondary	Link road/ secondary
	Speed flow Type	Two lane standard	Two lane standard
	Traffic flow Pattern	Inter-urban	Inter-urban
	AADT-2020	123	123
	Pavement Type	AC	AC
	Length (Km)	76.3	76.3
	Width of carriage way (m)	6.5	6.5
	Shoulder (m)	1.25	1.25
	No. of Lane	2	2
	Surface Class	Sealed	Sealed
	Climate Zone	Sub-tropical	Sub-tropical
	Flow Pattern	Two way	Two way
Geometry	Super elevation	8	8
	Average Horizontal Curvature (degree/km)	80	30
	Vertical rise + fall (m/km)	16	24
	Vertical rise + fall (no/km)	5	5

	Speed limit (km/hr)	50	50
	Altitude (m)	2000-2500	2000-2500
Condition of road	Ride Quality (default value)	Good	Good
	Surface texture (default value)	New	New
	Structure adequacy(good, fair and poor)	Good	Good
	Condition at the end of the year	2023	2023
	Roughness (IRI-m/km)	2.5	2.5
	Surface Material	Bituminous	Bituminous
	Analysis start period	2019	2019
	Analysis period	19	19
	Compaction method	Mechanical	Mechanical
	Last re gravel year	2022	2022

3.1.8.2. Vehicle Fleet

Regarding traffic data for estimation of traffic measures on subject roads, AADTs, Vehicle composition, Vehicle-Km, Vehicle Category and Traffic growth factor were determined. Available secondary data were collected from the ERA Design management Directorate, Director. The basic characteristic of vehicle category in this study is presented table below.

Table 6: Vehicle classification adopted by ERA Geometric Design Manual

Vehicle category	No of axles Vehicle	Vehicle types and capacities
Car	2	Small car and Taxis
Land Rovers (4WD)	2	Pick-ups, Land Rovers, Land Cruisers, Jeeps, etc.
Small Bus (SB)	2	Buses up to 27 passenger seats
Large Bus (LB)	2	Buses with passenger seats above 45
Small Truck (ST)	2	Delivery vans and light goods trucks up to 3.5 tons capacity
Medium Truck (MT)	2or3	Trucks with carrying capacity above 3.5 tons and below 7.5 tons
Heavy Truck (HT)	6	Trucks and tankers with carrying capacity above 7.5 tons

Vehicle category	No of axles Vehicle	Vehicle types and capacities
Truck and Trailer (TT)	4	Trucks with trailer and semi-trailer and tanker trailer

Source: ERA Geometric Design Manual, (2013)

3.1.8.3. Average Daily Traffic (AADT) and Growth Rate

In this study, the traffic has been adjusted accordingly using growth rates recommended by the Consultants. The Consultants had determined different growth rates by vehicle types during the design period. The AADT and the growth rates adopted for this study are presented in Tables 3.2 and 3.3 below.

Table 7: AADT of project Roads

Dabat – Kirakir – Ketema- Neguse Design –Build road project Contract 1: Dabat – Ajire									
Year	Car	Utility	S/Bus	L/Bus	S/Truck	M/Truck	H/Truck	T and T	Total
2012	0	38	57	27	62	60	56	9	309
Alaba -Angcaha -Wato Road Project									
Year	Car	4 WD	S/Bus	L/Bus	S/Truck	M/Truck	H/Truck	T and T	Total
2023	0	174	296	352	365	212	78	15	1492

Robe–Gasera–Km 60 Design and Build Road Project								
Year	Car/4 WD	S/Bus	L/Bus	S/Truck	M/Truck	H/Truck	T and T	Total
2020	107	150	74	131	120	116	70	768
AdiArkay-Telemt Road Project								
Year	Car/4 WD	S/Bus	L/Bus	S/Truck	M/Truck	H/Truck	T and T	Total
2019	20	37	11	25	19	6	4	123

Table 8: Summery of Traffic Growth rate for Dabat – Kirakir – Ketema- Neguse Design –Build Road Project

Vehicle Type	2003-2012
Car	11.9
Utility	10.2
Small Bus (SB)	3.7
Large Bus (LB)	11.6
Small Truck (ST)	6.0
Medium Truck (MT)	10.6
Heavy Truck (HT)	-27.8
Truck and Trailer (TT)	11.9

Source: Final Engineering report of Dabat – Kirakir – Ketema- NeguseDesign –Build road project

Table 9: Summery of Traffic Growth rate for Alaba -Angcaha -Wato Road Project road project

	Vehicle Type	2014-2018(Prep. & Imp. period)	2019 –2029 (Traffic service period)2030	2038 (Traffic service period)	Growth rate
Passenger vehicles	Car	10.44	10.44	9.66	10.05
	L/R	10.44	10.44	9.66	
	Small us (SB)	10.44	10.44	9.66	
	Large Bus (LB)	10.44	10.44	9.66	
Freight Vehicles	Small Truck (ST)	11.58	11.58	10.09	10.84
	Medium Truck (MT)	11.58	11.58	10.09	
	Heavy Truck (HT)	11.58	11.58	10.09	
	Truck and Trailer (TT)	11.58	11.58	10.09	

Source: Final feasibility study of Alaba -Angcaha -Wato Road Project road project

Table 10: Summary of Traffic Growth rate for Robe–Gasera–Km 60 Design and Build Road Project

Years	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2015
Cars/4 WD	9.1	9.1	9.1	7.9	7.9	7.9	7.9	7.9	6.7	6.7	6.7	6.7	6.7	6.1	6.1	6.1	6.1	6.1	5.6	5.6	6.1
S/Bus	9.1	9.1	9.1	7.9	7.9	7.9	7.9	7.9	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	5.6	5.6	6.7
L/Bus	8.5	8.5	8.5	7.4	7.4	7.4	7.4	7.4	6.4	6.4	6.4	6.4	6.4	5.8	5.8	5.8	5.8	5.8	5.3	5.3	5.8
S/Truck	8.5	8.5	8.5	7.4	7.4	7.4	7.4	7.4	6.0	6.0	6.0	6.0	6.0	5.5	5.5	5.5	5.5	5.5	5.0	5.0	5.5
M/Truck	9.1	9.1	9.1	7.9	7.9	7.9	7.9	7.9	6.7	6.7	6.7	6.7	6.7	6.1	6.1	6.1	6.1	6.1	5.6	5.6	6.1
L/Truck	9.1	9.1	9.1	7.9	7.9	7.9	7.9	7.9	6.7	6.7	6.7	6.7	6.7	6.1	6.1	6.1	6.1	6.1	5.6	5.6	6.1
Articulated (T&T)	8.5	8.5	8.5	7.4	7.4	7.4	7.4	7.4	6.4	6.4	6.4	6.4	6.4	5.8	5.8	5.8	5.8	5.8	5.3	5.3	5.8

Source: *Review of Feasibility, ESIA, RAP & Preparation of Concept Design, Cost Estimate & Bidding Document for Robe - Gassera - Ginir Design & Build Road Upgrading Project [DB]*

Table 11: Summary of Traffic Growth rate for Adi Arkay-Telemt Road Project

Vehicle Type	2001-2016
Car	17
Utility	
Small Bus (SB)	28
Large Bus (LB)	
Small Truck (ST)	41
Medium Truck (MT)	
Heavy Truck (HT)	
Truck and Trailer (TT)	

Source: Final Feasibility Study report of Adi Arkay-Telemt Road Project

3.1.9. Analysis

Vehicle operating costs depend on the following

- Types of Vehicle using the road
- Traffic Volume on the Road Section
- Road geometry (particularly, the curvature, gradient and road width)
- Road surface condition (primarily roughness and texture depth)
- Driver behaviour

The prediction of Vehicle resource consumption is done for each vehicle type in the following order

1. Fuel consumption
2. Oil consumption
3. Tyre consumption
4. Vehicle utilization
5. Parts consumption
6. Labour hours
7. Capital costs
8. Overhead

3.1.9.1. The Relationships

The quantities of different vehicle operating cost were generated using the relationship together with default parameters. The relationships are presented below from HDM-4 manual volume 4.

1. Fuel consumption

Annual average fuel consumption

The annual average fuel consumption in liters per 1000 vehicle-kilometers of each vehicle type is required for reporting purpose, and it is calculated as follow;

$$\frac{\sum_{p=1}^{n} HRYRp*HVP*FCkp}{\sum_{p=1}^{n} HRYRP*HVP} \quad \text{[3.3]}$$

Where:

Fc_{kav} - annual average fuel consumption of vehicle type k (km/h)

$HRYR_P$-the number of hours in traffic flow period p

HV_p- the hourly traffic flow in period p expressed as proportion of AADT

FC_{kp}- fuel consumption of vehicle type k during traffic flow period p

2. **Lubricating oil consumption**

The annual average oil consumption (liters per 1000 vehicle- kilometers) is given by:

OIL_{kav}= OILCONT+OILOPER*FC_{kav}…………………………………………………………… [3.4]

Where

OIL_{ka} oil consumption (1/1000km)

OILCONT oil loss due to contamination (1/1000km)

OILOPER oil loss due to operation (1/1000km)

FC_{kav} annual average fuel consumption (1/1000 km)

3. **Tyre consumption**

The annual average number of tires consumed per 1000 vehicle kilometers for each vehicle type k is calculated from the formula:

$\frac{\sum_{p=1}^{n} HRYRP*HVP*TCKP}{\sum_{p=1}^{n} HRYRP*HVP}$…………………………………………………………………........………. [3.5]

Where:

TCkav- annual average number of tires consumed per 1000 veh-km by vehicle type k

HRYRp-the number of hours in traffic flow period p

HVp - the hourly traffic flow in period p expressed as proportion of AADT

TCkp-number of tires consumed per 1000 Veh-km by vehicle type k during traffic flow period p

4. **Vehicle utilization and service life**

Annual number of kilometers driven

AKM_0= $\sum_{k=1}^{n} AKMVi * PCTVi/100$……………………………………………………….... [3.6]

Where:

AKM_0 - baseline average number of kilometers driven per year, input by the user (km/year)

$AKMV_i$-average number of kilometers driven per vehicle of age I per year, input by the user (km/year)

$PCTV_i$ - percentage of vehicle of age I in the fleet (for i=1,2…n)

Annual number of working hours

HRWK0= $\sum_{i=1}^{n} HRWKVi * PCTVi/100$……………………………………………………… [3.7]

Where:

HRWK0 - baseline average number of vehicle working hours per year, input by the user (hrs/year)

HRWKVi- number of working hours per vehicle of age I per year

PCTVi-percentage of vehicles of age I in the fleet (for i= 1, 2… n)

5. **Parts consumption**

Annual average parts consumption

$$\mathbf{PC_{kav}}=\frac{\sum_{p=1}^{n} HRYRp*HVp*PCkp}{\sum_{p=1}^{n} HRYRp*HVp}$$ …………………………………………………………….. [3.8]

Where:

$\mathbf{PC_{kav}}$-annual average parts consumption per 1000 veh-km, expressed as a friction by the average new vehicle price

$HRYR_P$- the number of hours in traffic flow period p

HV_p -hourly traffic flow in period p expressed as proportion of AADT

PC_{kp}-parts consumption per 1000 veh-km by vehicle type k during traffic flow period p, expressed as a friction of the average new vehicle price

6. **Labour hours**

The annual average numbers of labor hours per 1000 veh-km are calculated as follows:

$$LH_{kav} = \frac{\sum_{p=1}^{n} HRYRp*HVp*LHkp}{\sum_{p=1}^{n} HRYRp*HVp}$$ …………………………………………………………… [3.9]

Where:

LH_{kav}-Annual average number of labor hours per 1000 veh-km, of vehicle type k

$HRYR_P$-Number of hours in traffic flow period p

HV_P-The hourly traffic flow in period p expressed as a proportion of AADT

LH_{kp}-Number of labor hours per 1000 veh-km for vehicle type k during traffic flow period p

7. Capital costs

Annual average capital cost

The annual average capital cost per 1000 vehicle-kilometers is calculated as follows:

$$CAPCST_{kav} = \frac{\sum_{p=1}^{n} HRYRp*HVp*CAPCSTkp}{\sum_{p=1}^{n} HRYRp*HVp} \qquad [3.10]$$

Where:

$CAPCST_{kav}$ -Average capital cost per 1000 veh-km for vehicle type k

$HRYR_p$ -Number of hours in traffic flow period p

HVp-Hourly traffic flow in period p expressed as a proportion of AADT

CAPCSTkp -Capital cost per 1000 veh-km for vehicle type k during flow period p

8. Crew hours

The annual average number of hours for each crew member per 1000 vehicle-kilometers is calculated as follows:

$$CH_{kav} = \frac{\sum_{p=1}^{n} HRYRp*HVp*CHkp}{\sum_{p=1}^{n} HRYPp*HVp} \qquad [3.11]$$

Where

CH_{kav} -Average number of hours per crew member per 1000 Veh-km for vehicle type

$HRYR_p$ the number of hours in traffic flow period p

HV_p-the hourly traffic flow in period p expressed as proportion of AADT

CH_{kp}-number of hours per crew member per 1000 veh-km for vehicle type k during traffic flow period

9. Overhead costs

The annual average overhead cost per 1000 vehicle-kilometers is calculated as follows:

$OC_{kav} = \frac{\sum_{p=1}^{n} HRYRp - HVp * OCkp}{\sum_{p=1}^{n} HRYRp * HVp}$ ………………………………………………………………… [3.12]

Where:

OC_{kav}-Annual average overhead costs per 1000veh-km for vehicle type k

$HRYR_p$-The number of hours in traffic flow period p

HV_p -The hourly flow in period p expressed as a proportion of AADT

OC_{kp} -Overhead cost per 1000 veh-km for vehicle type k during traffic flow period

CHAPTER FOUR

4.1. RESULT AND DISCUSSION

4.1.1. Profile of Respondent and Questionnaire Response Rate

Out of a total of 48 questionnaires 16 distributed to Contractor, 29 to consultant and the remaining 3 to staffs of Client. 42 (87.5%) professionals duly completed and returned the questionnaires. As depicted in table 12, respondent professionals in the survey included are Contractor (28.12%), Consultant (62.5%) and Client (9.37%) the survey was conducted between December 2020 and February 2021.

Table 12: Summary of questionnaire distribution and response rate(N=3)

No.	Respondent	Total questionnaires distributed		Total questionnaires responded		Response rate (%)
		No.	%	No.	%	
1	Contractor	16	33.33	12	28.57	75
2	Consultant	29	60.42	27	64.28	93.1
3	Client(ERA)	3	6.25	3	7.14	100
	Total	48	100	42	100	87.5

The position held by respondents include project managers, Deputy project manager, Resident Engineers, Material Engineer, Quantity Surveyor, project counterpart Engineers and Senior and Lead Engineers of the client having total work experience from 4 years to 20 years in the road construction history.

4.1.2. Frequency of Occurrence of Reasons of Departure from Standard

The frequency of the occurrence of reasons for departure from standard were identified by using the following scale, namely never=1; seldom=2; sometime=3; always=4. From table 13 it was possible to rank the reasons of departing from standard by comparing their means. To limit construction costs or avoid excessive construction cost or cost/benefit (2.1), avoid land acquisitions (2) and avoid adversely impacting the natural environment, preserve right-of-ways, preserve historical or cultural resources and Compatibility with adjacent sections (1.8) were most ranking causes of departure from standard.

Table 13: Frequency of reasons of departure from standard

No.	Reasons for departing from standard	Contractor MS	Consultant MS	Client MS	Average	Ranking
8.1	avoid adversely impacting the natural environment	2.1	1.5	1.8	1.8	3
8.2	improve the natural environment or scenic value	2.06	1.29	1.82	1.7	4
8.3	avoid adverse social effects	1.29	1.65	2.29	1.7	4
8.4	avoid land acquisitions	2.06	2.06	1.84	2.0	2
8.5	preserve right-of-ways	1.82	1.71	1.88	1.8	3
8.6	preserve historical or cultural resources	1.65	1.71	2.12	1.8	3
8.7	accommodate the context of the site (such as community values related to the site)	1.76	1.71	1.65	1.7	4
8.8	limit construction costs or avoid Excessive construction cost or cost/benefit	2.12	2.24	1.94	2.1	1
8.9	Compatibility with adjacent sections	2.12	1.53	1.65	1.8	3
8.10	No plans for improvement of adjacent sections in the foreseeable future	1.88	1.12	1.47	1.5	6
8.11	Proposed improvements or changes in standards for the highway corridor	1.18	1.65	2	1.6	5
8.12	Low crash history and/or crash potential	1.47	1.41	1.21	1.4	7
8.13	Low traffic volumes	1.47	1.08	1.12	1.2	8
8.14	a requirement of a Standard is inappropriate in a particular situation	1.59	1.65	1.41	1.6	5
8.15	where the application of a Standard would have unintended adverse consequences;	2.06	1.29	1.24	1.5	6
8.16	Where innovative methods or materials are to be used; where an "Aspect not covered by Standards".	1.59	1.41	1.47	1.5	6

The causes of departure from standard from the table 13 above were also ranked in ascending order and the most frequent causes were identified, it is evident that the most frequent cause of departure from standard were to limit construction costs or avoid excessive construction cost, avoid land acquisitions and avoid adversely impacting the natural environment, preserve right-of-ways, preserve historical or cultural resources and Compatibility with adjacent sections were most ranking causes of departure from standard.

To supplement the result of the questionnaire survey desk study was conducted. Hence, 5 road projects were randomly selected from projects that have departure from standard issue of ERA and surveyed documents were Contractor's request for departure from standard, Contract documents, design review, correspondence letters, final feasibilities and engineering design reports and other complementary documents. According to the desk study the type of design criteria, causes and mitigation measures were identified by using their frequency. Hence, some of the major causes of departure from standard are;

- To minimize/avoid the removal of ROW Obstructions (like Electric pole, water pipe line) and due to safety reasons by increasing its visibility at bridge approach.
- To minimize unnecessary depth of cut which have environmental impact due to huge excavation which are not environmentally friendly as they slash through the natural topography and leave heavy construction scars resulting in steep and long roadside slopes susceptible to erosion and incapable of supporting vegetation/plant cover and topsoil (or disfigured landscape), the deep cut would have problems related to drainage which may be expressed as blocking the side storm which otherwise could be made to flow to its natural course and to avoid deep cut section which is undesirable in town sections because of the deep cuts which would not be easy to provide access with on the left and right side communications.
- To minimize height of fill to provide better access for residents, to avoid huge and expensive retaining walls on the valley side as it lets the project road susceptible to failure.
- The need for use of switch back curve in traversing steep ascent and decent mountainous and escarpment section.
- For a very difficult section of the project as the alignment climbs down from hill top to which has more than 400m elevation difference, The departure from standard is adopted to pass the alignment in acceptable side slope of the road way in this difficult topography, To minimize intrusion into the landscape; deep excavation of the slope invariably disturbs the natural stability of the ground by the removal of lateral support and a change in the natural ground water conditions which may trigger slope instability problems.
- Existing bridge structure approach where unnecessary excavation avoided and better approach provided.
- To protect the road from danger of over flooding by raising the embankment height and to provide appropriate minimum cover for the proposed cross drainage structures.

This is therefore, based on the finding of the desk study survey, some of the major cause for departure from the standard were to minimize/avoid the removal of ROW Obstructions, to minimize unnecessary depth of cut, to avoid deep cut section which is undesirable in town sections, to minimize height of fill to provide better access for resident and avoid huge and expensive retaining walls, to pass the alignment in acceptable side slope of the road way in the difficult topography, to protect the road from danger of over flooding by raising the embankment height and to provide appropriate minimum cover for the proposed cross drainage structures.

Table 14 below shows a summary of desk study for reasons, proposed mitigation measures types of design criteria and terrain type mostly affected by departure from standard in randomly selected 5 road projects administered by Ethiopians Roads Authority.

Table 14 Summery of Departure From Standards from Deck Study

Project Name	Reasons for Exceptions to Standards	Design Proposal to Mitigate Exceptions	Terrain Type	Standard	Exception/ Departure	Applicable Standard	Design Exception
Dabat -Keraker-Ketemanigus Design And Build Road Project, Contract 1: Dabat–Ajire	In order to avoid deep cut section which in undesirable in town sections because of the deep cuts which would not be easy to provide access with on the left and right side communications	Shorten the length of difficult section as far as possible, which is less than 100m and Guide posts.	Rolling Type (town section)	7 %	9%	ERA GDM 2013	gradient
	The deep cut would have problems related to drainage which may be expressed as blocking the side storm which would otherwise could be made to flow to its natural course	Guard railing will be provided to insure the safety of the driver operation as per ERA-Design Manual or any additional required as per the best engineering practice.					
	To avoid construction of high fill or high and expensive retaining walls on the valley side as it lets the project road susceptible to failure	• shortened the maximum length of the difficult section as far as possible, which is less than 400m • Provided relief gradient section with a gradient of 6% for a minimum of 200m before and after the difficult section to relax the travelling operation.	Escarpment	8	10%	ERA GDM 2013	Gradient
	To minimize excessive spoil material, which can give rise to a variety of problems including erosion of the spoil itself, the smoothening or removal of natural vegetation, instability within the spoil material itself, especially when infiltrated by water, slope overloading and resultant failure and disruption of existing runoff patterns and siltation of water courses and drainage channels and disruption of agricultural practices.	• Provide guide post sign to restraint the drive speed • Provide guard railing to insure the safety of the driver operation.					
	To minimize intrusion into the landscape; deep excavation of the slope invariably disturbs the natural stability of the ground by the removal of lateral support and a change in the natural ground water conditions which may trigger slope instability problems.						

Project Name	Reasons for Exceptions to Standards	Design Proposal to Mitigate Exceptions	Terrain Type	Standard	Exception/ Departure	Applicable Standard	Design Exception
	To minimize the slope stake distance as it may touch high stayed boulders and let it to fall down to the project road						
	The alignment traverses through a mountainous section with very steep side slope at these locations. The departure from standard is adopted to pass the alignment in acceptable side slope of the road way in this difficult topography.	• Traffic Signs for Sharp Curve and Speed Limiters (like speed breaker and/or physical warning like Ramble strip) • Guard Rail/ Guide Post	Escarpment	80	50		Horizontal Curve Radius
	The route immediately faces a big mountain where it requires the alignment to climes up in acceptable gradient. In the process of doing this, the proposed alignment gradually includes up to the mountains using two switch back curves and the listed horizontal curves.	Traffic Signs for Sharp Curve and Speed Limiters (like speed breaker and/or physical warning like Ramble strip), Guard Rail/ Guide Post.	Escarpment	80	50		Horizontal Curve Radius
Robe - Gasera - Km 60 Design and Build Road project	To minimize/avoid the removal of ROW Obstructions (like Electric pole, water pipe line) and due to safety reasons by increasing its visibility at Bridge approach.	provide Traffic signs, speed bumps, and planting Cactuses and rumble strips	Flat	410	115	ERA GDM	Horizontal Curve Radius (min) (m)
	To protect the road from danger of over flooding by raising the embankment height and to provide appropriate minimum cover for the proposed cross drainage structures	Designing the road as fill section by making the proposed finished road grade above the existing ground level and using minimum 0.5% grade for earthen fill side ditches where it is practical.	Flat	0.5	0.3		Gradient (%)
Design and Build of Debark – Zarima (limlimo bypass) road project	Making the radius above the proposed will result the slope stake significantly far from the edge of the road which will result unstable embankment and problem of getting better surface for retaining wall construction.	Traffic Signs for Sharp Curve and Speed Limiters (like speed breaker and/or physical warning like Ramble strip), Guard Rail/ Guide Post shall be provided as per the requirement.	Mountainous	120	80	Contract Document	Minimum Horizontal Radius
	The previously selected route in this section is prone to land slide and the realignment is carried to avoid this land slide in acceptable gradient and side slope. Therefore, the departures from the standard of these curves are related with the land slide				50/40/30		
	To climb down an elevation of more than 130m from mountain tops to the selected location by reducing			8	10		Gradient

Project Name	Reasons for Exceptions to Standards	Design Proposal to Mitigate Exceptions	Terrain Type	Standard	Exception/ Departure	Applicable Standard	Design Exception
	excessive cut sections. The provision of gradients less than the proposed one may trigger slope stability and land slide problems along steep side slope of mountains.						
Dabat – KerakerKetemaNigus Design and Build Road Project; Contract 2: Ajire – Keraker – KetemaNigus	To traverse through a mountain located immediately after crossing river at the only possible location from the river crossing to the leveled surface at the top of mountain by reducing excessive earthwork volume in a deep box cut section.	• Traffic Signs for steep gradients and Guard Rail/Guide Post shall be provided as per the requirement. • Traffic signs and pavement markings, and rumble strips, Speed Limiters (like speed breaker and/or physical warning like Ramble strip) Guard Rail/ Guide Post shall be provided as per the requirement.	Mountainous	8	10	ERA GDM 2013	Gradient
	• To climb up an elevation of more than 80m along mountains section by reducing excessive cut sections which may triggers slope stability and land slide problems. • Making the Gradient below the proposed will extends the excessive cut section which results the limit of access to village residences.						
	To climb up an elevation of more than 300m along steep sides of mountain chains by reducing excessive deep cut sections.		Escarpment				
			Mountainous	8	10		
	To avoid deep cut ,High fill section and huge retaining wall		Escarpment	8	9.98		
	To minimize depth of cut sections which are not environmentally friendly as they slash through the natural topography and leave heavy construction scars resulting in steep and long roadside slopes susceptible to erosion and incapable of supporting vegetation/plant cover and topsoil (or disfigured landscape).		Mountainous	80	67.72		Minimum Horizontal Radius
Alaba - Angcaha - Wato Road Project	• use switch back curve in traversing steep ascent and decent mountainous and escarpment section • Exciting structure approach where the exciting topography requires smaller radius • To avoid unnecessary high fill embankment and need for huge retaining walls • To minimize unnecessary depth of fill and provision of sufficient tangent length with adjacent curve	➢ Placement of advance warning signs (speed limits) ➢ Provision of guard rail and speed calming system	Mountainous and escarpment	12	9	ERA GDM	Gradient

Project Name	Reasons for Exceptions to Standards	Design Proposal to Mitigate Exceptions	Terrain Type	Standard	Exception/ Departure	Applicable Standard	Design Exception
	• Its village section where right of way is major control and using the minimum radius set on the standard result excessive excavation resulting box cut highly affects the settlement • Depth of cut and height of fill is kept as minimum as possible to provide better access for residents	➢ Application of delineations (pavement marking and road studs)					
	• Exiting bridge structure approach where unnecessary excavation avoided and better approach provided.						
	• To avoid unnecessary depth of cut and harmonize the cross section with existing cut section • To avoid unnecessary depth of cut in excess of 20m on the average at the centre line for over 400m distance • To avoid huge depth of cut and reduce environmental impact due to excessive exaction • Its s set of two switchback curve sections where huge depth of cut is avoided in excess of 20m • To minimize depth of cut section which are not environmentally friendly as they slash through the natural topography and leave heavy construction scars resulting in steep and long roadside slopes susceptible to erosion and incapable of supporting vegetation cover and topsoil or disfigured land escape) • Its existing bridge crossing approach which requires excessive height or retaining wall • In order to keep vertical height clearance of existing stricture • reduced to avoid curved bridge construction and super elevated bridge • The shorter distance Between Subsequent PI's		Flat	100 Km/h	70Km/h		Speed
				410	180		Minimum horizontal curve radius

Source: Contractor's report for departure from standard to request Employer's approval

4.2.4. Ranking of Occurrence of the types of Departure from Standard

The frequency of the occurrence of the type of departure from standard/ design exceptions were identified by using the following scale, namely never=1; seldom=2; sometime=3; always=4. From table 15 it was possible to rank the type of departure from standard/ design Exceptions frequently requested. A pre-existing design exception (8.6), A new Design Exception (7.9) and A Design Exception based on similar designs elsewhere on the road network (7.4)were most ranking types of departure from standard requested.

Table 15:Ranking of Types of Departure from Standard (N=3)

No.	**Types of Design Exceptions**	**Contractor MS**	**Consultant MS**	**Client MS**	**Average**	**Ranking**
7.1	A pre-existing Design Exception	**7.7**	8.67	9.3	8.6	1
7.2	A Design Exception based on similar designs elsewhere on the road network	6.3	8.67	7.3	7.4	3
7.3	A new Design Exception	4.3	11.33	8	7.9	2

Based on the questionnaire survey the first frequently occurred type of design exception is pre-existing design exception and the second is a new design exception and the third is design exception based on similar design.

4.2.4. Frequency of Occurrence of type of Roadway Construction mainly Affected by Departures from Standards

The frequency of the occurrence of the types of roadway construction mainly affected by departures from standards: were identified by using the following scale, namely never=1; seldom=2; sometime=3; always=4. From table 16: new construction ranked first with mean of 5.2, reconstruction ranked second with the mean of 4.5 and the third bridge widening (4).

Table 16:Ranking of the Type of Roadway Construction affected by Departures from Standards(N=5)

No.	Type of Construction	Contractor MS	Consultant MS	Client MS	Average	Ranking
11.1	New construction	5	6.6	4	5.2	1
11.2	Reconstruction	3.8	5.20	4.6	4.5	2
11.3	3R (resurfacing, restoration, and rehabilitation)	2.6	4.00	3.8	3.5	5
11.4	Total bridge replacement	2	5.20	4	3.7	4
11.5	Bridge widening	2	5.20	4.8	4.0	3

There for, from questionnaire survey and desk study the type of road way mostly affected by departure from standard identified. Hence, new construction, reconstruction and bridge widening rank first, second and third respectively and from desk study mostly affected road construction is new construction.

4.2.5. Ranking of Mitigation Measures for Departures from Standards

The types of mitigation measures which is frequently used to mitigate the impacts of departures from standards: were identified by using the following scale, namely never=1; seldom=2; sometime=3; always=4. From table 17 it was possible to rank the Mitigation Measures as follows:

- For steep grades mostly used mitigation measures was advance signing, both conventional and dynamic with mean score of 1.07, guardrail were ranked second with mean score of 0.79 and climbing lanes ranks third with mean score of 0.72
- For horizontal curve radius mostly used mitigation measure to provide advanced warning was signing with mean score of 0.91 ranked first, the second Pavement marking messages with mean score of 0.81 and the third dynamic curve warning systems with mean score of 0.67 and to provide delineation: mostly used mitigation measure were reflectors on barrier ranked first, the second was Post-mounted delineators and third Chevrons with mean score of 0.76, 0.65 and 0.61 respectively. To improve the ability to stay within the lane enhanced pavement markings was the first with mean score of0.73,the second was widen the roadway with mean score 0.69 and the third was lighting with mean score of 0.55,To improve the ability to recover if driver leaves the lane: Paved or partially paved shoulders was the mostly used with mean score of 0.71 and Safety edge the second with mean score of 0.60.To reduce the crash severity if driver leaves the roadway the first mitigation measure was remove or relocate fixed objects the second Shield fixed objects and steep slopes and the third Traversable slopes with mean score of 0.70, 0.59 and 0.52 respectively.

- **For shoulder width mostly used mitigation measure was** select optimal combination of lane and shoulder width based on site characteristics ranks first with mean score of 0.72 and Signing to provide advanced warning of lane width reduction ranks second with mean score of 0.62, to improve the ability to stay within the lane: Wide, recessed or raised pavement markings, Lighting and Delineators ranks first, second and third with mean score of 0.73, 0.71 and 0.70 respectively. To improve the ability to recover if the driver leaves the lane Paved or partially-paved shoulders ranks first with mean score of 0.74 and Safety edge treatment ranks second with mean score value 0.64.To reduce crash severity if driver leaves the roadway Remove or relocate fixed objects ranks first with mean score of 0.63, Shield fixed objects and steep slopes ranks second with mean score of 0.55 and the third traversable slopes with mean score of0.53, To reduce crash severity if driver leaves the roadway remove or relocate fixed objects ranks first shield fixed objects and steep slopes second and third traversable slopes with mean score of 0.63, 0.55 and 0.53 respectively.
- **Potential mitigation strategies for deficient cross slope are:** Signing to provide warning of slick pavement is the mostly used mitigation measure with mean score of 0.64 and to improve surface friction Open-graded friction courses (HMA pavement)was ranks first with mean score of 0.53 and Pavement grooving (PCC Pavement) ranks second with mean score of 0.46 and to improve drainage Open -graded friction courses (HMA pavement) ranks first and Transverse pavement grooving (PCC Pavement) ranks second with mean score of 0.54 and 0.52 respectively.
- **Potential mitigation strategies for vertical clearance are:** Signing to provide advance warning ranks first with mean score of 0.81 and to prevent impacts with low structures large vehicle restrictions ranks first with mean score of 0.72and second mostly used was alternate routes with mean score of 0.69and the third was bridge Jacking may be a consideration to address bridges with minor deficiencies with mean score of 0.45

Table 17: Frequency of mitigation measures for Impacts Caused by Departures from Standards

No.	Type of Mitigation Measures	Contractor MS	Consultant MS	Client MS	Aaverage	Ranking
	13.1. For steep grades					

No.	Type of Mitigation Measures	Contractor MS	Consultant MS	Client MS	Aaverage	Rank ing
	a. Advance signing, both conventional and dynamic,	0.8	1.3	1.1	1.07	1
	b. A brake-test pullout area	0.19	0.40	0.53	0.37	5
	c. An innovative truck escape ramp.	0.74	0.72	0.40	0.62	4
	d. Climbing lanes	0.70	0.79	0.67	0.72	3
	e. Guardrail	0.84	0.81	0.72	0.79	2
	13.2. For horizontal curve radius					
	13.2.1. **To provide advanced warning**:					
	e. Signing	0.9	0.9	0.93	0.91	1
	f. Pavement marking messages	0.84	0.84	0.74	0.81	2
	g. Dynamic curve warning systems	0.56	0.67	0.79	0.67	3
	13.2.2. **To provide delineation:**					
	a. Chevrons	0.51	0.67	0.65	0.61	3
	b. Post-mounted delineators	0.47	0.77	0.70	0.65	2
	c. Reflectors on barrier	0.84	0.72	0.72	0.76	1
	13.2.3. To improve the ability to stay within the lane					
	a. Widen the roadway	0.74	0.63	0.70	0.69	2
	b. Skid-resistant pavement	0.47	0.47	0.65	0.53	4
	c. Enhanced pavement markings	0.79	0.67	0.74	0.73	1
	d. Lighting;	0.56	0.67	0.42	0.55	3
	e. Audible and vibratory treatment	1.04	0.21	0.28	0.51	5
	13.2.4. To improve the ability to recover if driver leaves the lane:					
	a. Paved or partially paved shoulders	0.56	0.79	0.79	0.71	1
	b. Safety edge	0.53	0.53	0.74	0.60	2
	13.2.5. To reduce the crash severity if driver leaves the roadway					

No.	Type of Mitigation Measures	Contractor MS	Consultant MS	Client MS	Aaverage	Ranking
	a. Remove or relocate fixed objects	0.74	0.65	0.70	0.70	1
	b. Traversable slopes	0.56	0.58	0.42	0.52	3
	c. Breakaway safety hardware	0.47	0.49	0.47	0.48	4
	d. Shield fixed objects and steep slopes	0.84	0.47	0.47	0.59	2
	13.3. For shoulder width					
	1. Select optimal combination of lane and shoulder width based on site characteristics	0.74	0.67	0.74	0.72	1
	2. Signing to provide advanced warning of lane width reduction	0.84	0.53	0.65	0.67	2
	3. To improve the ability to stay within the lane:					
	a) Wide, recessed or raised pavement markings	0.74	0.81	0.65	0.73	1
	b) Delineators	0.60	0.77	0.74	0.70	3
	c) Lighting	0.79	0.74	0.60	0.71	2
	d) Audible and vibratory treatment	0.28	0.53	0.37	0.39	4
	4. To improve the ability to recover if the driver leaves the lane:					
	a. Paved or partially-paved shoulders	0.74	0.77	0.70	0.74	1
	b. Safety edge treatment	0.88	0.72	0.33	0.64	2
	5. To reduce crash severity if driver leaves the roadway					
	a. Remove or relocate fixed objects	0.84	0.47	0.58	0.63	1
	b. Traversable slopes	0.47	0.63	0.49	0.53	3
	c. Breakaway safety hardware	0.42	0.49	0.40	0.44	4
	d. Shield fixed objects and steep slopes	0.74	0.51	0.40	0.55	2
	13.4. Potential mitigation strategies for deficient cross slope are:					

No.	Type of Mitigation Measures	Contractor MS	Consultant MS	Client MS	Aaverage	Rank ing
	1. Signing to provide warning of slick pavement	0.79	0.65	0.49	0.64	1
	2. To improve surface friction:					
	a. Pavement grooving (PCC Pavement)	0.42	0.56	0.40	0.46	2
	b. Open-graded friction courses (HMA pavement)	0.56	0.51	0.51	0.53	1
	3. To improve drainage:					
	a. Transverse pavement grooving (PCC Pavement)	0.47	0.63	0.47	0.52	2
	b. Open -graded friction courses (HMA pavement)	0.65	0.56	0.42	0.54	1
	13.5. Potential mitigation strategies for vertical clearance are:					
	1. Signing to provide advance warning;	0.84	0.74	0.86	0.81	1
	2. To prevent impacts with low structures:					
	a. Alternate routes	0.84	0.72	0.51	0.69	2
	b. Large vehicle restrictions.	0.70	0.77	0.70	0.72	1
	c. Bridge Jacking may be a consideration to address bridges with minor deficiencies.	0.37	0.53	0.44	0.45	3

Therefore, from the questionnaire the most mitigation measures for departure from standard with the respective design criteria were identified. Hence, advance signing, both conventional and dynamic, guardrail and climbing lanes are mostly used mitigation measures for steep grades. For horizontal curve radius are provide advanced warning; signing, pavement marking messages, dynamic curve warning systems mostly used mitigation measures and to provide delineation: reflectors on barrier, post-mounted delineators and chevrons are mostly used mitigation measures. To improve the ability to stay within the lane enhanced pavement markings, widen the roadway and lighting are mostly used mitigation measures. To improve the ability to recover if driver leaves the lane; paved or partially paved shoulders and safety edge, to reduce the crash severity if driver leaves the roadway the first mitigation measure was remove or relocate fixed objects the second shield fixed objects and steep slopes and the third traversable slopes with are mostly used mitigation measures.

- **For shoulder width mostly used mitigation measure was** select optimal combination of lane and shoulder width based on site characteristics and signing to provide advanced warning of lane width reduction, to improve the ability to stay within the lane: wide, recessed or raised pavement markings, lighting and delineators. To improve the ability to recover if the driver leaves the lane paved or partially-paved shoulders and safety edge treatment. To reduce crash severity if driver leaves the roadway remove or relocate fixed objects, shield fixed objects. To reduce crash severity if driver leaves the roadway remove or relocate fixed objects and shield fixed objects are mostly used mitigation measures.
- **Potential mitigation strategies for deficient cross slope are:** Signing to provide warning of slick pavement is the mostly used mitigation measure and to improve surface friction open-graded friction courses (HMA pavement) and pavement grooving (PCC Pavement) and to improve drainage open -graded friction courses (HMA pavement) and transverse pavement grooving (PCC Pavement) are mostly used mitigation measures.
- **Potential mitigation strategies for vertical clearance are:** Signing to provide advance warning and to prevent impacts with low structures are large vehicle restrictions, alternate routes and bridge jacking may be a consideration to address bridges with minor deficiencies.

And from the desk study the most frequently used mitigation measures are for minimum radius of curve and using of radius above the standard are traffic signs for sharp curve are speed limiters (like speed breaker and/or physical warning like ramble strip), guard rail/ guide post, speed bumps, and planting cactuses and, designing the road as fill section by making the proposed finished road grade above the existing ground level and using minimum 0.5% grade for earthen fill side ditches where it is practical, pavement markings, placement of advance warning signs (speed limits), application of delineations (pavement marking and road studs).

4.2.6. Rank of Terrain types mainly affected by Departures from Standards

The types of terrain which is mainly affected by Departures from Standards: were identified by using the following scale, namely never=1; seldom=2; sometime=3; always=4. From table 14 it was possible to rank terrain type: the first affected train type was Escarpment with mean score 7.83, the second affected was mountainous with mean score of 7.08 and the third one was rolling with mean score 5.33.

Table 18: Ranking of Terrain types mainly affected by Departures from Standards (N=14)

No.	Terrain Type	Contractor MS	Consultant MS	Client MS	Aaverage	Ranking
14.1	Escarpment	7.00	8.00	8.5	7.83	1
14.2	Mountainous	6.75	7.00	7.5	7.08	2
14.3	Rolling	4.50	5.75	5.75	5.33	3
14.4	Flat	3.75	4.50	7.25	5.17	4

From the desk study and survey the terrain type mostly affected identified. Hence, the first affected terrain type is escarpment then the second mountainous and the last rolling and flat.

4.3. Vehicle Operating Cost of HDM-4 Model

The vehicle operating cost determination was done into ways. The first one was considering the design standards and the other consideration was by departing from design standards. The result is on annual base which impels the annual average costs per 1000 vehicle-kilometers. For instant, the total VOC for 20 year analysis period on the road network which are Dabat – Kirakir – Ketema- Neguse Design –Build road project Contract 1: Dabat – Ajire the VOC when the analysis is made with design standard is ETB: 1,876,295.62 and with departure from standard is ETB: 1,885,461.60, for Alaba -Angcaha -Wato Road Project is ETB: 2,294,339.36 when it is with design standard and when the design is departs from the standard is ETB: 2,443,648.60 and for Robe–Gasera–Km 60 design and build road project analysis with design standard is ETB: 2,047,253.21and with departure from standard is ETB: 2,214,319.65 and for Adi Arkay-Telemt road project VOC when the analysis made within standard is ETB: 2,908,865.69 and when the analysis is made with departure from standard is ETB: 3,333,987.12.

The comparison of VOC for departure from standard and with design standard for the selected study area was analyzed for 20 years are presented in figure below.

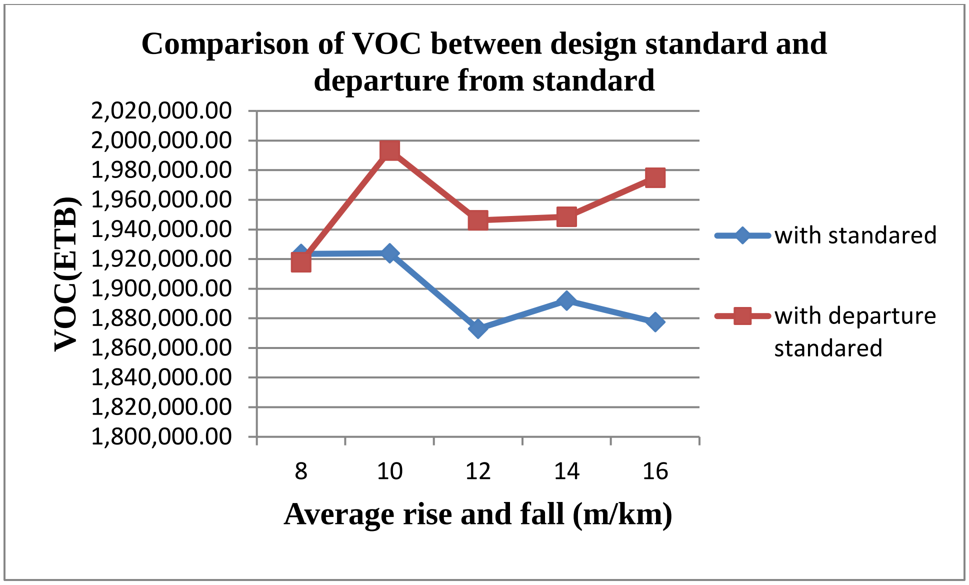

Figure 2: Comparison of VOC for departing from standard and with standard for average rise and fall for Dabat – Kirakir – Ketema- Neguse Design –Build road project Contract 1: Dabat – Ajire.

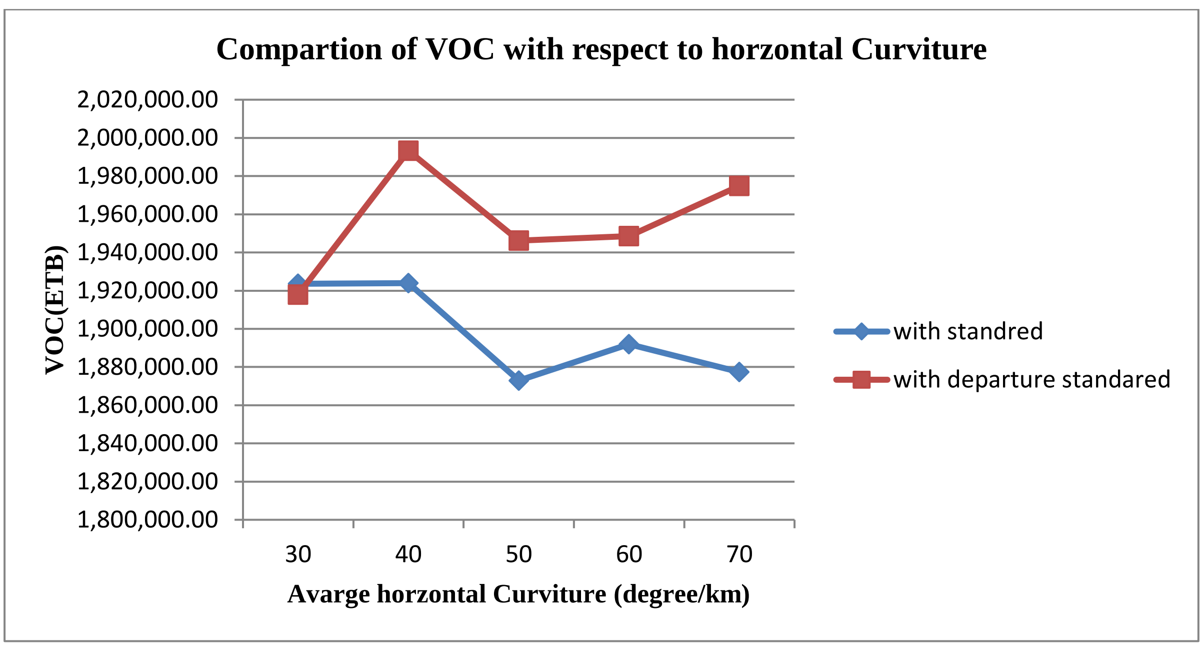

Figure 3: Comparison of VOC for departing from standard for Average horizontal Curvature for Dabat – Kirakir – Ketema- Neguse Design –Build road project Contract 1: Dabat – Ajire.

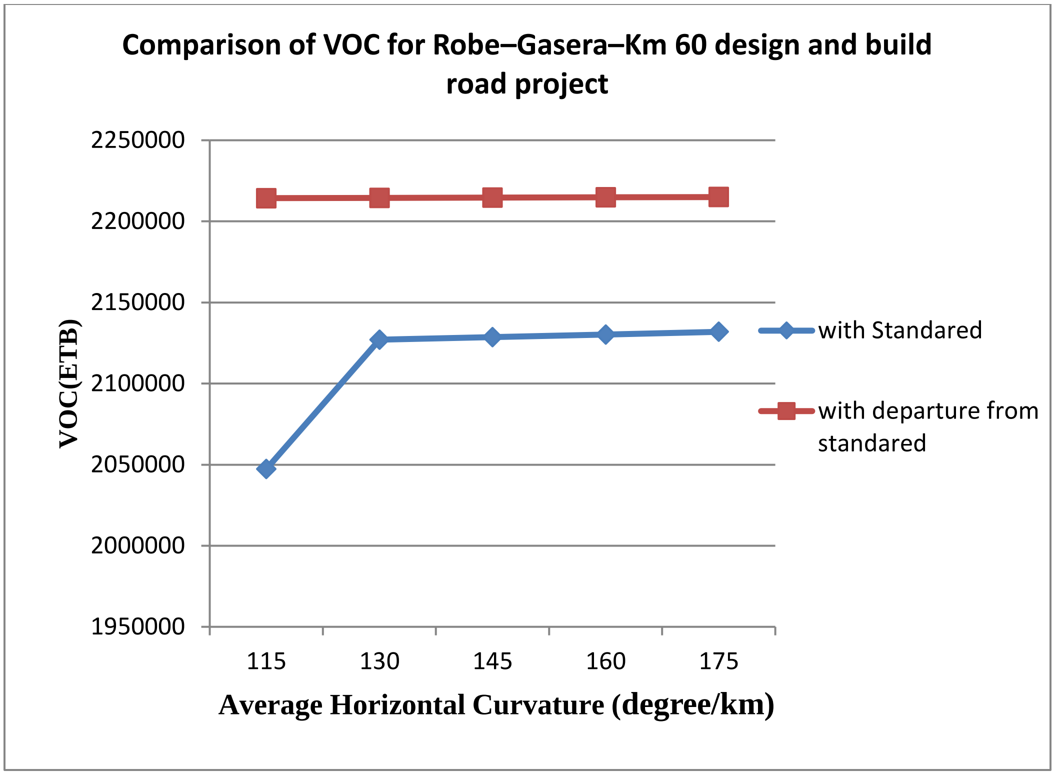

Figure 4: Comparison of VOC for departing from standard for Average horizontal Curvature for Robe–Gasera–Km 60 design and build road project.

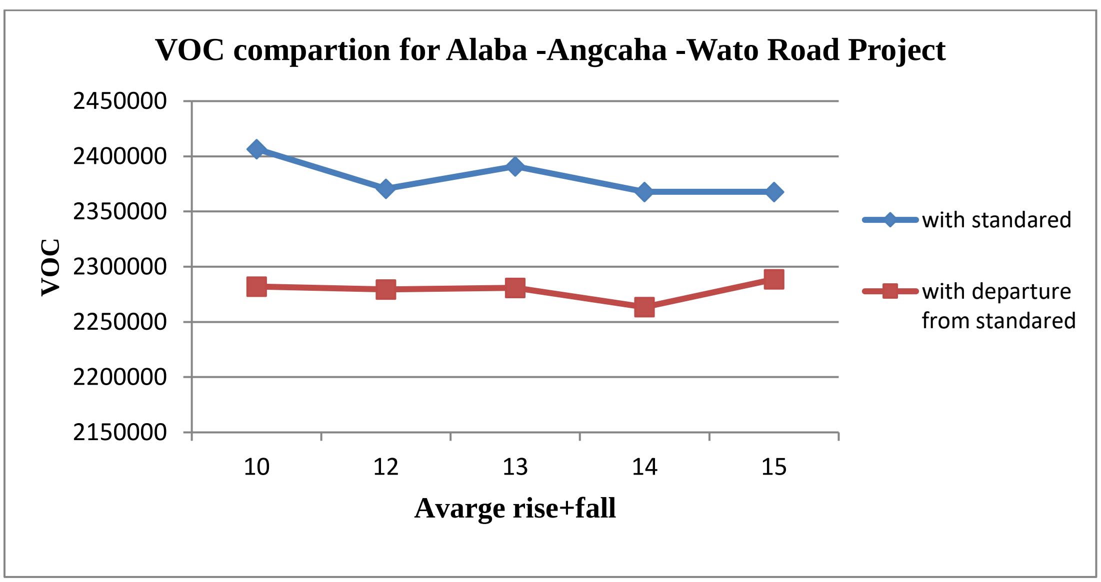

Figure 5: Comparison of VOC for departing from standard and with standard for average rise + fall for Alaba -Angcaha -Wato road project.

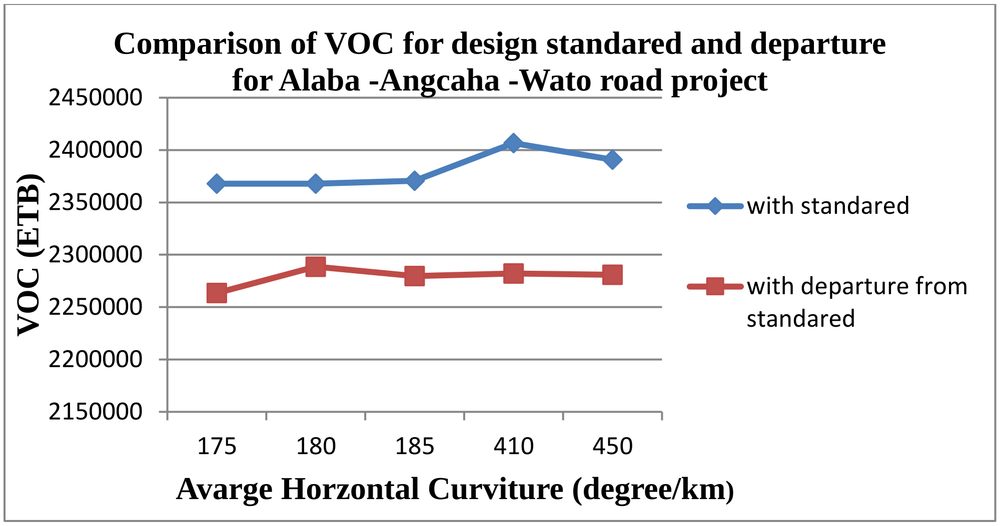

Figure 6: Comparison of VOC for departing from standard with standard for average horizontal Curve Radius for Alaba -Angcaha -Wato road project.

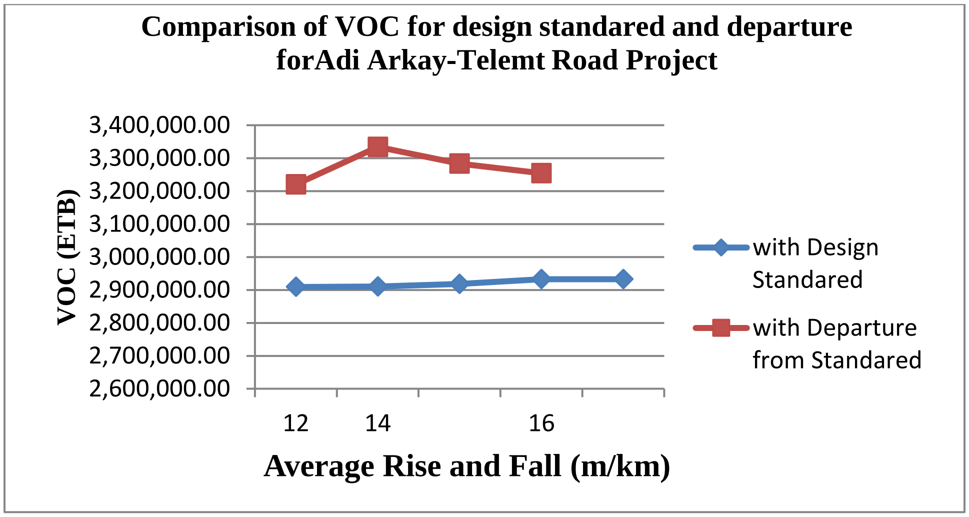

Figure 7: Comparison of VOC for departing from standard and with standard for Average rise + fall for Adi Arkay-Telemt road project.

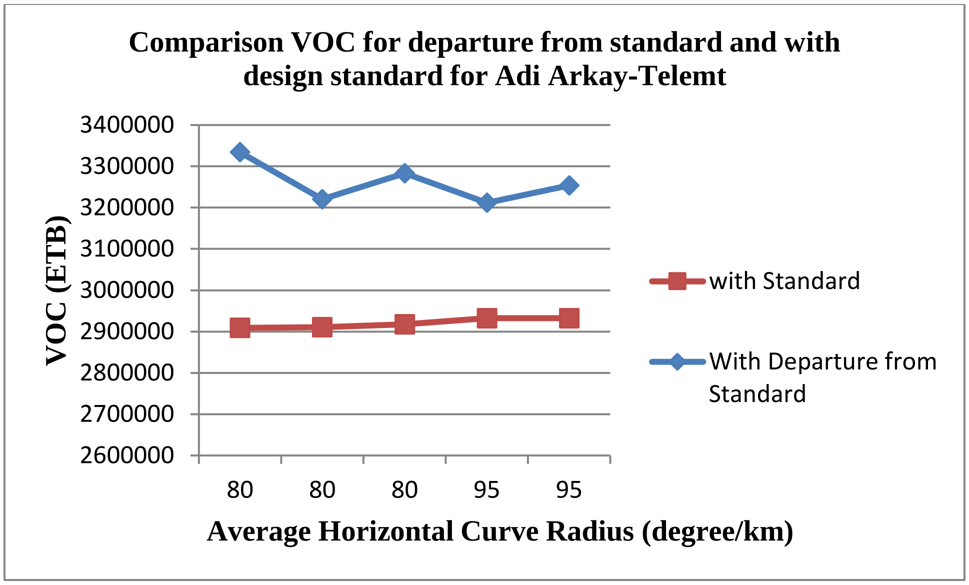

Figure8: Comparison of VOC for departing from standard and with standard for Average Horizontal curve for Adi Arkay-Telemt road project.

The Figure 1-8 above show that rise +fall (gradient) and average radius of horizontal curve departs from the standard the VOC increases for Robe–Gasera–Km 60 design and build road project and Dabat – Kirakir – Ketema- Neguse Design –Build road project Contract 1: Dabat – Ajire and Adi Arkay-Telemt road project. However, it decreases for Alaba -Angcaha -Wato Road Project.

Moreover, departure from standard have impact on road life time cost than that of with design standards and it is well known that departure from standard of design criteria have impact on safety of the road user some of the impacts are using gradient above maximum grade have an increase chance of vehicle accident rate due to vehicles losing traction and vehicles can start to slide on icy surfaces, increase difficulty on cyclist as gradient deviates from standard more cyclist would have to dismount and push, they are prone to wobble and deviation from a straight line. Hence, steep grades have higher accident rate than that of mild and level sections and for horizontal curves departed from standard causality of crashes seem to be more dominant it has more head on, opposite direction side wipe crashes, rollover and night time crashes.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

Based on the result of analysis the following conclusions have been arrived.

- As per the respondents survey and desk study the most frequent causes of design exception in road projects of Ethiopia were identified. Hence, limit construction costs or avoid excessive construction cost, avoid land acquisitions and avoid adversely impacting the natural environment, preserve right-of-ways, preserve historical or cultural resources and Compatibility with adjacent sections, to minimize unnecessary depth of cut, to avoid deep cut section which is undesirable in town sections, minimize height of fill, provide better access for resident and avoid huge and expensive retaining walls, pass the alignment in acceptable side slope of the road way in the difficult topography, protect the road from danger of over flooding by raising the embankment height and provide appropriate minimum cover for the proposed cross drainage structures are the most ranked common cause of departure from the standard.

- The most identified ranked mitigation measures to the design exception was identified from both respondents and the desk study are
  - ✓ Steep grades:-advance signing, both conventional and dynamic, guardrail and climbing lanes.
  - ✓ For horizontal curve: advanced warning; signing, pavement marking messages, dynamic curve warning systems mostly used mitigation measures and to provide delineation: reflectors on barrier, post-mounted delineators and chevrons, speed limiters (like speed breaker and/or physical warning like ramble strip), guard rail/ guide post, speed bumps, and planting cactuses.
  - ✓ To improve the ability to stay within the lane enhanced pavement markings, widen the roadway and lighting are mostly used mitigation measures
  - ✓ To improve the ability to recover if driver leaves the lane; paved or partially paved shoulders, to reduce the crash severity if driver leaves the roadway remove or relocate fixed objects and shield fixed objects and steep slopes are mostly used mitigation measures.
  - ✓ For shoulder width mostly used select optimal combination of lane and shoulder width based on site characteristics and signing to provide advanced warning of lane width

reduction, Potential mitigation strategies for deficient cross slope are: Signing to provide warning of slick pavement is the mostly used mitigation measure.

- ✓ Potential mitigation strategies for vertical clearance are: Signing to provide advance warning and to prevent impacts with low structures are large vehicle restrictions may be a consideration to address bridges with minor deficiencies.

- The most identified predominant type of design exception is pre-existing design exception and the type of road way mostly affected by departure from standard is new construction; the terrain type mostly affected by design exception is escarpment.
- The VOC determined by HDM-4 method for those analysis made by using design criteria departs from the standard is greater than from those done by using design standard.

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RECOMMENDATION

Based on the findings of this research discussed in chapter four with main conclusion listed above. The following recommendations are made.

- It is noticed that departure from stranded has higher VOC than those with in design standard. Hence, the Contractor should submit his departure from standard report for employer approval by considering and incorporating the comparison of VOC for both with design standard and with departure from standard and both the Employer and the Employer's representative properly check before giving approval for the same.

- Geometric Design Manual of Ethiopian Roads Authority (ERA) should include design guideline to reduce VOC of departure from standard and put it as one of the criteria to submit the departure from standard request.

- The establishment of an independent organization, who has the authority to command coordinate all stakeholders in Ethiopia roads authority road projects is vital to follow up the proper implementation of mitigation measures in order to alleviate impacts caused by departure from standard.

- One cause of departure from standard is cost such as to limit construction costs or avoid excessive construction cost and avoid huge and expensive retaining walls. Hence, cost comparison should be made between the cost of the same and road user cost.

- During concept design and feasibility study of the project departure from standard should be clearly justified in order to reduce additional time and cost of the project.

- Finally, I recommend my fellow researchers for future studies of departure from standard in Ethiopia roads construction projects as it is proven to be a potential study area during this study process.

FUTURE STUDY

- In this research, only VOC was considered out of road user cost components. Therefore, future studies should consider construction, maintenance and other road user cost components.
- The effect of departure from standard on VOC was evaluated using HDM-4 software based upon the data collected in the selected four study areas. In this regards, assessment of the effects should be extended to other location using others methods for more generalized conclusion.
- In this research only impact on VOC was considered out of other impacts. Therefore, future studies should consider other impacts like safety impacts, environmental impacts of departure from standard.
- For VOC analysis the selected projects was ongoing projects. Therefore, future studies should consider projects on the design and completed project.

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Appendix-A

Appendix: A

Cause and Impact of Departure from Standards/Design Exceptions in Road Design and Construction Projects (The Case of Ethiopian Roads Authority)

Questionnaire

- Since this survey is required for academic research, the data obtained will be held confidential. Your prompt response is highly essential for the fulfilment of the study
- Please answer all questions.
- If you have any query on this survey, you are kindly requested to contact me directly on tel. **09-30-85-40-67.**

Objective of the Research

The goal of this research is to examine the critical causes and effects of Departure from Standard/ Design Exceptions in selected national works contract of Ethiopian Roads Authority projects. By understanding the causes and effects the Employer, Consultants and Contractors will be able to recognize the focus point to minimize such related Departure from Standard in future Ethiopian road projects:

- To identify the type of departure from standard during the design and construction in federal road projects of Ethiopia in the case of Ethiopian Roads Authority.
- To identify the cause of departures in the national road projects of Ethiopian Roads Authority.
- Investigate different mitigation measures.
- Indicate the impact of departure from standard on VOC by using (HDM-4) Vehicle Operating Costs Module of selected road projects.

SECTION A: PROFILE

1. Which of the following best describes your company?

No	**Company description**	**Tick only one box**
1.1	Contractor	
1.2	Consulting engineering	
1.3	Client (ERA)	

2. How long have you worked in the construction industry? ......years........months

3. How long have you worked for your present company? ....years........months

4. What is your current position in your organization? ....

5. How long have you been in your present position? ....years........months

6. Have you ever been involved with the administration of Departures from Standard?

Yes □ No □

Section B: prevalence of departure from standard

7. Which departure from standard/ design Exceptions mostly occur?

No.	**Types of Design Exceptions**	**Never**	**Seldom**	**Sometime**	**Always**
7.1	A pre-existing Design Exception				
7.2	A Design Exception based on similar designs elsewhere on the road network				
7.3	A new Design Exception				

8. Following are possible causes for departing from standards on Road Design and Construction; indicate how frequently each of them occurs on national works contract of Ethiopian Roads Authority projects that you were involved.

No.	**Reasons for departing from standard**	**Never**	**Seldom**	**Sometime**	**Always**
8.1	avoid adversely impacting the natural environment				
8.2	improve the natural environment or scenic value				
8.3	avoid adverse social effects				
8.4	avoid land acquisitions				
8.5	preserve right-of-ways				
8.6	preserve historical or cultural resources				
8.7	accommodate the context of the site (such as community values related to the site)				
8.8	limit construction costs or avoid Excessive construction cost or cost/benefit				

No.	Reasons for departing from standard	Never	Seldom	Sometime	Always
8.9	Compatibility with adjacent sections				
8.10	No plans for improvement of adjacent sections in the foreseeable future				
8.11	Proposed improvements or changes in standards for the highway corridor				
8.12	Low crash history and/or crash potential				
8.14	Low traffic volumes				
8.16	a requirement of a Standard is inappropriate in a particular situation				
8.17	where the application of a Standard would have unintended adverse consequences;				
8.18	Where innovative methods or materials are to be used; where an “Aspect not covered by Standards”.				

9. From your experience with Departure from Standards in national works contract of Ethiopian Roads Authority projects, indicate which design criteria frequently affected by Departures from Standards:

No.	Design Criteria	Never	Seldom	Sometime	Always
10.1	Design speed				
10.2	Lane width				
10.3	Shoulder width				
10.4	Horizontal alignment/Curve Radius				
10.5	Super elevation				
10.6	Vertical alignment/Gradient				
10.8	Stopping sight distance				
10.9	Cross slope				
10.10	Vertical Clearance				

10.11	Lateral offset to obstruction				
10.12	Bridge width				

10. From your experience with Departure from Standards in national works contract of Ethiopian Roads Authority projects, indicate which types of roadway construction mainly affected by Departures from Standards:

No.	**Type of Construction**	**Never**	**Seldom**	**Sometime**	**Always**
11.1	New Construction				
11.2	Reconstruction				
11.3	3R (resurfacing, restoration, and rehabilitation)				
11.4	Total bridge replacement				
11.5	Bridge widening				

11. Following are mitigation measures for design exceptions/departure from standard, indicate how frequently each of them are being applied on national works contract of Ethiopian Roads Authority Road projects that you were involved.

No.	**Type of Mitigation Measures**	**Never**	**Seldom**	**Sometime**	**Always**
	11.1. For steep grades				
	e. Advance signing, both conventional and dynamic,				
	f. A brake-test pullout area				
	g. An innovative truck escape ramp.				
	h. Climbing lanes				
	E. Guardrail				
	11.2. For horizontal curve radius				
	To provide advanced warning:				
	h. Signing				
	i. Pavement marking messages				
	j. Dynamic curve warning systems				
	To provide delineation:				

No.	Type of Mitigation Measures	Never	Seldom	Sometime	Always
	f. Chevrons				
	g. Post-mounted delineators				
	h. Reflectors on barrier				
	To improve the ability to stay within the lane				
	a. Widen the roadway				
	b. Skid-resistant pavement				
	c. Enhanced pavement markings				
	i. Lighting;				
	j. Audible and vibratory treatment				
	To improve the ability to recover if driver leaves the lane:				
	a. Paved or partially paved shoulders				
	b. Safety edge				
	To reduce the crash severity if driver leaves the roadway				
	e. Remove or relocate fixed objects				
	f. Traversable slopes				
	g. Breakaway safety hardware				
	h. Shield fixed objects and steep slopes				
	11.3. For shoulder width				
	1. Select optimal combination of lane and shoulder width based on site characteristics				
	2. Signing to provide advanced warning of lane width reduction				
	3. To improve the ability to stay within the lane:				

No.	Type of Mitigation Measures	Never	Seldom	Sometime	Always
	e) Wide, recessed or raised pavement markings				
	f) Delineators				
	g) Lighting				
	h) Audible and vibratory treatment				
	4. To improve the ability to recover if the driver leaves the lane:				
	e. Paved or partially-paved shoulders				
	f. Safety edge treatment				
	5. To reduce crash severity if driver leaves the roadway				
	a. Remove or relocate fixed objects				
	b. Traversable slopes				
	g. Breakaway safety hardware				
	h. Shield fixed objects and steep slopes				
	11.4. Potential mitigation strategies for deficient cross slope are:				
	9. Signing to provide warning of slick pavement				
	10. To improve surface friction:				
	a. Pavement grooving (PCC Pavement)				
	b. Open-graded friction courses (HMA pavement)				
	11. To improve drainage:				
	a. Transverse pavement grooving (PCC Pavement)				
	b. Open -graded friction courses (HMA pavement)				

No.	Type of Mitigation Measures	Never	Seldom	Sometime	Always
	11.5. Potential mitigation strategies for vertical clearance are:				
	1. Signing to provide advance warning;				
	2. To prevent impacts with low structures:				
	d. Alternate routes				
	e. Large vehicle restrictions.				
	f. Bridge Jacking may be a consideration to address bridges with minor deficiencies.				

12. From your experience with Departure from Standards in national works contract of Ethiopian Roads Authority projects, indicate which terrain types mainly affected by Departures from Standards:

No.	Terrain Type	Never	Seldom	Sometime	Always
13.1	Escarpment				
13.2	Mountainous				
13.3	Rolling				
13.4	Flat				

13. Do you have any further comment, suggestion or contribution relative to Departure from Standard?

Appendix-B

The tables below summarize the vehicle fleet characteristics as well as economic VOC data. Costs are expressed in economic terms based on financial prices expressed as market prices. The financial costs have been converted to economic costs by using the standard conversion factor recommended in the recently updated "National Economic Parameters and Conversion Factors for Ethiopia" by the MoFED (June 2008) and the conversion factor from financial to economic cost are taken from related study and final feasibility study report AdiArkay-Telemt road. Hence, for vehicle prices unit cost and for tires is 0.9 and for crew listed in the table below.

Car	4WD (Utilities)	Small Bus	Large Bus	Medium Truck	Heavy Truck	Truck & Trailer
0.76	0.76	0.76	0.33	0.33	0.76	0.33

Table 1: Vehicle Fleet Characteristics

	Cars	**Utilities**	**Small Buses**	**Large Buses**	**Small Trucks**	**Medium Trucks**	**Heavy Trucks**	**Trucks & Trailers**
Passenger Car Space Equivalent	1	1	1.5	2.5	1.5	2.5	2.5	3.75
No. of wheels	4	4	4	6	4	6	10	22
No. of axles	2	2	2	2	2	2	3	6
Tyre type	Radial-ply	Bias-ply	Radial-ply	Bias-ply	Bias-ply	Bias-ply	Bias-ply	Bias-ply
Base no. of recaps	1.3	1.3	1.3	2.4	1.3	2.4	2.4	3.6
Retread costs (%)	15%	15%	15%	15%	15%	15%	15%	15%
Annual km	15,000	20,000	80,000	45,500	55,000	70,000	75,000	60,500
Annual working hours	500	600	2,000	2,000	1,000	2,500	3,000	2,000
Average life (years)	13	13	15	15	10	15	15	15
Private use (%)	85%	20%	15%	0%	0%	0%	0%	0%
Passengers (no.)	4	6	20	45	2	2	2	2
Work related passenger trips (%)	15%	80%	85%	100%	100%	100%	100%	100%
Operating Weight (ton)	1.2	1.6	4.5	15	5.5	9	30	50
ESALF	-	0.1	0.3	1.5	1	2.5	4.5	6.5

Source: Roads under Nekempt, Jima, Sodo, Shashemene and Dire Dawa Phase II Road Condition, Treatment Type, Implementation Methodolgoy and Maintenace Action Plan Report for unpaved roads,July 2018

Table 2: Summary of VOC and travel time costs input data- (Economic unit prices in ETB)

	Cars	**Utilities**	**Small Buses**	**Large Buses**	**Small Trucks**	**Medium Trucks**	**Heavy Trucks**	**Trucks &` Trailers**
New Vehicle Price	484,403	1,052,276	1,026,056	1,874,111	886,011	1,063,746	2,314,391	4,952,124
Replacement tyre	1,609	1,856	3,467	5,991	4,277	7,082	8,019	10,696
Fuel (per litre)	16.26	17.90	17.90	17.90	17.90	17.90	17.90	17.90
Lubricant oil (per litre)	56.40	56.40	56.40	56.40	56.40	56.40	56.40	56.40
Maintenance labour cost (ETB/hour)	20.78	20.78	20.78	20.78	20.78	20.78	20.78	20.78
Crew wages (ETB/ hour)	-	-	17.02	48.01	18.63	25.08	35.83	46.58
Annual Overheads	5,553.93	10,032.91	12,236.56	19,474.59	13,186.11	64,181.93	101,262.48	141,041.16
Annual interest (%)	10	10	10	10	10	10	10	10
Passenger working time (per hour)	19.13	19.13	2.90	2.90				
Passenger Non-work time (per hour)	6.7	6.7	1.0	1.0				
Cargo costs (per hour)					1.36	4.03	7.72	15.23

Source: Recent studies and Consultant's estimates (updated to 2017 to reflect current prices)