ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES
INSTITUTE OF TECHNOLOGY
SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING
(CONSTRUCTION TECHNOLOGY AND MANAGEMENT STREAM)

APPLICATION OF WEB BASED CONSTRUCTION COMMUNICATION IN ETHIOPIAN FEDERAL ROAD PROJECTS

By
Getu Tilahun

Advisor: Professor Abebe Dinku (Dr.Ing.)

June, 2014
Addis Ababa, Ethiopia

APPLICATIONS OF WEB BASED CONSTRUCTION COMMUNICATION IN ETHIOPIAN FEDERAL ROAD PROJECTS

By Getu Tilahun

Advisor: Professor Abebe Dinku (Dr.Ing.)

A Thesis submitted to School of Graduate Studies of Addis Ababa University
in partial fulfillment of the requirements of the Degree of Master of Science
in Civil Engineering
(Construction Technology and Management Major)

June, 2014
Addis Ababa, Ethiopia

Acknowledgements

My special thanks is reserved for my advisor Professor, Dr.Ing Abebe Dinku for his guidance to construction practice in the global scope and throughout the study of the thesis. He has been patiently guiding and shaping all the way through the steps of this research project.

I would also like to express my appreciation to Ethiopian Roads Authority Research Team for their instant response on the request for input for research study.

My great thanks also goes to Ethiopian Roads Authority for sponsorship granted on my study of master of science with extended thanks to Addis Ababa University Institute of Technology for the joint effort in my achievement.

Last but not the least is to forward my deep thanks to my family who patiently and diligently supported in my study.

Abstract

Due to fragmented nature of construction, real time communication is rarely possible requiring more efficiency and effectiveness in information exchange and decision making. Since an integral component of a construction process is accompanied by set of decisions, delay in response would lead to an integral component of delays in project execution accumulated over project life to an overall project cost and time overrun with possible loss in desired quality.

Study application of Web Based Construction Communication aimed at assisting evidenced real time communication and decision making, information storage, retrieval, manipulation and transmission among project participants parallel to the paper based project communication scheme has been conducted using simple and user friendly web site designed to operate on locally used common browsers.

Project information is collected from Ethiopia Roads Authority and imported to the database and file system designed for data storage and retrieval. The functionality of the website is then tested and found effective to enhance evidenced real time communication.

Apart from serving as documentation and retrieval of project information, the website includes online discussions tools similar to forum type aimed for general discussion and RFI comment exchange. Project daily activity photographs and daily site records are uploaded to the site for display and comment by the parties.

Therefore, the web based construction communication developed can help to have an evidenced real time communication for decision delivery and document management system to contribute to a way out of project overruns with competitive advantage in the complex construction industry.

Keywords: construction project information management, real time communication, web based construction communication

ABBREVIATIONS/ACRONYMS

RAI	:	Rural Access Index measures the number of rural population who live within 2 km from an all weather road as a proportion of total rural population.
WBC^2FRP	:	Web based construction communication in Federal Road Project
RFI	:	Request for inspection
GTP	:	Growth and transformation plan
PASDEP	:	Plan for Accelerated and Sustained Development to End Poverty
RSDP	:	Road Sector Development Program
ERA	:	Ethiopian Roads Authority
ERIMS	:	Ethiopian Road Information Management System
GIS	:	Geospatial information systems
ERAMS	:	Web Based Ethiopian Roads Authority Management System
PAT	:	Performance Assessment Tool
KPIs	:	Key Performance Indicators
PFI	:	Private Finance Initiative
IT	:	Information Technology
ICT	:	Information Communication Technology
HTML	:	Hypertex Markup Language
XHTML	:	Extensible Hypertex Markup Language
CSS	:	Cascading style sheet
HTTP	:	Hypertext Transfer Protocol
ECTP	:	European Construction Technology Platform
ASP	:	Application Server Provider
SSL	:	Secure Socket Layer
TLS	:	Transport Layer Security
WAMP	:	Windows, Apache, MySQL and PHP
SQL	:	Structured query language
PHP	:	Hypertext preprocessor

Table of Contents

List of Tables

List of Figures

1 Introduction

1.1 Background

Ethiopia is located in the centre of the Horn of Africa. It covers an area of 1.14 million square Kilometers (944,000 square miles). Ethiopia's central plateau varies in height between 2,000 and 3,000 metres. In the north and centre of the country there are some 25 mountains whose peaks rise over 4,000 metres (13,200ft), the highest being Ras Dashen at 4,543 metres (14,538ft) and the lowest point is 125m below sea level. The population according to the 2007 Census was 73,918,505 and the current population estimate is now 86 million. Approximately 17% of the population is estimated to live in urban areas [1].

General profile information about Ethiopia is shown in Table 1 below

Table 1: Country Profile of Ethiopia [1]

Official Name	Federal Democratic Republic of Ethiopia
Population:	86 million
Capital:	Addis Ababa
Area:	1.14 million square Kilometers (944,000 square miles)
Major languages:	Amharic, Oromo, Tigrinya, Somali
Major religions:	Christianity, Islam
Life expectancy at birth m/f (years, 2011)	**59/62**
Main exports:	Coffee, hides, oilseeds, beeswax, sugarcane, flower
Gross national income per capita:	$1,110 ((PPP international $, 2012, WHO)

Ethiopia is composed of nine regions: Tigray, Afar, Amhara, Oromia, Somali, Benishangul-Gumuz, Southern Nations Nationalities and People Region (SNNPR), Gambella and Harari Regional States; and two Chartered Cities - Addis Ababa and Dire Dawa. The regional states of Ethiopia are indicated on the country map shown below.

Figure 1: Regional States and Administrative Cities in Ethiopia

The government's long-term economic development strategy – Agricultural-Development-Led-Industrialization (ADLI) – is geared to the transformation of the economic structure. The strategy involves an export-led external sector, and internal emphasis on agriculture to supply commodities for exports, domestic food supply and industrial output, and expand markets for domestic manufacturing [1].

The current Growth and Transformation Plan (GTP), finalized in November 2010, was built on the implementation of previous poverty reduction strategies, the Sustainable Development and Poverty Reduction Program for 2002/03−2004/5 and the Plan for Accelerated and Sustained Development to End Poverty for 2005/06−2009/10 (PASDEP) which laid out the directions to achieve the Millennium Development Goals by 2015 and the basis for Ethiopia to reach 'middle-income' status by 2020−25. In March 2012, the IMF said Ethiopia would achieve this earlier if its rapid growth continued [1].

Linked to the achievement of the GTP, Road Sector Development Program, RSDP-IV forms a strategic pillar of Government's Growth and Transformation Plan and in terms of its physical and financial plans it is the largest ever program undertaken in the sector [2].

Infrastructure expansion constitutes part of Millennium Development Goals to transform Ethiopia to a Middle Level Income Economy. In view of that recognizing the importance of road transport in supporting social and economic growth and its role as a catalyst to meet poverty reduction targets, the Government of Ethiopia has placed increased emphasis on improvement of the quality and size of road infrastructure in the country [3].

In the context of Ethiopia's geography, pattern of settlement and economic activity, transport plays a vital role in facilitating economic development as 95% of the movement of people, and goods is still carried out by road transport. In particular, it is road transport that provides the means for the movement of peoples and agricultural products from rural areas to urban areas and movement of industrial goods, modern agricultural inputs and peoples from urban areas to rural areas. Road transport also provides a means for the utilization of land and natural resources, improved agricultural production and marketing, access to social services, and opportunities for sustainable growth [3].

To address constraints in the road sector, mainly low road coverage and poor condition of the road network, the Government formulated the Road Sector Development Program (RSDP) in 1997. Over the Sixteen years of the RSDP, physical works have been undertaken on a total of 81, 629km out of 92,828km expectations levering to 88% accomplishment [3].

In order to bring the RAI from its level of 27% (2010) to 50% and 100%, the total road network of the country will need to increase from its 48,793 km (2010) to 83,604 km and 167, 207 km respectively. This will require construction of an additional 36, 152 km and 118, 430 km of all-weather road to achieve the RAI targets of 50 and 100% respectively. Moreover, to meet the Millennium Development Goals of Middle Level Income Economy the country's road network has to escalate to 286,000km indicating a gap of 204,371km [3].

However, given the country's road infrastructure needs, the road sector is expected to implement massive highway investments in years to come and then to consistently maintain the road network at a high standard. However, Ethiopia's current road sector will unlikely have the capacity to scale up and deliver upon such expectations without extensively modernizing its business process and organization performance [3].

Besides, the effort of developing the country's road network to the level of Middle Income Countries calls for systematic approach where strategic planning will be very important. That is why modernization initiative is developed and published under the title Modernization and Transformation Initiative (Volume I – Main Report), August 2013.

One of the modernization initiatives which is the Ethiopian Road Information Management System(ERIMS) is a fully web based GIS-enabled application developed using industry leading technologies like Microsoft ASP.NET and ArcGIS server (web GIS application for .NET framework) [3].

With the initiative ERA plans to have an overall improvement attempt to increase transparency of procurement process through a digitized and web based communications with s takeholders, improve the quality of procurement process through standardization of documents and expediting the procurement process by utilization of database system. With the existing practice, for instance, 70% of the procurement process of Consulting Services tenders are requiring more than the bid validity of 90 days. The new target with modernization puts completion of all (100%) procurement process of a project well ahead of specified bid validity date [3].

It is inferred that in order to scale up the capacity of road sector to Ethiopia's current expectations to come to Middle Level Economy, modernizing business process and organization performance is crucial. Accordingly, ERA is upgrading its organizational performance to world class agency backed with web based technology.

Consistently, researches and literatures mutually explain that communication and the transfer of information on construction projects are becoming increasingly complicated. Projects are incorporating more participants and these participants are often quite geographically diverse. Shrinking project durations, complex details, and innovative contracting methods are also requiring project participants to effectively and efficiently communicate and share project information [4].

The growing concern for business efficiency and effectiveness in other industries has made back up the use of information technology infrastructures. Computerized manufacturing, electronic tendering, e-Banking and marketing can be sited as typical examples. This has made other sectors to grow faster than the construction industry.

To the contrary, due to fragmented nature of construction, real time communication is rarely possible. Countries which are under transformation where construction of infrastructures such as railways and highways are under way lead to inefficiencies in existing transportation. Construction of remote projects from construction parties also face problem of real time decision making which is common in road construction.

Such fragmentation requires construction industry to be more effective and efficient in delivering real time communication as compared to other business sectors. But, the traditional way of paper based communication has gained momentum with inefficiencies with regard to locally bound information.

To counteract this problem, web based project construction communication can therefore assist in improving real time information flow and decision making wherever the actor is or whatever the time may be. Information or decision seeking party can post the message on the web where upon arrival the actor is able to reply an evidenced information or decision. The actor can then respond as long as he is in access of network and computing facility.

The WC^2FRP system is developed to allow communication among client, consultant and contractors which can be extended for use within an organization.

1.2 Statement of the problem

During the previous phases of Road Sector Development Program, considerable overruns in terms of time, cost and quality has been recorded in constructions undertaken both by local and international firms under Federal Road Projects [3].

The following table is extracted from Ethiopian Roads Authority Road Sector Development Program 16 Years Performance Assessment Report for design management.

Table 2: Design management gaps [3]

Areas of Improvement	**Existing (Baseline value)**
Quality of Design Service Contract Document	>40 % time overrun of the Consultancy contract
Quality of construction cost estimation	**Engineers' Cost estimate** ± 15% from the contract document
Quality Design outcome observed during the construction stage	**Variation** 8% cost and 22% time overrun from the Contract amount
	Change in Quantity 7 % cost and 22% time overrun from the contract amount
	Claims and disputes 2 % cost overrun from the Contract amount

Similarly, Table 3 is extracted from the report for contract management.

Table 3: Contract management gaps [3]

Indicator	**Baseline (June 2013)**
Construction costs: construction wastes which includes rework, idle labor, wastage of usable materials	Baseline not specified
Construction Time Gap: Time gap from Original Engineer's Estimate to practical completion	**63%**
Defects: number of defects on substantial completion and final handing-over	**>100 no. of defective works**

Research findings of Getachew Tsegaye (2009) and Becker and Behailu (2006) also confirm similar discrepancy as tabulated below for 12 asphalt concrete surfacing Federal Road Projects [5].

Table 4: Physical and Financial Accomplishment of some Federal Road Projects [5]

No	Projects	Total Length (km)	Type of Surfacing/work	Physical (length-km)		Financial (million Br)		Completion time(month)		%		
				Plan	Accom	Budget	Disb	Plan	Acco	Phy Accom	Fin Disb	Comp Time
1	A.A-Jimma	342	AC	342	342	405.9	650.1	36	73	100	160.16	203
2	A.A-Modjo-Awassa	263	AC	263	263	310.1	386.1	36	49	100	125.00	136
3	Modjo-Awash Arba	160	AC	160	160	227.4	375.4	36	68	100	165.00	188
4	Gewane-Mille	146	AC	146	146	249.0	357.6	40	51	100	143.61	128
5	Awash-Hirna	141	AC	141	141	256.5	297.4	36	62	100	115.94	172
6	Hirna-Kulubi	91	AC	91	91	188.1	225	30	64	100	119.62	213
7	Kulubi-DengegoDire-Dawa & Dengego-Harar	80	AC	80	80	162.2	220.5	36	63	100	135.94	210
8	Tarmaber-Kombolcha	187	AC	187	187	289.8	383.2	36	60	100	132.22	166
9	Woldia-Alamata	78	AC	78	78	150.3	230.9	36	62	100	153.63	172
10	Betemariam-Wukro	117	AC	117	117	203.4	240.5	36	67	100	118.24	186
11	Debremarkos-Merawi	220	AC	220	220	327	575.8	36	39	100	176.09	108
12	Awash-Arba Gewane	136	AC	136	136	192	192.0	30	38	100	100	131
	Total					2,961.7	4,135.5	424	696	100	139.60	164

From study by the researchers, Ethiopian Roads Authority during its previous three phases of Road Sector Development Programs, has encountered considerable overruns in terms of time, cost and resulted in undesired quality in constructions undertaken both by local and international firms.

Even though there may be various reasons for the problems, construction communication problems are pointed out as an integral part of the causes for overruns.

Table 5 indicates problem points identified related to construction communication, documentation and other problems while study by the researchers.

Table 5: Problems related to communications and documentation

Author	Problem	Relation to this research
Getachew Tsegaye[5]	Communication risks	Directly related to research problem
Turkey Wakjira[6]	Simply a lack of knowledge and communication causes risk management failures.	Problems communicated to parties early will close knowledge gap on site with good communication channel.
	Poor communication between members of the project team and the project sponsor	Trilateral communication scheme will allow interaction among project management and client.
	Findings suggest that 22% of all constructability problems are related to ineffective communication of engineering information, plans, and specifications, especially inadequacies in project specifications.	Project information commented and approved found online is expected to solve the problem.
	Lack of proper communication and coordination	Up-to-date information shall be communicated to all stakeholders from common source.
	Poor project (site) management/ Poor cost control	Online management/cost control shall be made by the parties.
	Lack of prompt decision making (quick response) by client	Timely response of parties shall be tracked by trilateral project monitoring and evaluation.
	Poor Contract administration	Monitor contract administration online.
Abera Bekele[7]	lack of understanding of the contract conditions and the law under which the contract is being administered,	Monitor contract administration online.
	lack of proper record keeping by the contractor when required for evidence by the client	Documents shall be available online in common database.
	ambitious project scheduling by the contractor	Evaluate, comment and approve schedule online by all parties.
	Inadequate effort in the control of compliance of qualities, dimensions, etc, vis-à-vis to those set out in the contract document, and quality requirement,	Daily site record and photograph help to monitor expectations against executions.
	competence of professionals assigned by the consultant	Evaluate performance early online.

Author	Problem	Relation to this research
	not understanding or neglecting the conditions of contract by the consultant	Track decisions and information delivery online for early solution to the problem.
	not approving payment on time, not responding and deciding timely on variations, decisions, drawings, clarifications and instructions required,	Track response rate online for prompt decision and solution.

Moreover, ERA Modernization Initiative Report also addresses the existence of the problem setting a way forward towards modernization among which is Web Based Ethiopian Roads Authority Management System –ERAMS which is designed to ensure quality and monitor the progress achieved in implementation of the road delivery and management core process.

Since construction project overruns are beyond tolerable limit to achieve the targets set in the road sector development program, an overall system improvement in human resource development, construction technology and process is very important to bring those overruns to a reasonable limit. Capacity development programs undertaken by Ethiopian Roads Authority in human resource development is one of such measures in incapacitating the system. Training of human resources in various levels will bring technology transfer and improvement in quality output.

An integral component of a construction process is accompanied by set of decisions and requirements to attain quality product consistent with the requirement of end result in time and within the limited cost. An efficient and effective delivery of real time decision and execution principles to an integral part of the process can contribute to a way out of overall project overruns.

Identifying such gaps in the industry, this research is therefore, focused in delivering an evidenced real time decision delivery system and information transfer among client, consultants and contractors or within a single firm based on a web site developed for this purpose.

1.3 Objective

The objectives of a research delineate the ends or aim which the inquirer seeks to bring about as a result of completing the research undertaken. The objectives of a research project summaries what is to be achieved by the study [29]. The objective of the research is then set and itemized below.

1.3.1 General objective

The objective of Application of Web Based Construction Communication in Ethiopian Federal Road Projects is to assist in an evidenced real time communication, information storage, retrieval,

manipulation and transmission among project participants parallel to the paper based project communication scheme.

To improve project communications and documentation, this study presents a website based construction communication. The study demonstrates WBC^{2}FRP system improves project management for project teams in a construction project environment.

1.3.2 Specific Objectives

Specifically the objective of the research is to;

- Develop a simple and user friendly web site oriented at improving project communication, information storage, retrieval, manipulation, transmission and decision making.
- Enable parties to update data from anywhere and immediately upload data to the system to share real-time project-related information such that they can make effective decisions regarding the project.
- Test the functionality of the web site using local server installed on windows operating system.

1.4 Research Questions

- Can web-based construction collaboration assist in dynamic and real time information exchange?
- How can information exchanged in an electronic media be legally accepted in the local construction industry?

1.5 Scope of the study

The scope of the research is development of Federal Road Project specific website accessible to client, consultant and contractor aimed at facilitating trilateral real time communication parallel with the traditional paper and other means of communication in Ethiopia. Sample project information is collected from Ethiopian Roads Authority Federal Road Project to test the functionality of the website.

1.6 The Research Organization

The skeletal design of the thesis is framed from five chapters and an Appendix.

- Chapter 1 is an introductory overview to the research composed of eight sub-sections mainly background, statement of the problem, objectives, research questions, scope of the study, structure of the thesis, research methodology, and contributions of the research.
- Chapter 2 is a bout survey of literatures for body of knowledge on ERA modernization initiative, project management, project communication management, information technology, information communication technology and web based construction communication.
- Chapter 3 presents the research design and methodology in detail.
- Chapter 4 focuses on the analysis of results and discussions. It discusses on reports on output of the system which includes home page, contract overview, program of works, reporting, payment, requisitions (RFI), reference documents, request for resources, letters, variation orders, site diary, discussion, slideshow, drawings and photographic reports
- Chapter 5 forwards conclusions and recommendations of the research.

1.7 Research methodology

The research is an explanatory research exploring the existing construction practice and describing applications of web based communication in Ethiopia Federal Road Projects to real time evidenced communication and have better documentation. Better documentation for facilitating construction progress will be the effect of having real time communication which is favored by web based communication.

The following four methodologies are applied to achieve the objective of this research.

1. Establishing the basis of the research:
    - Literatures reviews on better communication of construction activity have been undertaken.
    - Various researches conducted in various related topics have been browsed through internet.
    - Study of website design suitable for construction communication has been conducted
    - Road construction under Federal Road Project has been taken as reference for full presentation of project information on the site.
2. Research Study: The research is conducted on the basis of the following basic procedures;
    - Obtaining information on communication problems.
    - Obtaining practical project information from Ethiopian Roads Authority to be incorporated on the website design.
3. Designing the website incorporating the actual project communications

4. Conclusion and recommendation: Recommendations are proposed and conclusions are drawn based on the findings of the research.

Figure 2 virtually traces the approach to the research finding.

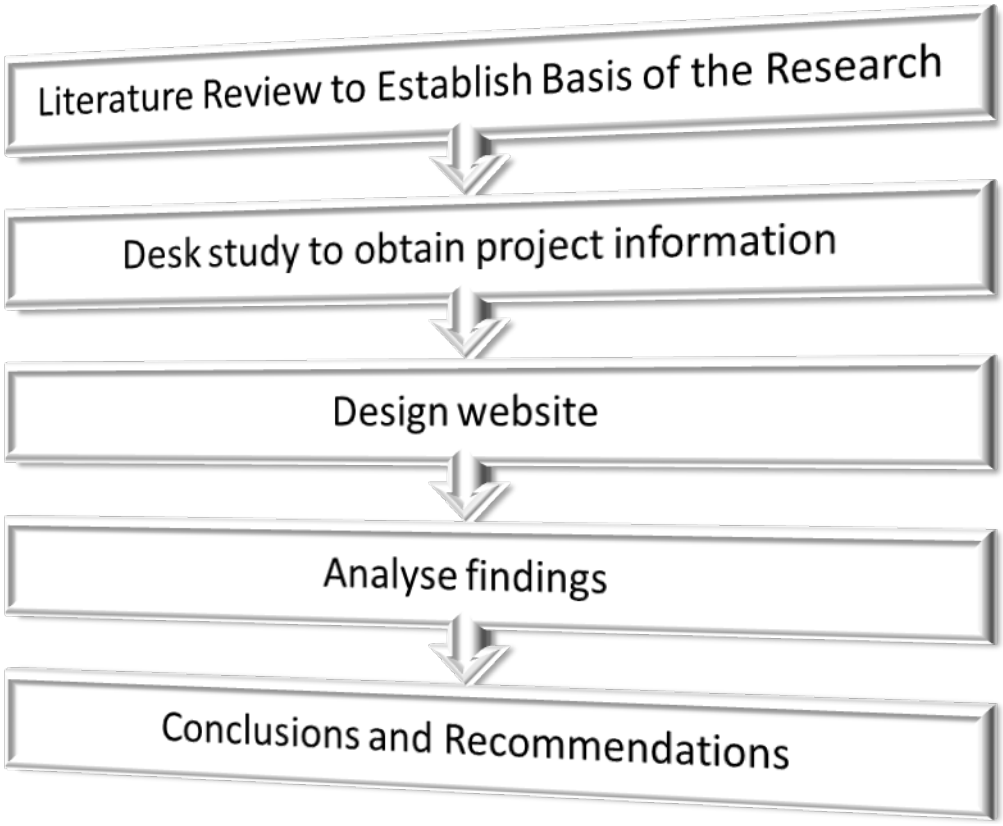

Figure 2 Research design

1.8 Contribution of the research

Real time communication is far better than delayed communications later than occurrence of an event. Web based communication implies real time communication aiding in the facilitation of decision making and solving shortage of senior professionals at project level.

Moreover, in web based construction communication, project information is stored in a common database where ease of retrieval and future reference aids in dispute resolution mechanism.

2 Literature Review

2.1 Introduction

It has been explained in the Background section that to meet the Millennium Development Goals of Middle Level Income Economy the country's road network has to escalate to 286,000km indicating a gap of 204,371km [3].

ERA states that, "the effort of developing the country's road network to the level of Middle Income Countries calls for systematic approach where strategic planning will be very important." That is why modernization initiative is developed and published under the title Modernization and Transformation Initiative (Volume I – Main Report), August 2013.

2.1.1 Modernization in Ethiopian Roads Authority, ERA

With Ethiopia's economic growth set to accelerate, the demand for modernization in road sector is enormous. Given the country's road infrastructure needs, the road sector is expected to implement massive highway investments in years to come and then to consistently maintain the road network at a high standard. However, Ethiopia's current road sector will unlikely have the capacity to scale up and deliver upon such expectations without extensively modernizing its business process and organization performance [3].

The major objective of the modernization and transformation initiative is to upgrade ERA to a world class road agency, characterized by organizational excellence, growth through engineering research and innovation, responsiveness, and most of all by customer-driven and oriented services.

The underlying assumption in the overall modernization initiative is to focus on modernizing the core road delivery process without disregarding enablers and routines. This will have two-fold implications: one thing it builds good image; second and most importantly the final outcome of the modernization initiative will be transforming the Authority in a way that it can significantly improve its performance and deliver services in civilized way [3].

Benchmarking the network of other countries indicate that, in order to be competitive enough to have a middle income economy, the country needs to have road density of 0. 26km/Sq. Km (260km/1000sq.km) in which case a road network of 286,000km would be required [3].

The effort of developing the country's road network to the level of Middle Income Countries calls for systematic approach where strategic planning will be very important. This also requires strong and credible database. The Ethiopian Road Information Management System(ERIMS) is part of the initiative to fill this gap. The Ethiopian Road Information Management System(ERIMS) is a fully

web based GIS-enabled application developed using industry leading technologies like Microsoft ASP.NET and ArcGIS server (web GIS application for .NET framework [3].

The overall improvement will attempt to increase transparency of procurement process through a digitized and web based communications with stakeholders, improve the quality of procurement process through standardization of documents and expediting the procurement process by utilization of database system. With the existing practice, for instance, 70% of the procurement process of Consulting Services tenders are requiring more than the bid validity of 90 days. The new target with modernization puts completion of all (100%) procurement process of a project well a head of specified bid validity date [3].

One of the modernization initiations targeted by ERA is in design management is based on a focus of achieving 90% accuracy for the coming five years on design projects leading designers to look into their way to cope with such accuracy.

2.1.1.1 Design Management

Ethiopian Roads Authority in its publication in October 2013, on Road Sector Development Program16 Years Performance Assessment, says that the extent of all the prominent failures related with design problems has reached to unacceptable level. In order to lead the sector towards the state of the art and quality design delivery, ERA as a major Employer, has taken the initiation to assess and tackle the problems emanated from ERA's in-house processes and the practice in the road sector [3].

ERA adds that it is worth to look into the accumulated knowledge in designing of simple to complex road projects in best performing countries. Currently developed countries made significant improvements based on lessons learnt from their previous practices and they are in a promising level getting sustainable projects (like US and Japan). Assessing these practices and adapting the applicable once that fit into Ethiopian situation will significantly assist to secure radical change in the road sector. The modernization of design management has used the design management practices in developed countries to share experiences and setting a benchmark for ERA's strategic orientation towards design quality improvement in the road sector [3].

ERA presented major areas of design improvement, existing gaps, best practices, and goals associated with design management as tabulated hereunder.

Table 6: Improving design management gaps [3]

Areas of Improvement	Existing (Baseline value)	Benchmarking Best Practices	Objectively Verifiable Indicators	Goal
Quality of Design Service Contract Document	>40 % time overrun of the Consultancy contract	Introducing clear job description for each Professional and its input. Preparation of project specific TOR. Quality control and assurance within the firm and the Client. introducing risk management during procurement & implementation	Less ambiguity, Well prepared contract doc.	to reach to 90% of original contract time
Quality of construction cost estimation	**Engineers' Cost estimate** ± 15% from the contract document	Introducing standard CMS for the sector. Establishing index for construction works. Introducing quantity surveyor in the design team.	Accuracy of input data by weighting each Possible Best Practices	to reach ±5% of the unit rate validation of ERAMS
Quality Design outcome observed during the construction stage	**Variation** 8% cost and 22% time overrun from the Contract amount	Adequate design period. Introducing design manager as a team leader (well experienced professional both in design and construction). Strictly applying the design manuals. Introduction and strict use of guidelines for the design. Experience sharing. Consultation and working closely with stakeholders. Introducing quality controlling mechanism within the firm and ERA.	1. Technical errors 2. Lack of sufficient stakeholders' consultations 3. Lack of sufficient projection of the traffic 4. Omissions	to reach to 5 % of cost and 10% of time overrun
	Change in Quantity 7 % cost and 22% time overrun from the contract amount	Including quantity surveyor in the design team. Use of advanced software. Use of experienced professional. Quantity estimation to be done in detail (for each town section, every 5km cut fill balance…). Strong quality control and verification by the firm and staff.	Errors in quantity estimation of every bill item	to reach to 4 % of cost and 10% of time overrun
	Claims and disputes 2 % cost overrun from the Contract amount	Introducing clear job description for each professional and its input in contract document preparation. Use of Guideline for particular specification and contract document preparation. Clear and accepted justification for departure. Use of experienced professional. Strong quality control and verification by the firm and staff.	1. Ambiguity (discrepancy and inconsistency) 2. Omissions of bill items or specifications 3. Inconsistency among Specifications, Drawings, BoQ etc document 4. Time related cost due to design related VOs	to reach to 1 % of cost

2.1.1.2 Contract Management

ERA states that dramatic performance improvements may be brought about in the construction supervision services should the supervision firms set clear measurable objectives, targets, milestones and performance indicators based on ERA's objectives. Based on the experiences of leading clients elsewhere in the world, Key Success Factors and Objectives are identified and

proposed on this regard. Moreover, Performance Assessment Tool (PAT) is also recommended to Measuring ERA's Satisfaction on Construction Supervision Services and on the overall project delivery [3].

Key Performance Indicators, KPIs are selected based on the current best practices and norms that leading clients all over the world are using in order to achieve a certain level of satisfaction with respect to supervision and works contracts [3].

The following table gives an insight on what is planned in modernizing the contract management (supervision) process.

Table 7: Improving contract management gaps [3]

Indicator	Baseline (June 2013)	Improvement per year	Current Performance of Leading clients and construction companies
Construction costs: construction wastes which includes rework, idle labor, wastage of usable materials		**Reduce by 15%**	In the last five years, leading clients in the world have achieved cost reductions up to 14% per year and on average 10% reductions are registered. Value management alone is believed to have reduced the construction costs by 10% in leading firms in the world.
Construction Time Gap: Time gap from Original Engineer's Estimate to practical completion	**63%**	**Reduce by 15%**	Leading clients in the UK are achieving reductions in construction time overrun, for example, by 20% per year. Florida Department of Transport (FDOT) - average Time overrun is only about 7.1% of the original Engineer's Estimate in 1997/8. Indiana Department of Transportation (INDOT) – Time Overrun between 1996 and 2001 was 4.5%.
Defects: number of defects on substantial completion and final handing-over	**>100 no. of defective works**	**Reduce by 15%**	Leading **clients achieve zero defects** upon handing-over of projects. Evidences suggest that the goal of zero defects is achievable within 5 years. UK Construction Task Force has recommended to **reduce defects by 20% annually**.

2.1.1.3 Road Asset Management

ERA modernization includes: development of road asset management policies and strategies, Road Information Data Base, Road Asset Management System, Road Asset Management Plan, Road Safety Improvement and Management Capacity Building [3].

2.1.1.4 Quality and Performance Management

It is stated that ERA has developed Web Based Ethiopian Roads Authority Management System – ERAMS which is designed to ensure quality and monitor the progress achieved in implementation of the road delivery and management core process. ERAMS is a tool mounted on a computer server in ERA Data Centre and accessed either of the Intranet or Internet over a secure website. ERAMS provides centrally connected data storage designed to allow additional systems to link with data already stored [3].

The "once only" data-entry concept provides consistency in numbering and naming of such elements as projects, contracts road numbers, descriptions and standards throughout the Authority. This system provides ERA with the facility to manage Contracts of Road Design, Works and Maintenance Contracts from Planning through to final Completion. The system contains a database of contracts linked together through projects, firms, Directorates, and individuals to enable consistent naming and accountable reporting. The facilities include Validations of Estimates, tender procedures, and Works Monitoring to Works Completion. In addition it holds ERA Performance Appraisal System for Consultancies, Contractors, ERA Teams and Senior Staff. The quality assurance task also goes beyond implementing ERAMS and for these there are different manuals developed [3].

Due to such client sophistication, demand for higher quality end products and services at lower price demands better project management practices to enforce tighter control on the projects activities. On the other side, projects today are far more complicated than ever before. They involve larger capital investments, embraces several disciplines, widely dispersed project participants, tighter schedules, stringent quality standards, etc [9]. Such multilateral pressure on construction project seeks for modern project management practice to be competitive in the industry.

2.2 Introduction to Project Management

According to A Guide to Project Management Body of Knowledge, project management is the application of knowledge, skills, tools, and techniques to project activities in order to meet or exceed stakeholder needs and expectations from a project. Meeting or exceeding stakeholder needs and expectations invariably involves balancing competing demands among scope, time, cost and quality [10].

Achievement of balance among the triple constraints of construction projects i.e cost, time and quality is an integrated management of the nine knowledge areas set by PMBOK® Guide which is typical of almost all projects. The nine knowledge areas include;

1. Project integration management.
2. Project scope management.
3. Project time management.
4. Project cost management.
5. Project quality management.
6. Project human resource management.
7. Project communications management.
8. Project risk management.
9. Project procurement management.

The process of integrating the nine project management areas then requires applications of up to date knowledge, skills, tools and techniques to compete in the competitive construction industry.

2.2.1 Challenges in project management

Due to challenges in construction industry to improve quality, competitiveness and profitability, culture of cooperation, teamwork and continuous improvement in the performance of the industry need to be secured [9].

It is stated that the changing construction environment is also influenced by other factors, which are interrelated and interdependent. Examples of such factors are [9];

- ***Globalization*** of the marketplace; many industries are facing a lot of pressure due to this factor. Tariff barriers are virtually falling and labour has become more mobile. Further, due to productivity improvements and advantages in economies of scale, some foreign firms are capable of competing with local firms on price, quality and delivery.
- ***The economical forces***; this factor may significantly affect the client organisation and subsequently can impact the initial objectives of their projects.
- ***Increases in project complexity***; project complexity has increased due to extent of scope and fragmented parties around the world having to communicate with one another for efficient project execution. The complexity of the projects is reflected by the large number of specialists who contribute to the decision-making process.
- ***The need to achieve faster results with the given resources***; this factor places severe time pressures on the entire project team.
- ***Rapid changes to project scope to expand benefits***; some scope changes take place very rapidly before even realising the benefits of the changes.
- ***New procurement practices***; the emergence of new procurement practices changes the way the team members are interrelated. For example, procurement schemes such as Private Finance Initiative (PFI) and partnering have impacted construction project management. Such schemes bring the government and the private sector firms together in large-scale infrastructure projects in which very high quality standards, tight schedules and cost targets are aimed at. With the government's greater involvement in standardizing contractual procedures for PFI schemes, the commitments of all parties have become clearer and more visible.
- ***Client sophistication***; this has become a major driver for productivity improvements in construction. Clients demand higher quality end products and services at lower price. This has created buyers market whereby firms compete for projects at lower margins and hence demand better project management practices to enforce tighter control on the projects activities.

Due to such challenges in project management, streamlining the process of project management then requires applications of up to date knowledge, skills, tools and techniques which pressurizes project management practice to look for information communication technology.

2.3 An Overview of Construction Information and Communication Management

2.3.1 Definition

McCreadie and Rice identified and categorized a range of information definitions: information as commodity or resource, information as data, information as representation of knowledge, and information as part of the communication process [11].

Wikipedia Free Encyclopedia defines Construction Communication, within an organizational context, as it is to convey an instruction to influence the actions/behaviors of others, or may involve an exchange of, or request for information during a construction project [12].

Communication is also defined as a process in which the participants create and share information with one another in order to reach mutual understanding [13].

2.3.2 Overview

As per the findings of Yuan Chen and John Kamara construction sites are information intensive environments from design offices to project construction sites. Various construction personnel in the field need large amounts of information ranging from project design drawings to personal diaries to support their ongoing works. Because of the intensity and diversity of construction information, the efficiency of information management is crucial to the construction industry and has been recognized as an important competitive advantage to construction companies [14].

Dainty, Moore and Murray stated that communication within project-based environments presents special challenges. This is especially true within the construction industry, where interaction tends to be characterized by unfamiliar groups of people coming together for short periods before disbanding to work on other endeavors [15].

Research conducted on the problem of communication in constructions has also stated that efficiency and effectiveness of the construction process strongly depend on the quality of communication. Four reasons are mentioned why improvements in communication are needed [16].

- The first reason is that an improvement in the communication within the building team, in project teams and between project manager and contractors, could reduce failure.
- Second, more open communication at all levels could lead to innovations and better technical solutions.
- Third, communication improvements in early phases of projects would positively influence the quality as perceived by all stakeholders involved.

- Finally, improved communication during the briefing might lead to better decision making, for example less haste in moving to solutions and better ways of looking at the requirements first.

The research also found that even more than in other industries, human factors seem to determine most whether construction projects develop in a good way or not: there needs to be some kind of "chemistry" between the individuals involved to make the process go well.

2.3.3 Construction Project Communication Management

As defined by McCreadie and Rice, information is commodity or resource and there should be careful planning and management from feasibility to commissioning stage as is the case with other resource planning.

PMBOK explains " project communication management includes the process required to ensure timely and appropriate generation, collection, dissemination, storage and ultimate disposition of project information." It adds "perhaps no process is more important in the design and construction of a project because of the number and diversity of the key players, and because it is vital to the success of the project that the communication of information be timely and accurate. Consequently, considerable thought and planning is required to provide a system that meets the two criteria."

According to PMBOK communication process includes;

- **Communications planning**(is determining the information and communication needs of stakeholders)
- **Information distribution(**involves making information needed available to project stakeholders in a timely manner)
- **Performance reporting**(involves collecting and disseminating performance information to stakeholders with information about how resources are being used to achieve project objectives)
- **Administrative closure** (consists of documenting project results to formalize acceptance of the project by the sponsor, or customer. It includes collecting project records; ensuring that they reflect final specifications; analyzing project success, effectiveness, and lessons learned; and achieving such information for future use.)

Poor communication management contribute to various payoffs in construction project delivery among which are time overrun, cost overrun, disputes arbitration, litigation and total abandonment.

Various researches on project delays have ranked communication problem as the first factor for delay [17]. The study identified that among seven most important causes of project delays is communication problem between parties. These are:

1. Lack of communication between parties
2. Slow decision making
3. Change orders
4. Inadequate contractor planning
5. Finance and payment of completed work
6. Subcontractor performance
7. Inadequate contractor experience

Salleh states that, "Since there are many parties involved in a project (owner, engineer, contractor, subcontractor), the communication between parties is crucial to the success of the project. Proper communication channels between the various parties must be established during planning stage. Problems with communication can lead to serious misunderstandings and therefore, delays in the execution of the project."

Salleh figured out that the similarity of several factors regarding project delay factors in his research compared to previous research findings from other developing countries confirmed that project stakeholders in developing countries face similar problems in spite of different natural, economic, political and social background. Salleh added that the difference is found in the priorities of the most important factors of delay [17].

As stated by O'Connor identified that poor specifications can cause construction rework and delays. The findings suggest that 22% of all constructability problems are related to ineffective communication of engineering information, plans, and specifications, especially inadequacies in project specifications [18].

Moreover, Finne, C has figured out that decisions taken at the design stage fix approximately 85-90% of the construction costs. Researchers have highlighted the problems encountered in projects due to inefficient communication at the design stage of the projects [19].

Therefore, proper project planning and design shall take into account the issue of contractibility as part of project communication planning from the very beginning.

2.3.4 Constructability Information and Clash Detection

As part of communications planning, Yuan Chen and John Kamara stated that the design team is a major element that takes responsibility for providing technical and engineering related information such as drawings, contracts, design clarification, construction and engineering methods, and specifications.

The design consultant shall communicate constructability information to other parties to avoid problems of clashes on construction and other constructability problems which may occur during construction stage.

The findings of the research of Getachew Tsegaye et.al have revealed that design risks were contributory to cost and time overrun and poor quality of works. The underlying cause of the risks is that designers lack construction experience and fail to fully address constructability problems that surface during construction.

However, development in information technology presented design and construction technologies such as building information modeling applications whereby design and construction is virtually done in the digital environment.

Ahimed Dorani et.al explain that time and space coordination can be checked to virtually eliminate workflow issues at the planning stage. Spatio-temporal conflict analysis, which is one of the key usages of 4 D modeling, occurs when an activity's space requirements interfere with another activity's space requirements, or with work-in-place. Two main types of spatio-temporal conflicts have been identified which are: (a) hard conflicts: interferences between physical components (e.g. conflict between old and new elevated highway structures); and (b) soft conflicts: interferences between different clearance volumes and work spaces (e.g. the space clearance required by an equipment) [20].

This indicates that the design team shall virtually schedule and construct the civil engineering building or highway to avoid constructability problems and communicate the whole information to the constructor and or the client.

Due to the fact that;

- communication within project-based environments presents special challenges in construction where interaction tends to be characterized by ***unfamiliar groups of people coming together for short periods;***
- even more than in other industries, ***human factors seem to determine most whether construction projects develop in a good way or not;*** and
- construction information is ***intensive and diverse***

the efficiency of information management is crucial to the construction industry and has been recognized as an important competitive advantage to construction companies. Conversely, efficiency and effectiveness of the construction process strongly depend on the quality of communication.

In order to satisfy client's needs and ensure that the design is constructible, the design stage must not only have the client's requirements as input, but also information about construction and the operation and maintenance of the facility [21]. This means, the design stage must be integrated with information about construction and use (life cycle considerations).

Moreover, during construction stage, Scanlin, J points out that communication consumes about 75% to 90% of a project manager's time and information therefore needs to be current and available on demand, whereas a construction firm surveyed its project managers and found that 15 percent of their workday was spent on searching for information [22] and [23]. The construction industry requires a system that can provide real time information and is efficient in information generation, communication, storage and retrieval. Such a system is essential for the quick detection of time, cost, scope and quality deviations from planned performance [24].

Therefore, there shall be a mechanism to improve efficiency and effectiveness of construction information and minimize subjectivity induced by human factors in the construction industry. Communication of real time accurate information is the requirement to minimize factors leading to overruns in the industry.

2.3.5 An overview of the paper based construction communication

2.3.5.1 Limitations in information communication

Yuan Chen and John Kamara have explained that construction sites are information intensive environments. Various construction personnel in the field need large amounts of information ranging from project design drawings to personal diaries to support their ongoing work and for their decision making. However, the main type of information that on-site construction personnel receive and transfer is paper based files, which include documents such as drawings, data collection forms, correspondences, progress information and specifications. The limitation of paper-based files has remained a major constraint in on-site information communication and exchange. Ineffective on-site information communication can result in construction personnel overlooking important issues that require a quick response and often cause on-site decisions to be deferred. Coordination of activities and management of operations on a construction site raises numerous queries and interactions between project participants, which need to be resolved quickly and efficiently to avoid downtime, rework, waste and cost overruns [14].

Because most small projects are still predominately traditional, some problems are associated with the traditional ways of retrieving and transferring information. These kinds of problems include the inefficient retrieval and transfer of paper-based information mediums, and the constant delay of information communication between project participants [14].

In order to improve the predominately traditional methods of information communication on construction sites,

- encouraging small firms to adopt and use Information Technology tools,
- more IT training for construction personnel,
- a reduction in the amount of paper-based forms and documents, and illustrative projects that examine the benefits that result from the use of IT on construction sites.
- For construction organizations that have already used Information Technology tools in their daily business proceedings, the design and management of information systems are very important. For example, intranet/extranet and other collaboration tools need to be sized to be able to cope with increased electronic traffic. Intranet/extranet and related application software should be properly designed and managed. Excessive use of e mails should be reduced through the encouragement of one-to-one discussions and group meetings [14].

The study includes remote access to electronic document management systems avoids carrying vast amounts of hard copy on work sites.

2.3.5.2 Limitations during claim analysis

Construction impact claims analysis is mostly carried out after closure of operations. Revisiting a project's history, however, necessitates the use of contemporaneous documents produced by all participating groups. This practice is becoming ever more expensive because documents–paper or electronic–are never found in one place, and project groups use different document storage systems that are not necessarily compatible. As such, documents sprawling to various project locations without discernable directory structures complicate backing up and archiving of files, and make locating and accessing documents a difficult task [25].

2.3.5.3 Merits of digital information exchange over paper based communications

- Project information can be accessed in digital form via local and wide area networks, thus overcoming the limitation of locally bound, paper-based archives. In addition to that, ability to manage paper-based documents in an electronic environment can give substantial benefits in the form of less storage space and reduced time for search and retrieval of documents [26].
- Meta-Data-Based construction as subset of web-based construction collaboration provides the convenience of timely, complete, and integrated information, which helps to speed up the decision-making process and increase its accuracy so that downstream parties can take faster action [27].
- Retrieving project information during claim analysis is difficult in paper based communication for paper documents are fragmentally stored as opposed to digital information filed common database.

It is then figured out that literatures mutually explain the inefficiencies in the paper based communications putting a way forward towards the use of best Information Communication Technology practices.

2.4 Introduction to Information Communication Technology

2.4.1 Overview

Information technology (IT) is the application of computers and telecommunications equipment to store, retrieve, transmit and manipulate data, often in the context of a business or other enterprise. The term is commonly used as a synonym for computers and computer networks, but it also encompasses other information distribution technologies such as television and telephones. Several industries are associated with information technology, such as computer hardware, software, electronics, semiconductors, internet, telecom equipment, e-commerce and computer services [12].

Humans have been storing, retrieving, manipulating and communicating information since the Sumerians in Mesopotamia developed writing in about 3000 BC, but the term information technology in its modern sense first appeared in a 1958 article published in the Harvard Business Review; authors Harold J. Leavitt and Thomas L. Whisler commented that "the new technology does not yet have a single established name. We shall call it information technology (IT)." Their definition consists of three categories such as techniques for processing, the application of statistical and mathematical methods to decision-making and the simulation of higher-order thinking through computer programs [12].

Information and communications technology (ICT) is often used as an extended synonym for information technology (IT), but is a more specific term that stresses the role of unified communications and the integration of telecommunications (telephone lines and wireless signals), computers as well as necessary enterprise software, middleware, storage, and audio-visual systems, which enable users to access, store, transmit, and manipulate information [12].

ICT can be considered to be built on the 4 C's – computing, communications, content, and human capacity. ICT is much more than computers and internet or even telephony. Applications of ICT can be divided under two broad categories. The first are those largely dependent traditional telecommunications networks (including the internet) that enable on-demand communications to provide information tailored to the user's convenience and needs. The second group of ICT applications is (Human Independent) where information is processed and decisions are arrived on the basis of preset criteria without human intervention at the time of decision making. Examples include sensor-based networks that determine automated climate control for buildings today, or, in the near future, sensor networks for malaria larvae detection. Many of the more-discussed applications of ICT for SD are of the first category, ranging from distance education programs, e-commerce, or e-governance, while the second class of applications remain largely unrealized [28].

2.4.2 Mediums of Information Transfer on Construction

Based on Chen Y. and Kamara J., mediums of information transfer on construction sites are;

- Meeting: receive, transfer or communicate construction information in on-site meeting;
- One-to-one Pass: exchange construction documents with other construction personnel;
- Fax: Construction information is transferred through fax;
- Telephone: communicate construction information through telephone calls;
- Email: Construction information is transferred through sending emails;
- Intra/Extranet: receive or transfer construction information by Intranet or Extranet(not accessible to general public, eg separate military network);
- Post: Construction information is transferred through postal services;
- Transfer of computer discs: Construction information is stored on computer discs that are transmitted to other construction personnel;
- Other.

The focus of this research is study of application of web based construction information communication as one of information transfer medium, an internet based communication.

2.4.3 Web site in general

A **website**, also written as Web site, or simply site, is a set of related web pages served from a single web domain. A website is hosted on at least one web server, accessible via a network such as the Internet or a private local area network through an Internet address known as a Uniform resource locator. All publicly accessible websites collectively constitute the World Wide Web [12].

A **webpage** is a document, typically written in plain text interspersed with formatting instructions of Hypertext Markup Language (HTML, XHTML). A webpage may incorporate elements from other websites with suitable markup anchors [12].

Webpages are accessed and transported with the Hypertext Transfer Protocol (HTTP), which may optionally employ encryption (HTTP Secure, HTTPS) to provide security and privacy for the user of the webpage content. The user's application, often a web browser, renders the page content according to its HTML markup instructions onto a display terminal [12].

Some websites require a subscription to access some or all of their content. Examples of subscription websites include many business sites, parts of news websites, academic journal websites, gaming websites, file-sharing websites, message boards, web-based email, social networking websites, websites providing real-time stock market data, and websites providing various other services (e.g., websites offering storing and/or sharing of images, files and so forth) [12].

2.5 Web Based Construction Communications

Project management through web based platform has lately become an important topic in construction. Substantial researches have been undertaken in developed countries for web enabled construction knowledge management system.

There are also several online project management software solutions serving online project management, communication, document exchange and management and construction collaboration. Some of them are PROCORE Online Project Management Software, Aconex, BuildTools, Intelex etc.

Some of online project management software solutions include;

- **Procore** is powerful Cloud-Based Construction Project Management Software for contractors, building owners, architects, and specialty subcontractors. Procore offers deep functionality with features such as document management, RFI management, submittal management, contract management, job scheduling, and email management [20].
- **Aconex's** web-based solutions allow project members to create and review documents and other project information from any location, and on any mobile device (iOS/Android). This includes RFIs, drawings, models, contracts, reports, and more [20].
- **BuildTools** is web-based, accessible from anywhere, and provides a foundation for all builder / client / subcontractor / architect communication. BuildTools manages all e-mail, site photos, weekly & daily reports, change orders, material selections, payment requests, project documents, punch-lists & warranty tracking. [20]
- **Intelex** provides a complete set of software solutions to help organizations in the construction industry manage operational, business and health and safety challenges. Track and manage incidents, contractors and training, mitigate risks, and ensure compliance across your business with Intelex's user-friendly, web-based solutions [20].

Web based communication for construction project management would be facilitated if the web based information management within the organizations is matured and incorporated in the day-to-day working. This would be facilitated through organization web sites having link to the project web sites for projects being executed by the organization. This would enable the information to flow freely in all levels and allow managers to learn of the organization and/or projects and their problems simultaneously so that decisions and instructions can be made and received uniformly [24].

A Web-based project management system is also a restricted network for project specific collaboration and communication. It supports information sharing, enables timely communication, and offers dynamic information for decision-making [4].

According to the European Construction Technology Platform (ECTP 2009), the future construction sector will involve innovative business concepts that will be enabled by seamless communication throughout the construction life-cycles (e-NVISION 2007). Researchers have been developing languages and computing machinery for making web content unambiguously interpretable by computer programs, with a view to automation of a diversity of web tasks. In addition, researchers are developing automated reasoning machinery to address some of the more difficult tasks necessary for seamless interoperation including a richer form of automated web service. (e-NVISION 2007) [30].

The process of e-Tendering, e-Procurement, e-Site and e-Quality constitute the core construction processes of the e-NVISION e-Business platform. The future e-Site scenario's main objective is to coordinate operations on the site in real time taking into account the events that occur at the building site: breakdown of machinery, unacceptable weather conditions, absence of manpower, change in the documentation, etc [30].

Therefore, centralized information systems that are accessible to all parties in a construction project are powerful tools in the quest to improve efficiency and to enhance the flow of information within the construction industry [31].

A large variety of forms and types of project information are required at different stages of a construction project. A wide range of professionals from many disciplines uses this information. The data is extremely dynamic, often changing from day to day throughout the project. There is a continuous cycle of creation, storing, manipulation, transmission, reformatting, application and revision. The time for each cycle can be very short [31].

The consequences of using inappropriate or inaccurate data can be costly and result in unnecessary delay. The efficiency of the construction development and operation cycle depends on the integrity and effectiveness of the information flowing between the client, design engineering, equipment manufacturing, contracting, and facilities management segments of the construction industry [31].

A centralized database is an integral part of an appropriately formed information framework. Any changes or modifications to information are recorded and disseminated automatically within the system thus ensuring that every discipline involved is working with the most up-to-date information. Such a system also removes the need for duplication and hence a potential for errors. By providing an efficient central data facility it is possible to create and maintain goals, schedules, standards, policies and procedures that are shared by all of those involved in the construction process [31].

Common features of such systems are [31]:

- Access to project information is possible from anywhere and at any time through the Internet.

- Team communication, collaboration and decision-making are improved through the increased transparency in the management process.
- Handling of data is cost effective and not prone to errors and delays caused in duplication.
- Project management is controlled and systematic.
- Updated information on progress is available to all and shared as soon as it is available.
- The quality of project data is high and meets the real needs of the professionals involved, as a result of the timely transmission of information between designated parties, use of specified task specific formats, data accuracy and backup in well-defined and powerful database repository.
- Historic data for past projects is available for retrieval for new applications, such as for project maintenance needs, new project planning etc.

2.5.1 Web based communication in various stages of construction

2.5.1.1 Design Stage

Research pointed out that project web site shall be developed from the design stage of the projects. It is also surveyed that decisions taken at the design stage fix approximately 85-90% of the construction costs. Researchers have highlighted the problems encountered in projects due to inefficient communication at the design stage of the projects [32].

Preliminary designs could be up loaded on the web through the project folder/web sites for immediate access. They could be red-lined, commented upon and circulated to all organizations involved in the design. As revisions occur, revised drawings could be maintained on the web and fully documented for future reference, leading to faster design process, with less time spent, and more expedient verifying, so that everyone has the right drawing. Correct and latest drawings would be downloaded for preparation of tender documents [32].

2.5.1.2 Tendering and Award Stage

Contractors could register online and access drawings and specifications through the Project Web sites, saving Owners the cost of printing and postal charges where required. Bid submissions, including financial and technical bids and schedules could be submitted through the project web sites. Bids opening and negotiation meetings could be held through virtual conferencing [32].

2.5.1.3 Construction Stage

The majority of the information flow in construction projects occurs at the construction stage, as during this stage all the project team organizations become active. Design detailing, change management, site coordination, material procurement and arrangement of manpower and machinery

is happening simultaneously at this stage and requires real time information management for tracking and monitoring the projects. With use of web based communication, everyone on the project team, including the Owner would have the opportunity to review, approve and comment before a document is issued to site, without sacrificing time or spending hours on meetings, faxes and phone calls. There would be immediate access to RFI responses, site photos, updated and supplemental drawings, project schedules, change orders, and field comments. This would reduce the risk of errors and rework by ensuring that everyone in the project team is working with the most current drawings and other documents. Site photos would help to share progress with those in remote locations, resolve issues and minimize site visits by monitoring construction from the office. Coordination meetings could be held through online conferences. All current and past versions of drawings and documents could be stored at the project web site, facilitating preparation of correct as-built drawings and **dispute resolution** at the end of the project [32].

2.5.1.4 Implementation of the Web based communication

There are three options currently available for organizations to implement Web based Construction Management: to develop the system in-house; to purchase packaged software from vendors and install it on organization's own server and to subscribe to an application service provider (ASP) from a service provider [32].

This research focuses on in-house type of system implementation prepared to serve the purpose of web based project management.

2.5.2 Legal and Security Issues

Regarding legality, paper work cannot be completely eliminated because legal documents are needed as physical evidence with blue ink signatures. For final drawing approval is done based on paper drawings… legally it seems we still have to do that today to get a stamped drawing. Once approved drawings are returned, they are scanned and made available online for the rest of the process. The approved paper documents are stored in a box and never reused again. The only documents that we request to have duplicated or hard copies of are the contracts which are signed originals, all the rest is handled electronically [33].

The assumption of this research also bases on important contract elements such as The Letter of Acceptance, The Tender and the Appendix to Tender, The Minutes of Negotiation and Addenda issued during the Tender Period, The Conditions of Contract, Part II, The Conditions of Contract, Part I; Method of Measurement, The Special Specifications, The Drawings, The Priced Bill of Quantities, Other documents, as listed in the Appendix to Tender signed in paper based signatures.

Contracting parties must expressly address electronic communications in their contract documents. The provisions must be clear as to which communications under the contract may and may not take place in electronic form [34].

Moreover, as a consequence of the legal uncertainties surrounding the validity of electronic signatures, to avoid the risk that a guarantee may be unenforceable all guarantees should continue to be entered into in paper form and be physically signed using handwritten signatures [34].

The following systems can be implemented to control security of the project information.

- Website shall be project specific and not be subjected to general public access.
- Internet security protocols such as Secure Socket Layer (SSL) or Transport Layer Security (TLS) assure the confidentiality and integrity of messages exchanged using an e-contracting system.
- Access to important project information by users shall be given with privilege corresponding to their authority and accountability level.

2.6 Summary of Literature Review

From review of literatures, the effort of developing the country's road network to the level of Middle Income Countries calls for systematic approach where strategic planning will be very important. However, Ethiopia's current road sector will unlikely have the capacity to scale up and deliver upon such expectations without extensively modernizing its business process and organization performance [3].

In principle, project management is the application of knowledge, skills, tools, and techniques to project activities in order to meet or exceed stakeholder needs and expectations from a project. These applications shall be done in as close as possible to real time basis in order to optimize constraints in construction projects.

On the other hand challenges in a construction industry are being diversified from time to time in different forms. Such challenges added to the fragmented nature of the construction industry require the most up to date knowledge, skills, tools, and techniques to be competitive in the system.

From survey of literatures, as one of the methods of streamlining project management practice, online project management system through web based platform is an important element of the construction industry of the developed countries.

It can be concluded that web based construction communication is one of system improvement mechanisms to streamline the construction management aiding to scale up road network to the level of Middle Income Countries as in the case of global practice.

3 Research design and methodology

3.1 General

The objective of the research is aimed assisting evidenced real time communication, information storage, retrieval, manipulation and transmission among project participants parallel to the paper based project communication scheme through the application of Web Based Construction Communication. Therefore the research design and methodology is focused at attaining this objective.

3.2 Research design

The research is an explanatory research exploring the existing construction practice and describing applications of web based communication in Ethiopia Federal Road Projects to have an evidenced real time communication process for decision making and have better documentation.

The approach to the solution of the research problem is systematically tracked from literature reviews of international and local sources to design of website compatible with the traditional paper based communication. Final conclusions and recommendations are then made.

Based on the idea of the research topic, researches conducted in Addis Ababa University Institute of Technology on Federal Road Projects have been surveyed for existence of the problem.

Researches and ERA reports explain that Ethiopian Roads Authority during its previous three phases of Road Sector Development Programs, has encountered considerable overruns in terms of time, cost and resulted in undesired quality in constructions undertaken both by local and international firms.

Even though there may be various reasons for the problems, construction communication problems were pointed out as an integral part of the causes for overruns.

On the basis of problems listed, survey of literatures was conducted to find out global practice on the status of construction communication in general and electronic construction communication in particular.

Various methods of communications based on electronics media have been surveyed as explained in the literature review.

Among these communications, application of web based construction communication is then selected for the contribution of the research in the local construction industry.

3.3 Obtaining Project Information for the Research

Project information data was collected from Ethiopia Roads Authority for Modjo-Edjere-Arerti-Gobensa, Sembo-Sholagebeya-Gorfu-Gobensa and Metehbila-Metehara Road Project, Contract III-LOT 2: Gindeber-Gobensa.

The obtained project information includes

- FIDIC Harmonized Edition March 2006,
- original design drawings,
- progress report,
- work program,
- Ethiopian Roads Authority Standard Technical Specification,
- FIDIC Condition of Contract 1987,
- FIDIC Interpretation,
- and guide to the use of FIDIC.

The project information obtained is uploaded to file system and website database and each were tested on the site.

3.4 Design of the website

Surveys of literatures have proven that real time communication is far better to solve actual problems on site in real time term as compared to traditional communication. Among the various mechanisms of real time communication exchange is the use of web site in the stream of electronic information communication technology.

Project specific website can be designed to serve the purpose of real time communication in the construction industry one of which will be dealt with hereof.

As explained in the literature review an in-house system type of web based construction communication is developed consisting of various communications as in the paper-based approach.

3.4.1 Administration of the website

In the WBC^{2}FRP, in an analogy to the current administration of contracts, the consulting engineer administers the website from server side since information upload from contractor has to be checked and approved before displaying online as authorized information.

The traditional paper-based communication can follow the digital transfer of information as an authorization. As in the case of facsimile transmission, formalized documents can also be scanned and communicated online.

3.4.2 System Database/System File

Since construction documents stored serve multipurpose function, proper organization and storage is very important. For most of web pages on WBC^{2}FRP, database is created for storage and retrieval purpose. Some files uploaded by authorized users are stored in file system in local folder.

3.4.3 Registration

To secure project information from unauthorized entering and/or retrieving of sensitive project data, authorized users are registered ahead of using. A unique User ID and password is recorded for authentication purposes.

3.4.4 System Architecture

For the design of the website, WAMP server is installed on Windows 7 operating system to run localhost.

Hypertext Preprocessor (PHP) script, Javascript, HTML form and Cascading style sheets (CSS) are used as programming and formatting applications.

Notepad^{++} is used to edit instruction languages and forms. The website is tested on Mozilla Firefox, Microsoft Internet Explorer and Google Chrome browsers and found operable.

Even though, it is possible to upload project information through outputs from different applications such as AutoCAD, Microsoft word and spreadsheets, hypertext markup languages and Planning software, it is preferable to use PDF files, scanned documents, ZIP files and images of various extensions for the following reasons;

- hypertext markup texts can contain destructive scripts which can cause system problem
- for authentication of the transferred document
- compressed files minimize in size for ease of data transfer

Project information transferred to the system can digitally be submitted to centralized system files or database. This information can then be accessed for timely decision or for future retrieval. In addition to allowing communications irrespective of time and space, documentation and ease of future reference will be made in a single website.

4 Results and Discussions

The findings of the study is web based project communication web site serving trilateral document exchange and storage and information communication mechanism with the main advantage of aiding real time project information communication and decision making scheme.

The result of the web site is discussed under the following integrated web pages.

4.1 Structural Composition of the Website

The structural composition of the Web Based Construction Communication in Ethiopia (WBC^2FRP) includes Home Page, Contract Overview, Program of Works, Reporting, Payment, Requisitions (RFI), Reference Documents, Request for Resources, Letters, Variation Orders, site diary, Discussion, Slideshow, Drawings and Photographic Reports which are discussed in the literature review.

4.1.1 Home Page

The web page or local file automatically loads when a web browser starts or when the browser's "home" button is pressed; this is also called a "home page". The user can specify the URL of the page to be loaded, or alternatively choose e.g. to re-load the most recent web page browsed [12].

The home page for the purpose of this research is just displaying information to be conveyed to all users of the site. The content of the home page can be varied to be used for;

- Business advertising
- New tender notices
- Construction news
- Call meetings
- Pass notices
- Announce good wishes etc

Presentation of the home page for WBC2FRP is displayed in Figure 2.

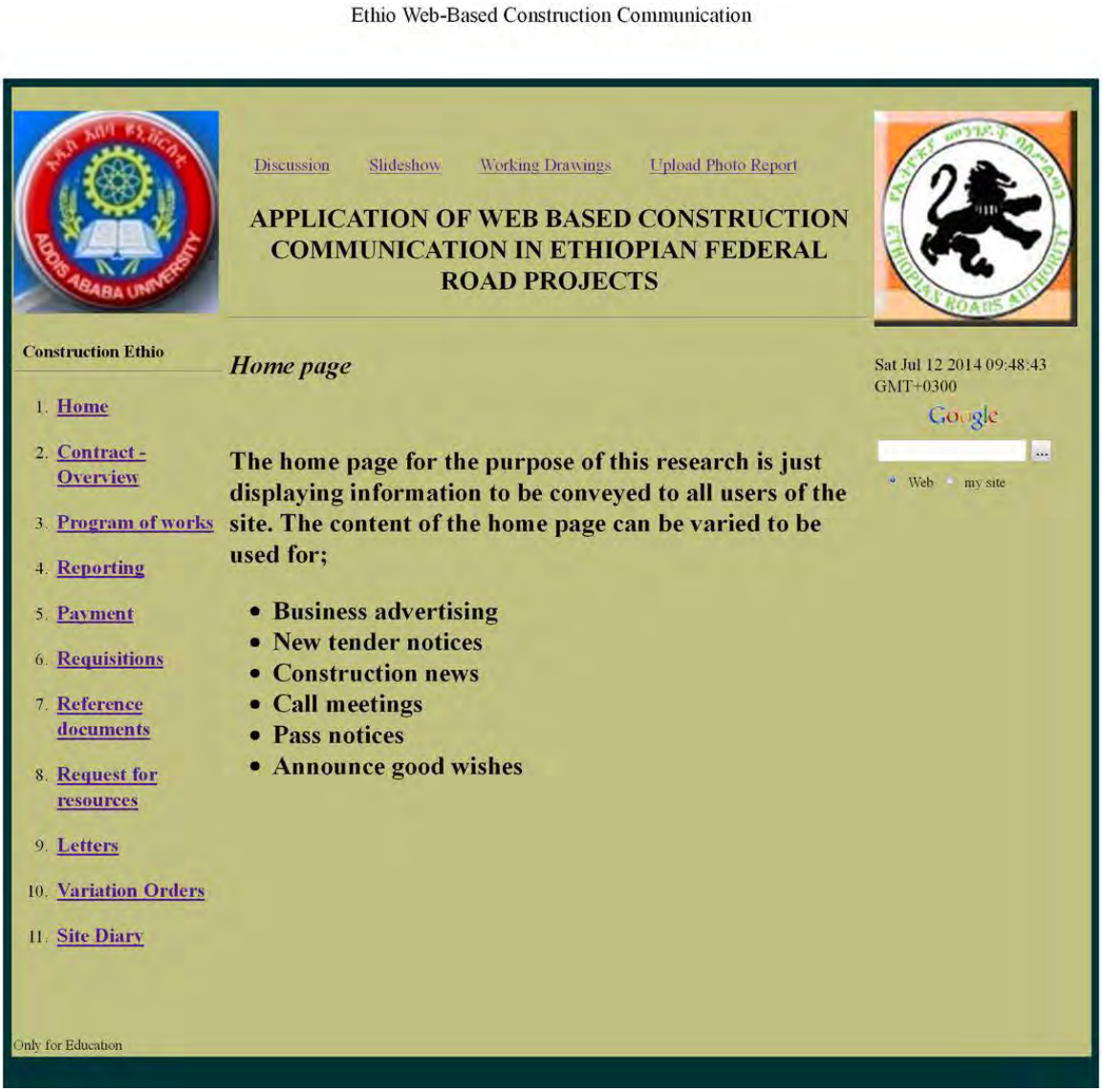

Figure 3 Presentation of home page

4.1.2 Contract Overview

Online reference to contractual documents or download to local machine can give an easy access for real time decision making irrespective of time when the decision maker wants to act and wherever he/she is.

The administrator of the website, the consultant, uploads components of signed contract document such as;

- The Letter of Acceptance
- The Tender and the Appendix to Tender The Minutes of Negotiation and Addenda issued during the Tender Period
- The Conditions of Contract, Part II;
- The Conditions of Contract, Part I;
- Method of Measurement
- The Special Specifications
- The Drawings;
- The Priced Bill of Quantities
- Other documents, as listed in the Appendix to Tender

In this website, the general conditions of contract, bill of quantities and design drawings are included in the respective web pages. The preferred contract document is allowed to display the first time the browser loads the page. However, a user can select his choice where after the page displays the enquiry.

4.1.3 Program of Works

As part of planning, work programs guide a way through the anticipated progress. This plan as the main monitoring tool shall be easily accessible to the parties. Master work program or revisions prepared by the contractor can be uploaded to the web as draft and commented by the engineer or client for approval. Work program prepared in such a way can then be tracked online against progress reports and adjustments can be made to monitor overruns.

The web page consists of upload part allowing program upload and display part of approved or draft work program.

Quick reference to method statement, barchart, cashflow, s-curve and resource requirement can be made from this web page. All components of the construction program prepared by the contractor and approved by the consultant will be displayed for reference. Draft work program can also be commented by the client.

4.1.3.1 Method statement

A work method statement, sometimes referred to as a safe work method statement is predominately used in construction to describe a document that gives specific instructions on how to safely perform a work related task, or operate a piece of plant or equipment [12]. It also includes analysis of average daily production of all activities and resources required to accomplish within stated period of time.

The method statement prepared for Gindeber-Gobensa is uploaded and made available for reference online by the parties. For a given activity on method statement, presence of actual resource on site referred from daily site record report can be checked and commented early to correct to the requirements within the proposed resources.

4.1.3.2 Barchart

Bar chart or network of activities in work program prepared on the basis of critical path method is a typical method to manage projects. Among network of activities, set of critical activities form critical path of the project dictating project completion time. Any deviation of activity time on the critical path affect the project time, cost and possibly quality.

Therefore, this critical element of work program shall be easily accessed to the parties regardless of time and space for good project management.

Barchart or network diagrams prepared on master work program or revisions made are uploaded by the contractor and commented and approved by Engineer for reference.

Barchart is allowed to display the moment the browser loads the page. The red bar on the network diagram directly takes users through critical activities of the project.

4.1.3.3 Cash flow Estimates/Cost Control

Schedule of cash flow estimate consists of anticipated monthly cash inflow, monthly financial claim of executed work, advance disbursement and repayment status, retention and release of retention sum and the net monthly expected payment to be effected.

Moreover, it indicates the monthly cumulative and percentage of work expected to be done. The user by loading the page with cash flow can refer to this schedule for comment or decision making purpose.

4.1.3.4 Plan S-curve

Plan S-curves demonstrates anticipated graphic cumulative cash flow against time commonly on monthly basis. It gives virtual observation of project growth against time.

Similarly, with selection of an S-curve page, users can retrieve the graphs for decision. The S-curve of Figure 4 demonstrates a plot of forecasted cash inflow on monthly ordinate. The slope of the tangent to the S-curve approximately differentiates to zero during off periods due to rainy seasons.

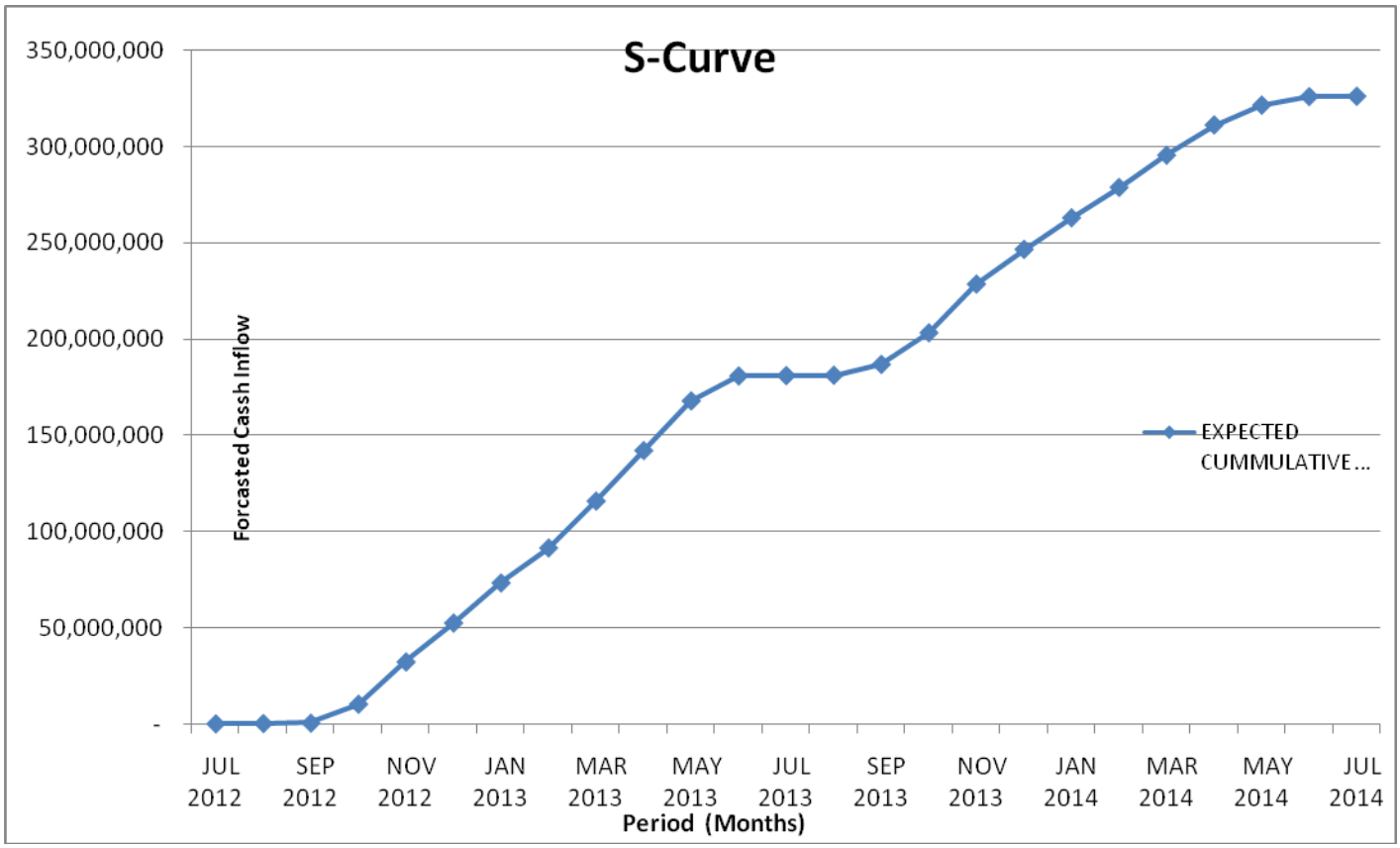

Figure 4: Plan S-Curve

4.1.3.5 Resource requirement

Resource requirement schedule is another critical part of the work program. Since resources are limited, managing of resource forms part of project management. The anticipated resource requirement can be compared against actual reports from site to ascertain the accomplishment of the progress.

Monthly requirement of each machinery and equipment are uploaded to this page for similar reference.

4.1.4 Reporting

Work programs prepared, commented and approved for tracking the project progress has to be evaluated for conformance or slippage if any.

A page with "Reporting" is created for uploading periodical reports. Reports uploaded by the contractor will be displayed after being checked and approved by the consultant. The web page consists of narrative report, project status summary, project physical progress, financial status and s-curve. All reports are stored in database for documentation and future reference.

4.1.4.1 Narrative Report

Narrative reports are parts of project progress reports that provide quantitative and qualitative reports such as executive summary, project information, problems encountered, insurance and other project related guarantees.

4.1.4.2 Project Status Summary

Project status summary provides a concise quantitative project status such as progress against schedule, slippage encountered and percentage accomplishment up to the reporting period.

Approved project status summary can be displayed for reference by the parties as is done on this web page.

4.1.4.3 Project Physical Progress

Physical progress of the project is used to display quantitative accomplishment versus plan which helps to monitor status of critical activities.

4.1.4.4 Financial Status

Financial status of the project is used to display detail quantitative accomplishment versus plan in terms of quantity and amount of work done. By checking the status of critical activities online, corrective measures can be taken especially for critical activities.

4.1.4.5 Plan vs Actual S-curve

Evaluation of actual S-curve plotted against plan S-curve helps parties to identify project growth, and slippages to take corrective measures. S-curve plotted against plan S-curve will be displayed when users browses S-curve page as demonstrated below. The actual S-curve of Figure 5 exemplifies an accumulated project slippage over project life ending with 2 months total slippage for not tracked early.

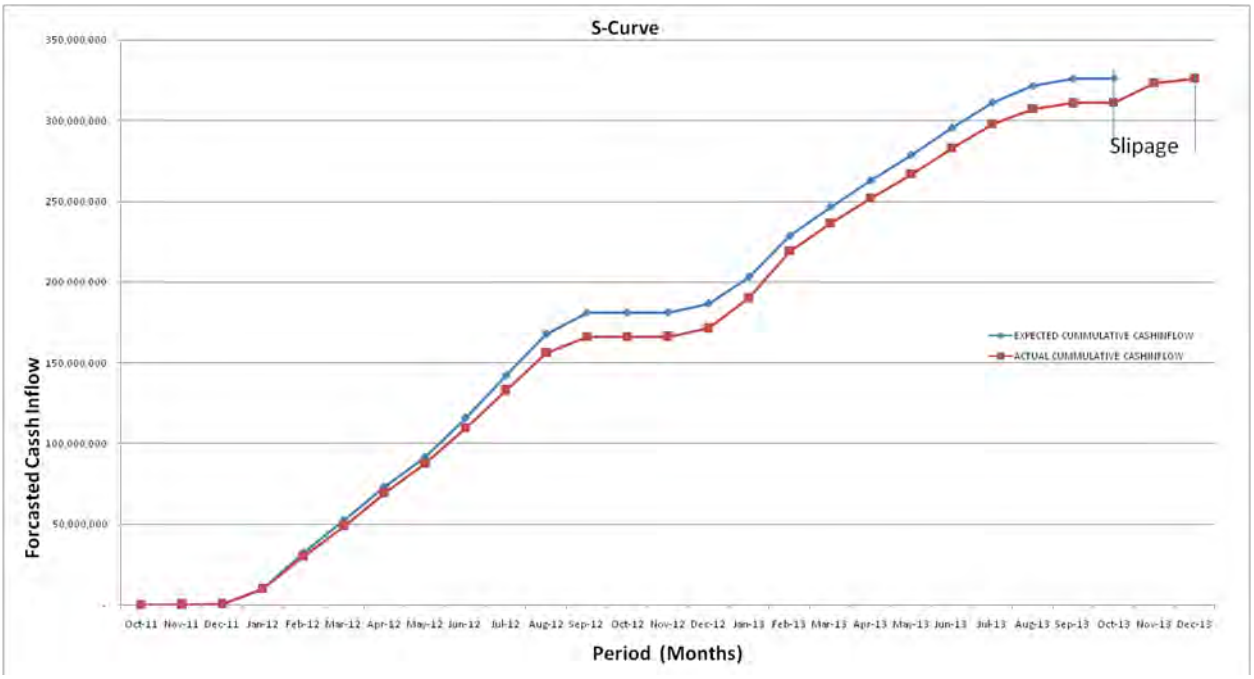

Figure 5: Plan Vs Actual S-Curve

4.1.5 Payment Certificates

The next part of web page display is payment link. Similar to the rest of the pages payment prepared by the contractor is submitted for approval by the consultant. While detail payment certificate is made ready for approval summary of payment status can be posted for quick reference.

All interim payment certificates are stored in database for documentation and future reference.

4.1.6 Requisition(RFI)

In the paper based approach, the Contractor shall give a minimum of 24 hours notice in writing to the Engineer to allow any inspection and testing to be carried out (Clause 1203 of ERA 2002). Request submission needs some time and means of delivery. After inspecting the activities, the Engineer gives approval or comment thereon which also requires time and means of delivery.

In the web based approach, forum type dialogue is presented for discussion. The contractor posts his request topic and the consultant replies a comment or approval after inspection. All the topics and replies are stored in database for documentation including comment by the client if any.

The client is therefore given better access to requests which was not common in the paper based communication.

4.1.7 Reference Documents

Reference document page allows users to have access of documents, formats and any available references pertinent to administration of the contract. All reference documents can be made ready for download. Commonly referred document can be displayed online without the need to download. The reference page counteracts the problem of fragmented storage of documents influencing decision making activity for documents are locally bound.

In web based construction communication, reference documents are not bound in space and time tracking with available network and computing facility extending to the use with smart mobile phones.

In Figure 6 , references documents such as ERA Standard Technical Specification, ERA Low Volume Roads Design Manual, Guide to the use of FIDIC, FIDIC Interpretation and Interim Payment Certificate Formats are uploaded for ease of reference.

Figure 6 Presentation of reference page

4.1.8 Letter

The letter section of the page is used to submit letters to database and have reply of them posted on the page. Signed letter which is representative of hard copy exchanges in the formal communication system will be submitted to increase authenticity of the documents. This also has the functionality that client has early access to communications for any comment or suggestions thereon.

Unlike reports, programs and payment certificates, the contractor can directly write a letter to the client and consultant as well in line with contractual requirement.

Figure 7 demonstrates that the contractor can upload letter for the client and consultant. Meanwhile, a query of the incoming letters gives the contractor to access to correspondences from the parties.

Similarly, the engineer can upload a letter for the client and the contractor whereas he is allowed to query for his incoming letters. The same is true for the client.

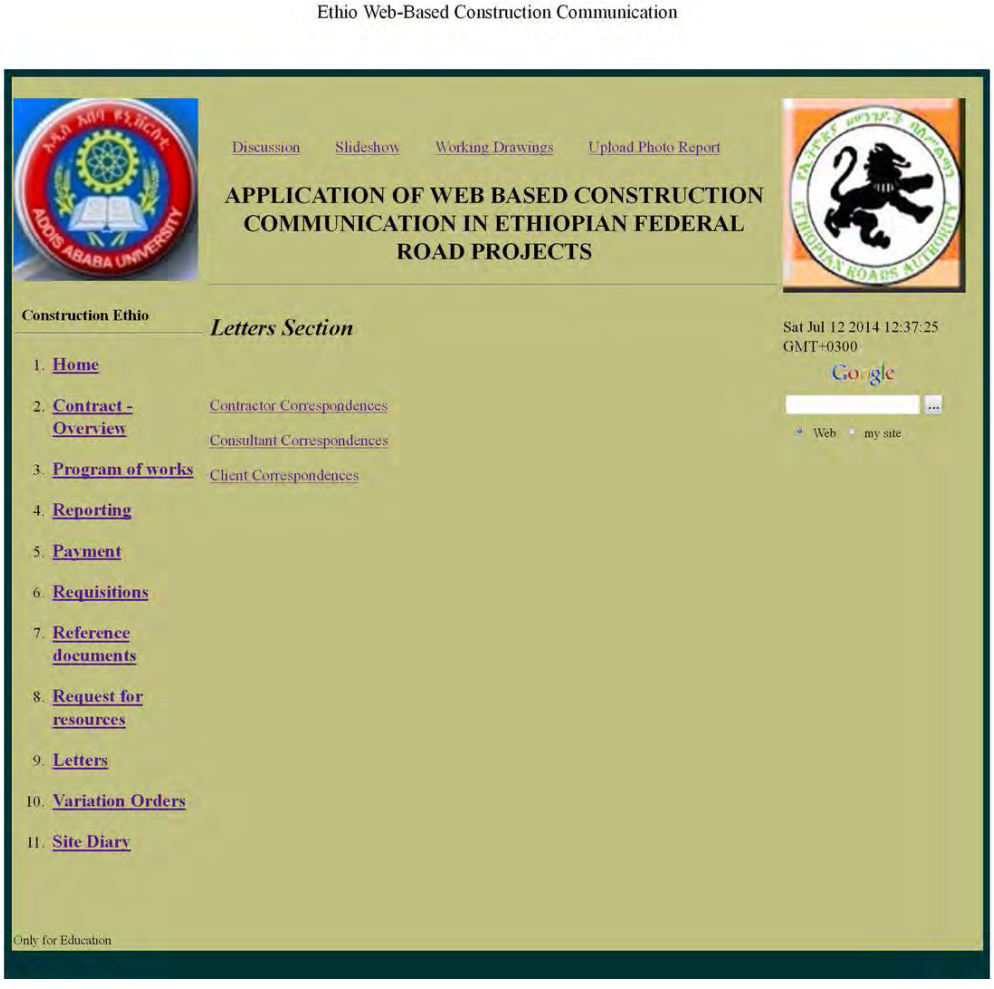

Figure 7: Presentation of Correspondence web page

4.1.9 Variation Orders

Variation orders proposed by the consultant and approved by the client are part of changes in quantity or scope affecting the project in terms of cost, time and possibly change in quality.

Even though variation orders are parts of written communications, separating from other letters will allow parties to pay special attention to changes in project cost and time. Moreover, unlike letters variation orders are displayed online for ease of reference.

4.1.10 Site diary

Abera Bekele (2005) pointed out that lack of proper record keeping as one of shortcomings leading to disputes in Federal Road Project. Therefore, to avoid such problems daily records of;

- Weather,
- on-going work executed,
- tests taken,
- any issues - plant, labour or materials, local disturbances, etc. that are affecting progress,
- materials delivered to site,
- instructions given on site,
- all verbal instructions to be confirmed in writing within 24 hours,
- requests for information from the Contractor,
- accident occurred on site,
- Performance status (text, photos),
- defects (text, photos),
- delays,
- (Partial) acceptance processes

shall be reported to centralized database. Moreover, a part from helping for future retrieval for any purpose, records stored in this manner help to take immediate action to influence the project.

4.1.11 Discussion

Similar to RFI information exchange, to have an online discussion of an issue or leave a message for communication, a simple forum type dialogue box is designed for discussion.

The topics and replies are stored in database for documentation. Any issue regarding the data on website or point of discussion can be raised and discussed.

4.1.12 Slideshow

As discussed in the literature review, site photos would help to share progress with those in remote locations, resolve issues and minimize site visits by monitoring construction from the office.

Site photographs visualizing the actual progress of activities can be posted daily or upon execution to envisage the correctness of the permanent work or conformity of temporary works such as false and formworks. Mistakes in construction can be rectified while the work is under progress. Through such mechanisms, works conducted in remote area in the country can be monitored online by senior professionals of the client, consultant and contractor.

The contractor or the Engineer uploads site photographs taken jointly with the consulting supervisors through "Upload Photo Report" page. The engineer imports the data to slideshow page which generates slideshow of the pictures so that all parties can envisage the current ongoing activities in line with the schedules.

4.1.13 Working Drawings

Similarly as discussed in the literature study, design detailing, and changes occurred require real time information management for tracking and monitoring the projects. With the use of this web page everyone on the project team, including the Owner would have the opportunity to review, approve and comment before a document is issued to site, without sacrificing time or spending hours on meetings, faxes and phone calls.

The contractor submits detail working drawings prepared onsite to the consultant. This allows the parties to observe the correctness of each detailing ahead of taking action.

Moreover, the web page solves shortage of senior professionals on site allowing them to look into critical details from head office located at remote area from the work.

4.1.14 Upload Photo Report

This is the page where the contractor is allowed to report periodical photographic reports for approval by the engineer. The engineer display commented and approved drawings for reference.

5 Conclusions and Recommendations

The main objective of the research was study of application of Web Based Construction Communication which is aimed at assisting evidenced real time communication, information storage, retrieval, manipulation and transmission among project participants parallel to the paper based project communication scheme.

To improve project communications and documentation, this study presents a web based construction communication. The study demonstrates that the WBC^{2}FRP system improves project management for project teams in a construction project environment.

5.1 Conclusions

The conclusion of the research is discussed as follows based on the specific objectives set forward.

1. The first specific objective was to develop a simple and friendly web site oriented at real time communication, information storage, retrieval, manipulation, transmission and decision making. In this regard, the study has assured that;
    - Trilateral ***communication*** and discussion is made possible
    - ***Project information storage*** in database and file system is designed and made possible to store all information for decision making and future reference
    - ***Retrieval*** of information stored is possible for processing
    - Project data ***manipulation*** is accessible mostly for the engineer action whenever desired.
    - ***Transmission*** of project information and decision exchange is made possible
2. In accordance with the second specific objective, the system enable parties to update data from anywhere and immediately upload data to the system to share real-time project-related information such that they can make effective decisions regarding the project. It has been discussed that an integral component of a construction process is accompanied by set of ***decisions***. Delayed action to the process has an integral component in the causes on project delays. To minimize such delay segments, the web site assures decision making mechanism wherever the decider is or at any time. Therefore, real time project communication is favored by the application of the system.
3. The third specific objective was to test the functionality of the web site using local server installed on windows operating system. The website is tested and functional on windows

operating system with Mozilla Firefox, Google Chrome and Microsoft Internet Explorer browsers.

5.2 Recommendations

1. The research has found that ERA has an objective of upgrading itself to a world class road agency, characterized by organizational excellence, growth through engineering research and innovation, responsiveness, and most of all by customer-driven and oriented services. The overall improvement will attempt to increase transparency of procurement process through a digitized and web based communications with stakeholders, improve the quality of procurement process through standardization of documents and expediting the procurement process by utilization of database system. ERA has also developed Web Based Ethiopian Roads Authority Management System –ERAMS which is designed to ensure quality and monitor the progress achieved in implementation of the road delivery and management core process. The modernization initiative then requires stakeholders to reengineer their business process to cope with such client sophistication.
2. Electronic project management shall be included in curriculum design in Construction Technology and Management Stream.
3. Applications of 4D building information modeling in local construction industry shall be studied to integrated planning, designing and construction of projects to avoid constructability problems leading to design risks.
4. Applications of Electronic Tendering in local construction industry shall be studied further to integrate web based project management with electronic contract administration.
5. Further research shall also be conducted to address legal issues in the use of electronic project management.
6. As in the case of traditional project administration, the engineer is expected to be responsible in administering the website.

References

1. Ministry of Foreign Affairs - MoFA Ethiopia, (www.mfa.gov.et, Accessed March 16 , 2014)
2. Road Sector Development Program (RSDP) 13 Years Performance and Phase IV, January 2011.
3. Road Sector Development Program16 Years Performance Assessment, October 2013 (WWW.ERA.gov.et, Accessed March 12 , 2014)
4. Aaron Charles Zutz(2010) "Web-based collaboration in horizontal construction", Iowa State University
5. Getachew Tsegaye(2009) "Design Risk Management In Ethiopian Federal Road Projects", Master of Science Thesis, Addis Ababa University, School of Civil and Environmental Engineering
6. Turkey Wakjira(2011) "Risk Factors Leading to Cost Overrun in Ethiopian Federal Road Projects and its Consequences", Master of Science Thesis, Addis Ababa University, School of Civil and Environmental Engineering
7. Abera Bekele(2005), "Alternative Dispute Resolution Methods in Construction Industry: An Assessment of Ethiopian Situation.", Master of Science Thesis, Addis Ababa University, School of Civil and Environmental Engineering
8. Abiy Zegeye, Alemayehu Worku, Daniel Tefera, Melese Getu, Yilma Sileshi, (2009) Introduction to Research Methods (Preparatory module for Addis Ababa University graduate programs)
9. Mustafa Alshawi (2003), Web-enabled project management: an emerging paradigm in construction
10. Construction Extension to A Guide Project Management Body of Knowledge (PMBOK ® Guide)-2000 Edition Published by Project Management Institute, Inc.
11. McCreadie M., and Rice R. E . (1999). " Part I: cross-disciplinary conceptualizations of access Information Processing and Management, 35(1), pp. 45-76."
12. Wikipedia Free Encyclopedia (Accessed March 8, 2014)
13. Rogers, E.M. and Kincaid, D.L. 1981, Communication Networks: Toward a New Paradigm for Research. The Free Press, New York.
14. Yuan Chen and John Kamara (2008), The Mechanisms of Information Communication on Construction Sites
15. Dainty, A., Moore, D. and Murray, M. 2006, Communication in construction; theory and practice, Taylor and Francis.
16. Hoezen M.E.L., Reymen I.M.M.J., Dewulf G.P.M.R., The Problem of Communication in Construction. University of Twente. Retrieved 23 December 2011 University of Twente
17. Rohaniyati Salleh, 2009, Critical Success Factors of Project Management for Brunei Construction Projects: Improving Project Performance
18. O'Connor.J.T.F. Hugo, et al. (1991) "Improving highway specifications for constructability, "Journal of Construction Engineering and Management 117(2): 242. 258.

19. Finne, C. "How the Internet is changing the role of construction information middlemen: The case of construction information services." IT con, 397-411, October' 2003.
20. Ahmad Doriani, 2012, Simulation-Based 4D Modeling for Planning and Scheduling of Elevated Urban Highway Reconstruction Projects, M Sc Thesis in Building, Civil, and Environmental Engineering, Concordia University, Montreal, Quebec, Canada
21. Kamara, J. M., Anumba, C. J., and Evbuomwan, N. F. O. (1996). "Integration of design & construction: A review of existing approaches." School of Science & Technology, University of Teesside.
22. Scanlin, J. "The Internet as an enabler of the Bell Atlantic project office", Proj. Mngmt. J., June, 6-7, 1998.
23. Opfer, N .D. " Intranet Internet Applications for the Construction Industry." ASC Proceedings of the 33rd Annual Conference, University of Washington – Seattle, Washington, April 2-5, 211 -220, 19
24. Nielsen, Y. and Sayar, T. "Web-based information flow modeling in construction." Proc. of ARCOM Seventeenth Annual Conference, University of Salford, 1, 219-229, 2001
25. Mamoon M. Hammad A Ph.D., P.Eng.(2002) Managing Project Documents Using Virtual Web Centers
26. Kurt Löwnertz (1998) Change and Exchange Electronic document management in building design
27. Nga-Na Leung, Swee-Lean Chan and Raja R.A.Issa, "Meta-Data-Based Collaboration In Construction Project Management"
28. Information and Communications Technology (ICT) www.cs.cmu.edu/~rtongia/ICT4SD_Ch_2--ICT
29. http://www.capterra.com/construction-management-software (Accessed, March 8, 2014)
30. Shion. Guha(2010); Collaboration in a Web Enabled Design Management System – a Case Study in Kolkata, India
31. David Scott, Professor and Head (Civil Engineering Department, Curtin University of Technology, Perth, Australia), Michael Kwan Wah Cheong, Research Assistant and Heng Li, Professor (Building and Real Estate Department, Hong Kong Polytechnic University); "Web-based construction information management systems"
32. Ahuja, Vanita and Yang, Jay and Shankar, Ravi (2006) Web Based Communication For Construction Project Management
33. Hugues Rivard, Professor(2004); Case Studies on the Use of Information Technology in the Canadian Construction Industry
34. Electronic Contract Administration – Legal and Security Issues Research Report; Australian Cooperative Research Centre for Construction Innovation.
35. Skibniewski, M.J. and Zhang, L "Economic feasibility of web-based project management solutions." Int. J. of Const. Mngmt., 103-121, 2005.
36. Nitithamyong, P ., and Skibniewski, M . J . (2004), " Web-based construction project management systems: how to make them successful." Automation in Construction, 13(4), pp. 491-506.

37. Olalusi O .C, J esuloluwa O ; "The I mpact of I nformation T echnology on N igerian Construction Industry"
38. Yacine Rezgui, A lain Z arli, A bdul Samad (Sami) K azi, Ian Wi lson; " Enhancing t he Competitiveness of the European Construction Industry in the Digital Economy"
39. Martin K eller, K arsten Menzel, R aimar J. S cherer; " Towards a Meta-Model for Collaborative Construction Project Management"
40. Nurshuhada Z ainon1 a nd H afez S alleh; "Dimensions o f information t echnology infrastructure f lexibility in improving management e fficacy o f c onstruction industry perspective: A conceptual study"
41. Central statistic Agency of Ethiopia (Accessed March 12 , 2014)
42. World B ank, E thiopia O verviewhttp://www.worldbank.org/en/country/ethiopia/overview, Accessed March 16 , 2014)
43. World Health Organization, WHO|Ethiopia, http://www.who.int/countries/eth/en/ Accessed March 16 , 2014)
44. How to Create a PHP/MySQL Powered Forum from Scratch, Website accessed Nov 2013
45. http://www.w3schools.com, Accessed November 2013
46. http://WWW.javascripttutorialspoint.com, Accessed November 2013
47. http://WWW.visualslideshow.com, Accessed November 2013