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Analysis of Gravel Road Problems in Ethiopia Mountainous Terrain

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Abstract The road sector in Ethiopia continues to develop its road network throughout the country at a tremendous rate with the aim of connecting all kebeles (administrative districts) to nearby higher class roads using all-weather gravel road solutions. These should provide access to the rural areas where most of the country's population is found, by means of the universal rural road access program (URRAP). Currently, Ethiopia is constructing many URRAP road projects which are susceptible to defects and there is not enough study that addresses the frequent causes. This study investigated the nature and causes of defects based on extensively reviewed literature, questionnaire responses, site visits and design reviews on two selected road projects, as well as in an interview with professionals. The major defects identified are poor vertical alignment and excessive road gradient, stoniness of the surface, inconsistency of road character without warning signs, poor drainage elements and aggregate loss. It was concluded that the lack of a prompt payment system, an ineffective project management system, inadequate and experienced human resources on the owner side, together with design error and omissions and insufficient data for design and construction in predicting underground conditions were some of the critical factors causing defects. The major causes of defects were shared 40 % by the consultant and 60% by the client.

Keywords Cause, Control, Defect, Effectiveness, Prevalence, Road, URRAP

1. Introduction

Ethiopia is a country with a population of 85.2 million people, eighty-three percent of whom live in the rural areas. The annual population growth rate is estimated to be 3.2 percent; the agriculture sector accounts for more than 85 percent of the population and earns 60 percent of foreign exchange (Alem, 2010 [1]).

The road sector development program was enacted in 1997 and accomplished the plan for the last 15 years in three phases. Unlike earlier phases of the Road Sector Development Program (RSDP), RSDP IV places a high emphasis on the construction of engineered low volume roads and includes a major investment in Woreda and kebele access roads under the universal rural road access program (FDREMTERA, 2011[2]).

The objective of Universal Rural Road Access Program is to connect all kebeles by road with all-weather, year-round access; this is designed to improve rural livelihoods by reducing the isolation of rural populations from their markets, social centers and other services centers.

URRAP is an ambitious programme, targeting the construction of 71,523 km access roads to all-weather standards (ERA, 2014[3]).” The programme uses [the] least expensive and most abundant resources, labour as well as naturally occurring road construction materials. Road works implemented under the programme will be predominantly labour or intermediate equipment based” (TOR, 2010[4]). The programme aimed to construct gravel roads with low cost mechanism by using local materials and labour force.

Due to the rise of the construction boom trend related to gravel roads network in the recent years, URRAP has been experiencing complaints about the lower quality of service on gravel roads. Frequently these roads have problems of crown, slope rate, super elevations, sight distances, curves, road gradient, oversize, ruts, potholes and drainage conditions. It is important to identify road project defects leading to failure, to provide the client with a better guarantee that delivers road projects with the required functions, and to be attentive to deficiency causes which should then help clients concentrate on preventative measures and the execution of controlling mechanisms.

Gravel roads account for a large portion of the rural roads in Ethiopia. In general, the causes of present problems of meeting standard requirements are not well identified to all parties involved in the construction process, due to the scarcity of studies that address the impact of this practice on social and direct costs. Therefore, the purpose of this study is

to close this gap by identifying areas of deficiencies and their causes in selected client projects and forward recommendations which would help to avoid or to minimize defects in URRAP road construction projects based on the findings of the study.

1.1. Defects in Gravel Roads

Gravel roads are the main constituent of the road network in most developing countries (SDCMUR, 1990[5]). In Ethiopia unpaved roads comprise a significant portion of the network and the overall percentage of unpaved roads will likely increase significantly in the future, due to the URRAP gravel road project. " URRAP roads have a designed layer of imported material, which is typically constructed to a specified standard width and provides an all-weather function according to design code 2 of Ethiopian Road Authority low volume standards and traffic carrying capacity between 25 to 75 AADT " (ERA LVM, 2011[6]). Low volume design class 2 standard of ERA pavement structure consists of a wear layer and a base layer. Due to this technique for improving the unpaved road, networks are becoming increasingly important.

Numerous gravel roads are currently designed with very low technical input and are built from the immediately obtainable resources (Haghbin, S, et al., 2014[7]). "Minimal attention is directed towards providing an adequate formation or effective drainage, or towards selecting suitable material for the prevailing conditions" (Mahgoub, H, et al., 2011[8]). Worthwhile benefits can be obtained from an appropriate level of engineering input (Ferry, 1986[9]).

It is difficult to precisely define the term "defect". We start with the SVENSK STANDARD (SS) 02 01 04 (1987[33]), which defines a defect as "the non-fulfillment of intended usage requirements". A defect refers to the observable facts of an unwanted circumstance in the road affecting serviceability, structural condition or appearance. Similarly, URRAP projects are experiencing complaints about the lower quality of service on gravel roads, particularly defects affecting the functional requirement of crown, slope rate, super elevations, sight distances, curves, road gradient, oversize, ruts, potholes and drainage conditions.

1.2. Source of Deficiencies

While defects appear in construction projects, an improved understanding would require their categorization into their roots or origin agents and causes. The origin agents are major stockholders of the project such as the client, consultant, contractor, and defects which are and were not directly related to the participants, such as weather conditions and unforeseen problems. The causes of defects can be categorized according to the originators identified in literature review and are discussed below.

Consultant-related Deficiency

Sometimes consultants directly induce defects or the shortcomings are expected because the consultant fails to fulfill certain requirements for carrying out the project related to the defect in design or to supervision by the consultant (Babatunde, S.O.1., et al.,2013[10]). As a consequence, defects will appear due to non-compliance with the requirements of the design codes and sound professional engineering judgment. Some of consultant-related causes of defects identified by the literature review are errors and omissions in design, ambiguous design details, inadequate working and shop drawing details, lack of experience, preparation of design with insufficient data, inadequate design with client's requirements and a lack of effective project supervision.

Owner-related Deficiencies

In some cases, the owner directly initiates shortcomings or the shortcomings materialize because the owner fails to fulfill certain requirements for carrying out the project. Clients cause defects due to a lack of adequate and experienced human resources, lack of sufficient project briefs and poor specifications, poor communication and slow decision-making in project management, owner-related financial difficulties, lack of a prompt payment system as the result of project cash flow problems, and right-of-way problems.

Contractor-related Deficiencies

The shortcomings may occur because the contractor fails to fulfill certain requirements for carrying out the project. The problem could have been avoided if the contractor had been experienced and was aware of possible adverse situations. Some of the faults of the contractor that lead to defects are contractor financial difficulties, contractor desire to improve his financial state, lack of experienced labor and necessary equipment, use of defective workmanship and the contractor's lack of experience.

Deficiency Related to Different Project Stage

The deficiencies were grouped under three stages of project activities: the design stage, construction stage and preservation stage. Construction defects can result from deficiencies in how something is designed, built, operated or maintained (Mikhail, C. and Chris, H.M., ASCE, 2005[11]). These groups assisted in developing a comprehensive enumeration of potentials of construction defect areas settled on four general categories of deficiencies – design, material, construction, and the way the structure is operated and maintained, in the following manner (Okuntade, T. F., 2014[12]).

Gravel roads are susceptible to poor road geometry and pavement distress. These deficiencies are manifested in the three attributes of cost, time and quality in construction projects.

There are common types of deficiencies, which include poor road geometry and pavement distress.

The geometric design of gravel roads should be the result of a careful balance between the purpose of the road, traffic volume, terrain, design standards, costs and the standard of maintenance to be adopted. The wide variety of topography, vegetation, climatic, economic and community factors result in the designer needing to input local knowledge of conditions to any economic procedure used (Henning, T. F. P., et al., 2008[13]). In literature review, poor vertical alignment, excessive road gradient, improper crown, inadequate super elevations, and cross-fall, poor drainage elements/improper drainage, widening problems, poor geometry of cross section elements, poor horizontal alignment and inconsistency (change) of road character without warning signs are major defects related to geometric design and construction features.

According to Jones, D. and Paige-Green, P., (2000[14]), typical types of distress encountered on unsealed roads include "loss of gravel, potholes, rutting erosion, corrugation, loose material, stoniness, dust and cracking."

Surface distress is defined as the visible manifestation of deterioration of pavement with respect to either serviceability or structural capacity (MoW, 1999[15]). Some gravel surface defects that reduce effective utilization for the entitled purpose are surface roughness, surface cracks, excess oversize/stoniness on the surface and corrugations. According to US.DTFHA, (1998[16) "Surface aggregate [is] lost in three ways: by dusting, by raveling, and by a process called sinking"

Some of pavement structural defects are rutting/ settlement, erosion, slipperiness and skid resistance and trafficability.

1.3. Effects of Defects

The effects of the construction industry deficiencies are manifested in the three attributes of cost, time and quality. These attributes, therefore, provide the basis for measuring the effect of the deficiencies on the industry's performance (De Wit, 1988[17]).

- Quality degradation such as: Riding quality, skid resistance and impassibility
- Defect is cost: The defect cost is defined as the value of resource consumption for rework as a consequence of a defect. Work time, materials and equipment time are consumed to correct the defect. Indirect defect costs can be divided in customer-incurred cost, customer dissatisfaction cost and loss-of-reputation cost (Harrington, 1987[18]). Customer-incurred cost occurs after project fails to satisfy the expectations.

1.4. Controls of Deficiency

Developing an effective construction deficiency management process is a challenging task, as it requires an integrated solution for coordinating everything involved for the purpose of the deficiency management. Deficiency controls in construction require an integrated solution to discipline and coordinate the documentation, drawing, process, flow, information, cost, schedule and personnel. The construction industry needs an effective construction deficiency controls mechanisms. From a literature review, different deficiency control mechanisms have been identified. The controls were grouped into four categories: conception stage, design stage, construction stage and controls for both design stage and construction. These groups assisted in developing a comprehensive enumeration of potential controls for deficiency.

Conception Stage Controls

Planning & preparation: The requirements of the client are identified and the constructive aspects and the standards of quality are defined through procedures (Alarcon, L.F and Mardones, D.A., 1998[19]).

Design Phase Controls for Deficiency

When considering design quality, McGeorge (1988[20]), stated that "a good design will be effective and constructible with the best possible economy and safety". But whilst the design itself needs to be "effective", it also needs to be communicated effectively through the documentation (Tilley, P.A., et al, 1997[21]) i.e. drawings, specifications, etc.

According to Tiley, P.A., (1998[22]), criteria to determine the level of documentation quality are timeliness, accuracy, completeness, coordination, and conformity. Some design stage controlling mechanisms of defects are the owner's involvement in the planning and design phase, clearer detailing of design and organizations and approvals of design works.

Construction Phase Controls for Deficiencies

- The ability to discuss problems with quick approval, decision procedures and managing construction quality, time and cost: Kress (1994[23]) asserts that the key objective of project administration is to achieve or surpass the expectations of the owner or user of the project. These expectations are typically expressed within quality, cost and time categories. Therefore, it is necessary to successfully manage the projects through appropriate preparation, scheduling and control, as the project needs a serious outlay and is connected with risks and uncertainties (Telsang, 2005[24]).
- Information clarification: Control of the flow of information, step-by-step verification of the needs prior to the process to make sure they are met or not, in order to avoid that design defects arrive at the construction site (Mardones, D. 1997[25]). This includes clarification of conflicting information, incorrect information, insufficient information and

questionable information.

Both Design & Construction Stage Controls for Defects

- Comprehensive site investigation: Comprehensive site investigations assist in proper planning for construction activities (Fisk, 1997[26]).
- Knowledge base of previous similar projects: From the outset, project strategies and philosophies should take advantage of lessons learned from past similar projects (CII, 1994b [27]).

2. Materials and Methods

2.1. Area of the Study

The area of the study is located in the south-western part of Ethiopia, in the Southern Nations Nationalities and Peoples' Regional state in Konta/Woreda. This region is about 500 km from Addis Ababa, the capital city of Ethiopia. It is located at 7°00`0`` to 7°30`0``N latitude and 36°30`0`` to 37°00`0``E longitude.

2.2. The Study Approach and Source of Data

The study explains, to some level of understanding, the causes of defects in URRAP road construction projects. An inductive survey was established on causes and impact of defects through systematic observations on special Southern Nations, Nationalities and Peoples URRAP road construction project with diligent investigation, in an attempt to collect facts. The study will be confined to randomly selected URRAP road projects in the mountainous part of SNNP of Ethiopia where a number of construction projects and industry stakeholders will be accessed.

As a first step for the development of the improvement methodology, it was necessary to collect information to obtain evidence about the type and frequency of design defects that affect the construction phase. This information was collected from two projects of a construction company; the construction sites were visited in each project in order to detect construction defect during audits and site observation.

Interviews with design and construction professionals were also carried out in order to identify the most common problems affecting the design, construction and effect of design on construction. Each interview was split into three parts in order to obtain information for different purposes (Mardones D, 1997[25]):

1. To determine the possible causes of design and construction defects in URRAP projects;
2. To know the effect of design defects on construction works;
3. To identify ways of preventing or solving design and construction defects.

The respondents' documents were collected using questionnaires from clients, contractors and consultants. The questionnaire survey contains both open-ended and closed-ended questions.

Archival documents such as design and as-built drawings which were investigated thoroughly were very important in identifying the frequent problems related to Southern Nations, Nationalities and Peoples URRAP road construction project, in particular the Konta / Woreda Kirara Mojo-Bakfarda and Duka-Zala-Koda-Maji URRAP construction projects. Design review and an as-built data check-up considering the low volume standard and different defects were observed during the audit and on-site visit of these roads.

The study examines the causes of defects on URRAP road projects to achieve the study objectives, a critical review of relevant literature was done coupled with the questionnaire survey to collect information on potential causes of defects with special emphasis on mountainous part of SNNP Ethiopia carried out by URRAP contractors. Through the literature review, causes of defects will be identified which provided basis for the formulation of the questionnaire. The identified causes were subjected to tests earlier by the professionals, in order to determine the relevance as the causes of defects in URRAP construction projects. The questionnaires were distributed to the construction professionals, consultants and contractors involved in handling Universal Rural Road Access Program projects.

2.3. Sample Process and Sample Size

Sampling strategies are categorized into two main groups, namely probability and non-probability sampling (Blaxter, et al, 2001[28]). Both sampling strategies are used in the study. From a list of selected URRAP road projects, a representative sample was derived through random samples.

For questionnaire distribution both probability and non-probability sampling strategies were used. Contractor and consultant were selected randomly, and purposive non probability sampling consists of hand picking interested professionals in the randomly selected projects. Sample size for questionnaires: according to Farooq, (1997[29]) the "size of the sample required from [the] population was determined on the basis of statistical principles for this type of investigative study. For such research, sample size was determined as follows" in equations 1 & 2:

$$n0 = (p*q)/ V2 \quad (1)$$

$$n = n0 / [1+ (no / N)] \quad (2)$$

Where:

n0= First estimate of sample size

P = Proportion of the characteristic being measured in the target population, for this study =0.5

q= Complement of 'p' = 1-p=1-0.5=0.5

V= Maximum standard error allowed is 10%

N= Population size for this study =100 URRAP contractors and complete in mountainous part of SNNP up to May 2015.

Sample size calculation

no = (p*q)/ V² =0.5*0.5/0.1*0.1=25

n = no / [1+ (no / N)] = 25/ (1+ (25/52)) =25/ (1+ (25/100)) =20 contractors

n: The sample size=20 URRAP projects contractors, their consultants and counterpart engineers (client contract administration engineers). The proportion of consultant to contractor is 0.4 & Client to contractor 0.1. One respondent was represented from each contractor professionals, two respondents from each consultant and client professionals.

2.4. Questionnaire Design

To examine what the causes of defects on URRAP road projects were based on, critical review of relevant literature, questionnaires were prepared to collect information on the defects' potential causes and the cost impact. Both closed-ended and open-ended questions were used.

"The main sections of the questionnaire on causes, effects and controls use basically an ordinal scale. This ordinal scale does not offer in its qualitative 5 point scales a direct quantitative comparison between its intervals. This scale will be transformed into an interval scale by assigning a weight to each interval" (Fouad G, 2005[30]). Thus think of intervals from 'never' to 'very often' and of intervals from 'no' to 'extreme' as an interval scale from zero to 100, to achieve this transformation which will enable carrying out the required parametric statistics in Table 1 below. The respondents must indicate how closely their feelings match with the question or statement on a rating scale identified in Table 1 below score for frequency of occurrences and effectiveness of controls.

2.5. Data Analysis

In the analysis, the "Mean Score" method was adopted to establish the relative importance of the causes of defects for URRAP construction projects in southern Ethiopia.

In Table 1 Likert's scale of five ordinal measures of agreement towards each statement has been used to calculate the mean score for each factor that is used to determine the relative ranking. "Prevalence and effectiveness indices will be calculated in the same way for defects, and controls will be ranked on the basis of their indexes with the first rank assigned to the highest index by using input parameters from Table 2 below. Sections on causes, effects, and controls respectively will be scored as follows to come up with an index to indicate its importance, or utilization as in the case of controls of each" (Samer A-J and Hussain A-M, 2015[31]). The arithmetic mean can be used as the measure of central tendency, standard deviation as the measure of dispersion as the statistical procedures (Cooper & Emory, 1995[32]). A prevalence index of each cause, effect or effectiveness of the control respectively will be calculated as follows in Table 2 below.

Importance or prevalence index for causes, effects or controls will be calculated as follows by using input parameters from Table 2 in equation 3 below.

$$MS=IIc1 = sum (fi*Si)/N \quad (3)$$

Where:

N = Total number of responses concerning each factor

S = Scores given to each factor

f = Frequency of responses for each score

MS = Mean Score = IIc1 =importance Index of cause 1

Table 1. Score for frequency of occurrences

Prevalence/ Effectiveness	very often/ extreme	Often/ high	Sometimes/ Average	Rarely/ Minor	Never/ No
Probability of happening	100%	51% - 75%	26% - 50%	0% - 25%	0%
Score	1	0.75	0.5	0.25	0

Table 2. Mean score formulas for prevalence and index of defect, its causes and effectiveness of controls

Prevalence/ Effectiveness	very often/ extreme	Often/ high	Sometimes/ Average	Rarely/ Minor	Never/ No
Probability of happening	100%	51% - 75%	26% - 50%	0% - 25%	0%
Scores given to each factor(S)	1	0.75	0.5	0.25	0
Frequency of responses for each score(f)	f1	f2	f3	f4	f5

3. Results and Discussions

3.1. Exploratory Study

Exploratory study was conducted in Konta/Woreda Kirara Mojo-Bakfarda and Duka-Zala-Koda-Maji URRAP construction projects in Southern Nations, Nationalities, and Peoples' Region. The construction sites were visited in each project in order to detect construction defects during audit site observation design and as-built drawings were investigated. Exploratory study revealed the prevalence of problems on URRAP road projects and the major defects identified are poor vertical alignment & steep grade sections, lack of appropriate on-site measurement during construction, lack of adequate material tests, limited sight distance, sharp curves and inadequate and unsafe clear zone, problems in cross drainage structures, ditch and check dams.

3.2 Questionnaire Study

Detailed questionnaires were designed and distributed for the assessment of defect on South Nation Nationalities and Peoples Region URRAP projects in Ethiopia. For this purpose the questionnaires were distributed to major stakeholders in the construction industry; these are contractors, consultants and clients (project owners). To make the analysis more comprehensive, a total of 40 questionnaires were distributed to consultants, contractors and clients (project owners) out of whom 37 questionnaires

were completed and returned.

3.2.1. Causes of Defect

The responses on the causes of defects will be looked at from three different perspectives. In this section we will examine the responses from client, contractors, consultants, and the overall responses on the causes of defect in URRAP projects. The study will also look at the categories of defect originators; such as owner generated, contractor generated, design or supervision consultants generated, and other causes. It is worth noting that the data from 4 URRAP client contract administration professionals, 15 consultant professionals and 18 contractors' professionals is widely dispersed and reflects differing opinions about the importance of each cause. Figure 1 below is a histogram of the overall importance index of causes of defect.

In Figure 1 the most common causes of defects from the overall responses of client, consultants and contractors are the lack of a prompt payment system, lack of project management, poor communication and slow decision. Errors and omissions in design, lack of adequate and experienced human resources on the owner side, insufficient data for design and construction in predicting underground condition all play a role.

According to the study, the consultants, contractors, owner(s), and others conditions are ranked as predominant origin agents in the decreasing order of defect contribution to project without considering weight age for most prevalence from the respondent point of view. For most prevailing top five causes of defect originators, the reasons are lack of a prompt payment system (where the originator is the owner), a lack of effective project management system (poor communication and slow decision) where the originator is the owner, errors and omissions in design by consultant, lack of adequate and experienced human resources on the owner side, and insufficient data for design and construction in predicting underground condition by the consultant. The percentage share of the originator's contribution on 22 defects causes are 32.73% by consultant, 31.82% by contractors, 26.36% by owner and 9.09% by other causes. Major defect cause originators contributions are shared 40 % by the consultants and 60% by the clients.

3.2.2 Defects

A section of the questionnaire listed 13 defects for URRAP projects in SNNPR of Ethiopia. Each respondent was asked to rate each issue based on his/her professional judgment. The list of effects of defects were analyzed and ranked according to their responses. Figure 2 below is a histogram of the overall prevalence index of defects.

It is apparent that overall rank of prevalent defect no.1 is "Poor vertical alignment and excessive road gradient" as the prime defect in URRAP projects. The study lists five prevalent defects from the overall responses of client, consultants and contractors. These are poor vertical alignment and excessive road gradient, stoniness on surface, inconsistence (change) of road character without warning signs, poor drainage elements/improper drainage & erosion and aggregate loss.

3.2.3. Controls of Defect

Controls of defect will be ranked and categorized based on the effectiveness index reported. The analysis will be carried out on data from consultants, contractors and clients. Finally, overall data will be analyzed calculating importance indices in Figure 3 below. The respondents rated the nine controls for defects based on his/her professional judgment and these are tabulated according to their means and standard.

It is apparent that overall rank control no.1 "Knowledge-base of previous similar projects" as the prime control of defects in URRAP project. Five of the most effective defect controls from the overall weighted responses of consultant, contractor and client are knowledge-base of previous similar projects, clear and brief detailing of design, planning & preparation, design review and approval and comprehensive site investigation. These controls are effective in safeguarding against occurrence of defects or to minimizing their impacts if they occur. Figure 3 below is a histogram of the overall effectiveness index of defect controls.

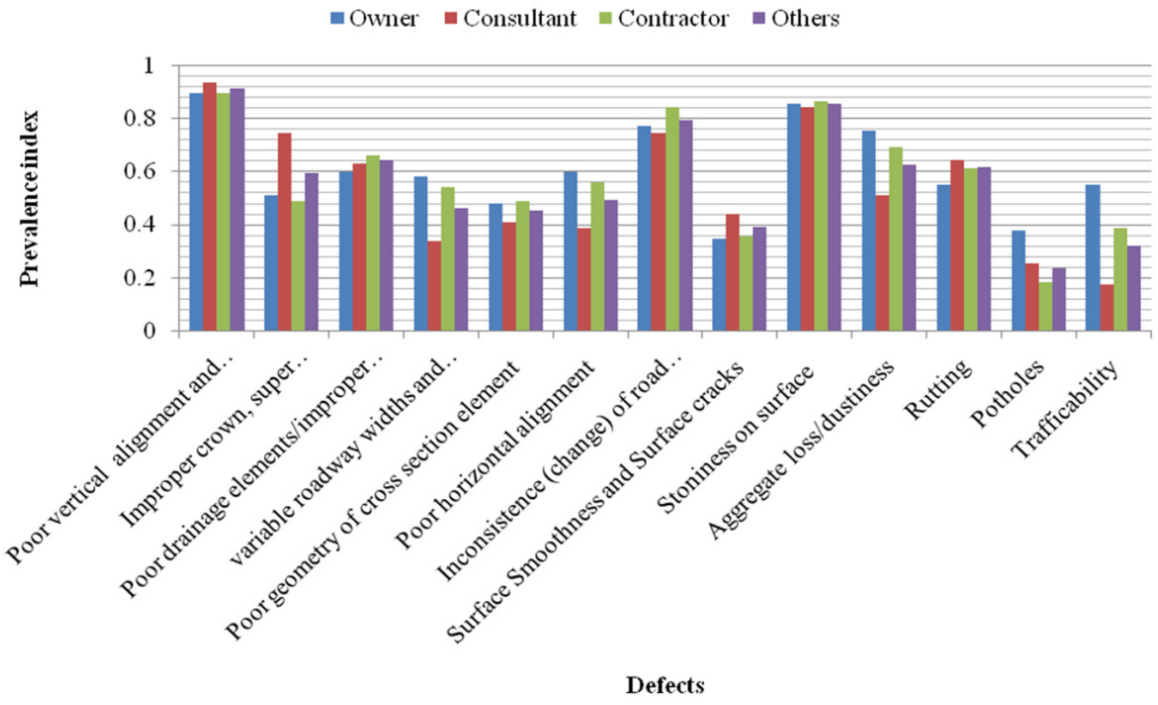

Figure 1. Prevalence index of defects

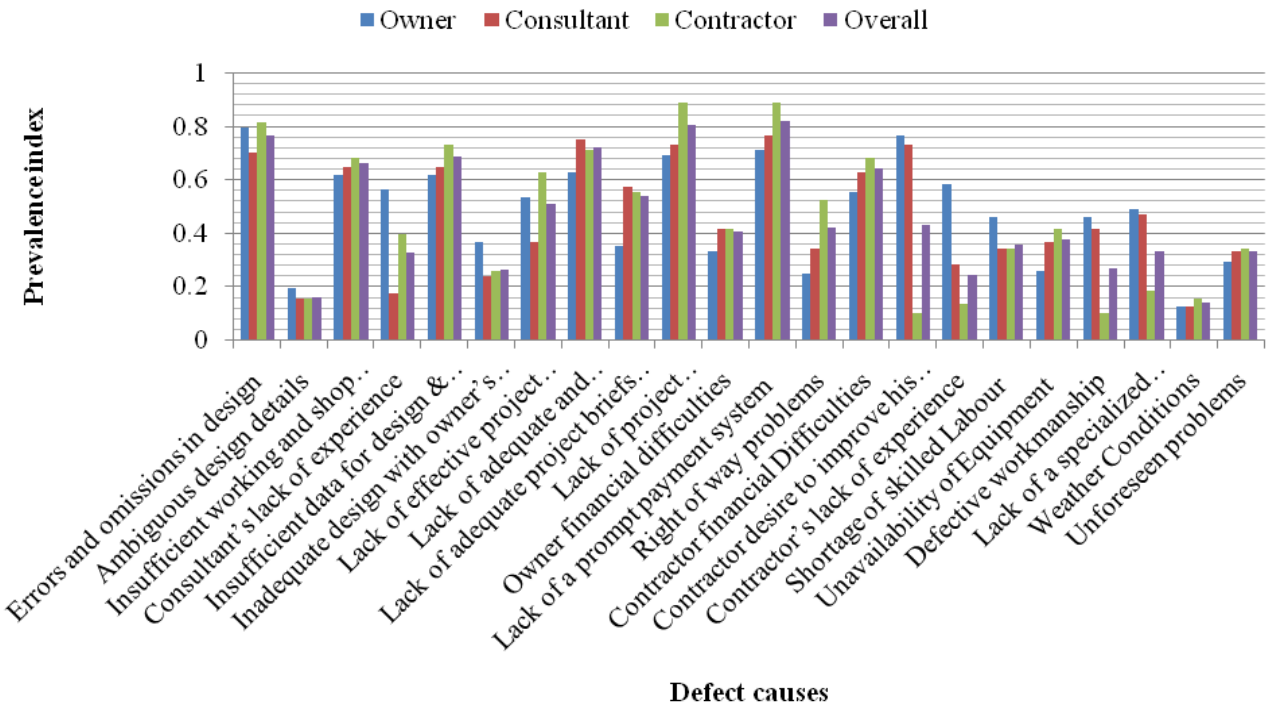

Figure 2. Prevalence index of defect cause

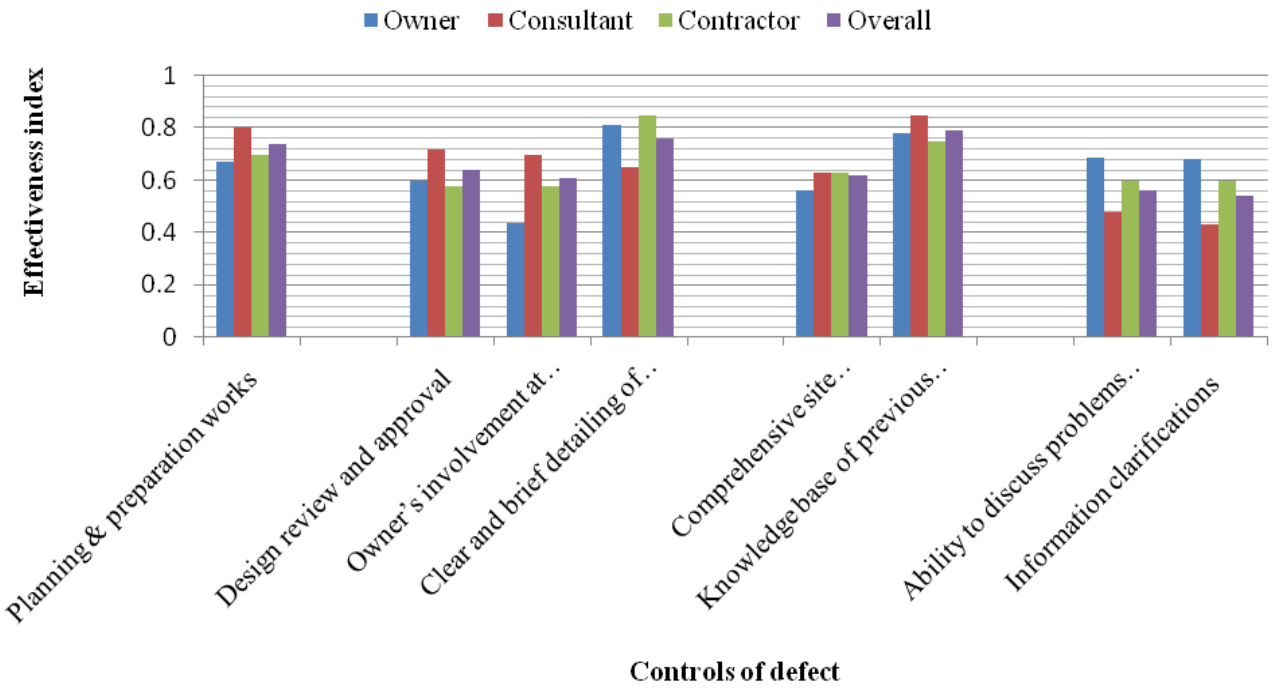

Figure 3. Effectiveness index of defect controls

3.2.4. Interview Discussion Findings

The following comments were made when interviewing senior professionals working in URRAP. The comments will give a further understanding of the possible causes of design and construction defects in URRAP projects, design defects on construction works and ways of preventing or solving these problems.

Possible causes of design defect:

- A designer that fails to meet the qualified standard of concern due to error, omission, negligence, inadequate design data are possible causes identified by URRAP senior professional.
- Possible causes of construction defects: Construction defects can arise from method, material or design problems such as:
- Poor workmanship / not carrying out the work in accordance with the acceptable standards of qualifications.
- Deficient quality assurance, quality control and organization of the work by contractor.
- The lack of site supervision and satisfactory check-up of the work by both the consultant and the contractor have authorized design and construction faults to be left unobserved.
- Construction deficiencies also may occur due to client's unwise decisions or a designer's failure to make complete, correct and well harmonized design and construction documents that offer adequate information for the contactor.
- Use of unacceptable materials that are of significantly lower quality than prescribed by specifications.
- Ways of preventing or solving these problems
- Present contract conditions that outline the rights, responsibilities and duties of the client and contractor; identify the levels of quality and standards to be meeting in the structure; and offer particulars essential to construct the assignment.
- Detailed check of harmonization of design and construction documents that are complete, correct, have consistencies of dimensions and reliability to construct a road without design defects.
- Early collaboration of contractor and consultant in order to address design and construction issues and continue communication throughout the project. Implementation of quality assurance throughout the construction period.
- Involving the client in an official and planned design check process.
- Clients provide the consultant with adequate time to develop the design.
- Constructability check of the design and construction documents by project manager during the design period of the project.

4. Conclusions

1. The research revealed the prevalence of defects on URRAP road projects. Major defects identified are poor vertical alignment and excessive road gradient, stoniness of the surface, inconsistence (change) of road character without warning signs, poor drainage

elements (improper drainage and erosion), and aggregate loss (dustiness).

2. Most prevalent defect causes are a lack of a prompt payment system, in effective project management system (poor communication and slow decision-making), inadequate and experienced human resources on the owner side, design error and omissions and insufficient data for design and construction in predicting underground condition.
3. Major defect cause originators contributions are shared 40 % by the consultant and 60% by the client.
4. Most effective controls to safeguard against occurrence of defect or to minimize their impacts are the knowledge-base of previous similar projects, clear and brief detailing of design, planning & preparation, design review and approval and comprehensive site investigation.

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