EACE Bulletin

Vol-10 No-1
December 2019

A PUBLICATION OF

THE ETHIOPIAN ASSOCIATION OF CIVIL ENGINEERS

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Content

2 Message from the President

3 Message from the Editorial and Publication Committee

4 Acknowledgement

6 Construction Audit Construction

18 Soaked California Bearing Ratio Value Determination From Laboratiory Dynamic cone Penetrometer

24 Implementation of Construction Health and Safety regulations, Their Effects on Workers Job Performance and Mitigation Measures in Building Project Sites of Hawassa City

33 Pre-fabricated concrete construction As an Alternative for the Ethiopian Housing Challenges

Those of you who are interested to submit papers for our Journal and Bulletin Please forward your papers up to **31st March 2020** to the following **Address:**

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Message from the Editorial and Publication Committee

It is with great enthusiasm that the Editorial and Publication Committee of the Association presents this publication to our respected readers. In response to our call for papers, 35 abstracts were submitted where 15 abstracts were accepted for full paper submission after double blind peer review procedure. From accepted 15 abstracts only 10 full papers were submitted and based on the review results, we eventually accepted 8 papers for our publications. We thank all those who submitted their abstracts and congratulate all authors of published papers in our publications. We commend their patience and understanding as the review process was painstaking and rigorous. We thank them for their commitment to scientific research, professional development, and the hard work put into doing the research and writing of the papers.

On that note, we would like to cordially thank our peer reviewers for their efforts, contributions and essential service as gatekeepers for the scientific integrity of published research papers. The Committee would also like to use this opportunity to express its heartfelt gratitude to organizations and individuals who sponsored publications of the Association.

It is our strong hope that this publication has its own humble contribution to the advancement of our profession at a national and global context. Hereby, we highly encourage members of the association to use this outlet to publish your papers in the upcoming publications.

"If you want to change the world, pick up your pen and write." Martin Luther

The Editorial and Publication Committee

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Acknowledgement

The Editorial and Publication Committee of the Association would like to acknowledge the contribution of those individuals who spared their precious time in reviewing the abstracts and papers submitted to this year's Journal and Bulletin of the Association. The Committee would like to cordially thank the following individuals for their professional contribution in reviewing submitted abstracts and papers.

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Editorial and Publication Committee (EACE)

CONSTRUCTION AUDIT

Conceptual Framework & Implementation Strategy

Shifferaw Taye [1]

Abstract

Conceptual framework for Construction Autdit has been provided and the major types of such audits discussed in light of their contribution to the development, productivity, sustainability, resilience, adaptability as well as competitiveness of the Construction Industry.

Discussions on the undesirable consequences of lack of Construction Audit both at the system- and project levels have been cited with the view of forwarding recommendations of for the institutionalization and legalization of the Audit process in the national Construction Industry.

Implementation strategies and the roles of the various stakeholders in the local context have been presented along with the regulatory and institutional framework needed to conduct such audits. Both short- and long-term strategies for the implementation of Construction Audit both a System- and Project-levels have been discussed in light of the tangential mention of same by the Ethiopian Construction Industry Development Policy.

Key Words:

Construction Audit, Construction Industry Audit, Construction Project Audit, Holistic Construction Industry Transformation, Compliance, Enforcement

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INTRODUCTION

Construction Audit is the process of assessing the state or product of the construction industry with reference to and against intended set of targets, expected states and outputs or certain established criteria. It is a review of various phases and aspects of the Industry at large and of Projects with the view of assessing the former on how it is led and managed under established policy directions, institutional as well as legal frameworks, whether those elements themselves are responsive to present needs to address several local, regional and global issues. Likewise, at project levels, it deals with the assessment and examination of how they have been planned, whether they have met technical requirements during design, further, how they have been and are managed and whether they are performing appropriately with reference to established regulatory-, technical- and performance provisions and requirements. The conceptual framework for Construction Audit is provided in Fig. 1 and this will be elaborated further subsequently.

This is a very generic and general description of Construction Audit and it is based on the fundamental premise that what is intended or executed shall be audited for it to be worthwhile pursuing. Accordingly, Construction Audit emanates from the basic principle of assessing and examining a process or its product with the view of identifying strength and weakness of each such component for building upon and disseminating what is good outcome while working on

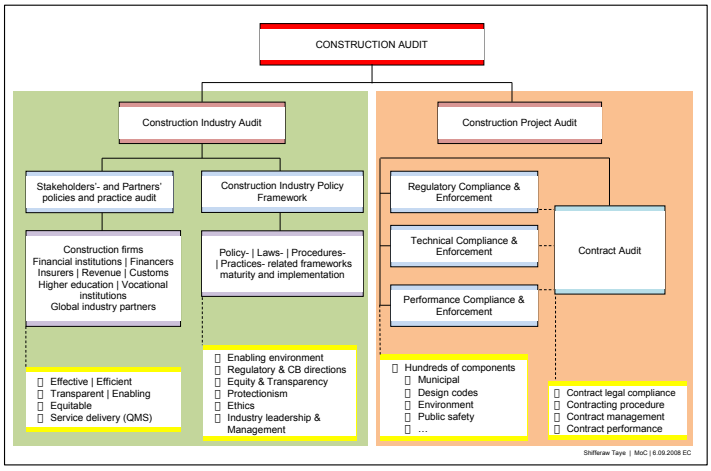


Fig. 1: Conceptual framework for Construction Audit.

fundamental causes of what may have brought about weak and undesirable results and subsequently, devise a mechanism by help improve performants and all other gaps and enhance the process so that future unwarranted outcomes are avoided.

Construction Audit, like any activity or process in the Industry must create value in the construction sector (and beyond) either at the system level or at project level or both. Those values of contributing to the development, productivity, sustainability, resilience, adaptability and competitiveness, DPSRAC in short, with an ultimate goal of bringing about a holistically

transformed Industry that is dynamic and forward looking while enhancing the qualities of vertical- and latera linkages. The vertical linkage refers to policy makers, regulatory framework designers, the Industry leadership and management and it addresses the qualities of policy frameworks, bylaws and organizational setups, leadership and management of the industry with a variety of stakeholders coming into picture. Horizontal linkage, on the other hand addresses both backward- and forward linkage, mainly, on the delivery process along with and all components therein.

In light of the above points, Construction Audit will add ample values to the Industry through

positively influencing the DPSRAC components singularly or in groups, thereby addressing the entire implementation and / or delivery process. When Construction Audit is supported and synchronized with Research & Dissemination activities, the complete cycle will enhance the overall Industry in light of the DPSRAC objectives leading to a dynamic Industry that is going to be founded on a solid foundation.

Construction Audit addresses two major components – Industry / System-level audit and Project-level audit. The various elements and subcomponents of Construction Audit are provided in Fig. 1. The System-level audit covers Industry-related policies, bylaws, regulations, companies, institutions related to the Industry bay way of their direct and indirect involvements, among others. Likewise, the Project-level audit addresses all issues related to construction projects – from conceptualizing and planning through execution, commissioning and, possibly, management, among others as will and to be presented in some details subsequently. The planning, design and implementation of Construction Audit based on scientific, practice-oriented and industry-related experience, taking into account its multi-disciplinary nature, will enhance identify both the capacity building needs and regulatory framework design for the industry.

The fundamental concept of Construction Audit is reporting of asked for and / or desired phenomenon or its delivery process "as is" and, at times, compared with "as planned". It is to be, thus, emphasized that the whole concept of Construction Audit revolves around comparative analysis of the relationship between what is intended and what is delivered or not delivered. However, it is not a control, fault-finding and criminalizing mission and, in fact and by far, the major objective is to assess and evaluate audit findings with the view of, among other points, creating a knowledge bank from which experience can be drawn for policy updates, procedure enhancement and / or outright change, taking corrective measures and the development of proven practices, otherwise known as best practices, in the case of positive audit findings.

CONCEPTUAL FRAMEWORK

Audit is a continuous process that will be undertaken periodically or as the need arises although the former is a well-structured model for improving the system-level process while both execution models are suited for project-level implementation. Construction Audit is, thus, practiced both at system level and at project level as shown in Fig. 1.

System- or Industry-Level Audit

This aspect of the Audit process deals with the assessment, evaluation and reporting on the overall performance of the Industry based on a variety of variable that influence its behavior. This is conducted by touching upon all aspects of the Industry in light of the DPSRAC goals. This Audit covers and addresses two major components:

Stakeholder's, Partners' policies and practices whose policies and operational frameworks will have direct and / or indirect influences on the performance of the Industry at large and on projects, at least indirectly, and

Construction Industry Policy, a variety of other legal frameworks and programs, practice frameworks maturity and implementation thereby coming up with strong and / or weak

ideas embedded in those elements with the ultimate goal of enabling concerned policy makers and regulatory framework implementers to come up with improvements and / or entirely new developments.

Stakeholders in the Construction Industry at system level consist of a large number of players including, but not limited to, financial and insurance establishments, revenue and custom authorities, educational and training institutions at all levels that feed the Industry with the human capital at various qualifications and levels, global industry partners, among others. Indeed, a clearer picture of operational guidelines, not least, for instant, with particular reference to foreign companies and institutions playing active roles in the Country's Construction Industry, can be issued out following a well-designed Stakeholders Audit in this regard.

Likewise, the concept of equity can be brought to light in view of how local construction companies and related setups operate in the Country following such an audit. This will, in turn when supported with well-organized Research & Dissemination activities, will provide policy makers and implementing institutions to design a regulatory mechanism that will address a variety of issues that is linked with fair distribution of wealth in the Industry by all active- and other players.

It is very essential that a well-planned audit – either desk- or field ones – of such institutions and establishments be made and reported in such a way that policy makers and Industry leading institutions be in a position to conceive, plan, design and implement policy and regulatory frameworks that will effectively and efficiently respond to outstanding scenarios that will influence the local constriction industry one way or another with the ultimate goal of creating conditions that will enhance journey towards nourishing the DPSRAC goals.

Likewise, Policy frame-related audit on the Industry addresses and examines the effectiveness and responsiveness of the Ethiopian Construction Industry Development Policy of 2013 and its various elements in respect of development goals, meeting societal needs and responding to the current and emerging global scenarios. This class of audit will work upon the nature of existing policies and regulatory frameworks in response to creating an enabling environment, bring about equity, transparency and level of protectionism scenarios as to their existence or otherwise, ethical standards and, no less important, the quality, competency and capability of the leadership and management of the Industry in respect of working towards DPSRAC goals.

In summary, System-level audits may cover the following:

- Processes quality for assessing qualifications, conduct certification and eventual registration of professionals and, based on needs, those of construction- and related firms as well as projects
- Examination of the manner in which relevant design and planning standards are identified, developed, implemented and maintained
- Construction Industry Policy and various inter-related legal framework
- Construction Industry performance
- Construction-related curricula of institutions of higher learning in light of the

content, quality and relevance of their products

- Validity and performance audit on KPI sets for the Industry
- Construction Industry contribution to national development

These are only a limited set of activities that have been extracted from the larger picture provided in Fig. 1 as related to Construction Industry Audit (or System-level audit).

A well-designed, target-oriented Construction Industry Audit will have the benefits of:

- Providing policy makers with evidence-based report that will be an input for policy and regulatory formulation as well as setting an integrated and strategic capacity-building directions.
- Revealing the harmony, or, otherwise lack of it, between and among policies of the Construction Industry on one hand and those of other stakeholder institutions with the view of addressing how the former can be crafted for adaptability to bring about the DPSRAC objects.
- Identifying good practices in the Industry and, subsequently, enhancing their implementation in the System on one hand and identifying not-so-good practices and help work towards their betterment or outright change.
- To identify potential dangers in the Industry so that a variety of mitigating factors can be designed and implemented.
- Create and improve the business process by which the Industry is led and managed and help create directives and procedures therein with the view of instilling the need for Construction Audit at all times.

Project-Level Audit

A construction project audit is a review of various phases and aspects of a project to ensure whether they have been planned and design according to established standards and, further, they are managed and performing appropriately with reference to established regulatory-, technical- and performance provisions and requirements Construction project audits are indispensable tools for assisting in determining and actively establishing project progress and control, cost recovery, internal project and overall company's financial, process quality and a variety of other controls, and ensure safety among other project management (PMI, 2017) and construction project management operations (PMI, 2016), (ECP-MI, 2019).

This class of the audit process covers both compliance and enforcement aspects of three major parts: regulatory-, technical- as well as performance- audits where in a variety of components such as, for example, financial, operational, tax, communication and information, among many others, are covered. Many of the elements in this audit class overlap and interwoven and may not be clearly and independently categorized.

Regulatory compliance generally covers a comprehensive review of an organization's adherence to regulatory guidelines including, but not limited to, the interaction of a particular project with its environment, social impact, construction-site requirements and related phenomena. Technical compliance refers for the technical guidelines including planning and design standards. Likewise, Performance Compliance addresses the management aspect of a project in light of integration,

cost, time, quality and a variety of other project- and construction-management components. In all the three cases, the enforcement aspect addresses the quality of the implementation process for ascertaining respective actions and conditions. In all cases, audit reports evaluate the strength and thoroughness of compliance preparations, security policies, risk management procedures, among others, over the course of a compliance audit.

One of the noticeable audits at the Project-level is the so-called Contract Audit and this generally examines written arrangements between and among different project parties and contrasts accomplished elements against agreed-upon terms of the contract delivery components and processes. A previous study (Shifferaw et al 2017) has revealed the state of major construction projects in light of their contract performance. A study made on carefully selected, fairly large-scale building-, road & transport-, as well as waterworks contracts, all described as reasonably huge projects, indicated how improper project planning, contracting and execution singularly or in combination has negatively influenced their performance.

Contract Audit is, thus, conducted with the intent of ensuring the amount and quality of services, including deliveries, are in accordance with agreed upon terms and conditions and, when it comes to the cost aspect of the audit, it is to ensure what is billed is an appropriate amount. More often than not, Contract audit seems to align with project funding, i.e, cost, control and compliance audit (Tilly 2010).

Project-level Construction Audit process and objectives are generally similar across various projects; they cover the following activities:

– Examine the level of the multi-component project delivery process and activities – from inception, to design, construction, possibly, post-construction management – study the bidding process, a variety of procurement activities and processes, project management implementation, monitoring and evaluation processes
– Active engagement in the process of examining design- and construction processes with the view of ascertaining whether and how effective the processes quality assurance and quality control activities have been designed and implemented.

Indeed, there are several beneficiary outcomes from Construction Project Audit; the main ones include,

– Ascertaining and consequently helping in bringing about a well-structured project delivery system through the design and implementation of scientifically- and practice-proven, knowledge-based project delivery process from inception to completion and covering all activities in-between to the last details
– Examine and conduct through assessment of the project planning and design process, i.e, all pre-bid-for-construction activities and processes, to ensure that complete and deliverable and constructible design products have been produced before embarking on construction works

  This is one of the major problematic areas in our local construction industry as witnessed on a number of large-scale projects. It has not been uncommon to hear, quote, "… we do design and construction parallel learning from mistakes and

improving on revelations …" as if an engineering design delivery process is completely a trial-and-error process to be left and managed by those who have no clue as to how the various professions interact among themselves in the project delivery process.

– Ensure a consistent, traceable and structured project delivery process that will help emerge out of difficulties if and when such a mishap takes place, and extract good practices from such revelations for dissemination into the project delivery process
– Examine and identify unnecessarily involved and problematic service- and other construction-project purchase processes and provide reports that will enable policy makers and implementing institutions to design a transparent, efficient, effective and accountable construction delivery process.
– Insure the inexistence of conflict of interests in the project delivery process and, in this context, provide policy makers and implementing agencies the need to define the roles of different stakeholders in the project delivery process.

  For instance, an excellent conflict-of-interest instance in the current project delivery process in the local context is the so called "Design and Project Management Consultancy Service (actually no more than supervision and contract administration in many cases)" where a designer will also act as the sole supervisor of the construction process (thereby leading to issuance of almost invariably incomplete a design output that will eventually call for reworks during the construction process).

Construction Audit Reports

Construction Audit both at System- and Project-levels is of different interest and targeted goals for and among different audiences including policy issuers and bylaws providers and implementers, among others. This is further diversified in light of the various elements and components to be audited and reported.

The reporting logic and formats of any construction audit process must be designed and in such a way that it effectively addresses the needs of the various stakeholders and no one report fits all even if the phenomenon to be audited can be one and the same. Those reports need to be useful and be able to stand fully self-contained as inputs to be responsive to the needs of those who will use them for further processing and actions. (This is why it is mandatory that those who will design the Construction Audit process must have all appropriate educational background, extensive industry experience and multi-disciplinary skill.)

Peculiar Features of Construction Audit

Activities to be carried out in and during a Construction Audit process call the following a priori:

a. The nature of Audit outcome both at Industry- and Project-levels is deterministic; that is, the nature of outcomes is predictable; auditors are aware of what to expect and what is at stake and how the audit process and activities will be conducted and findings reported.
b. There are benchmarks for comparison of audit results; that is, findings are always evaluated against certain targets at Industry-level while there are measurements and standards to be referred to at Project

level.

c. Construction Audit is carried out in a targeted manner addressing only issues within predefined scopes of work, which is determined and established by the project owner (Nalewaik, 2007) and reports are accordingly generated only as per agreed-upon standard both in terms of style and content. No audit activity will be conducted or reported beyond agreed-upon scope even when there could be more elements for audit unless and otherwise consent is granted by client or a legally authorized body.

d. While the goal of audit results and reports are generally established in advances, it is, likewise, important to agree upon the style and content of the reports, details both in width and depth of their contents in advance. These elements shall then be strictly addressed and adhered to as any additional report content may lead to violation of privacy to the minimum.

e. The privacy and confidentiality of an audit process and reports shall be respected by the audit team and reports shall only be disclosed to the client and / or authorized body. No information whatsoever shall be disseminated especially by the Audit team as anybody other than signatories to the audit process as to the nature, findings and / or content of the Audit report or audit process, the client, potential consequences, among others.

f. Unless agreement has been reached otherwise, all data used for the audit and all audit reports in whatever format that they are available shall be fully and complete ly handed over to the client; no such items, unless it is a public-domain one such as, for example, literature, may be retained by the auditing body, members or the auditing institution.

g. It is to be well-understood that the fundamental concept embedded in Construction Audit is to present audit findings "as is" based on evidences and facts and within the established scope of work. However, this may be supplemented by additional information if authorized to do so by the client.

h. All material data for use in the auditing process shall be availed by the client and the auditor may put request to the client for additional data or information. In particular, the audit team shall not interact with any other party while in the auditing process (and beyond) and the identity of auditors shall be kept confidential (for the safety and well-being of the professionals and the various subjects to the audit).

   It is also unethical (and can be criminal) act to disclose ones identity as an auditor or pose self to solicit for "rent-seeking" with the view of twisting audit findings and reports.

THE ETHIOPIAN CONSTRUCTION AUDIT EXPERIENCE

In general, project cost- and at time performance- audits have been practiced for year by the relevant Government establishments generally linked to budget utilization. Construction quality audits have also been practiced in certain public projects (STRANCOM 2006). However, Construction Audit is far from

cost-only audit and is a multi-disciplinary,

multi-faceted operation that involves engineers, architects, lawyers, management specialists, construction and project managers, accounting personnel, among so many other players.

While the Ethiopian Construction Industry Development Policy (2013) tangentially touch upon the idea of construction audit, its sense of consideration for the Concept revolves around the socalled value-for-money scenario essentially dealing with cost, time and quality audits (not even addressing "fit-for-purpose" audits) and generally confined to project-level audits.

However, this bigger picture of Construction Audit in its entirety was introduced by this Author into the Organizational Structure of a Government body (MoC, 2015) responsible for leading and managing the Industry in 2015 – some three years after it was mentioned in the Ethiopian Construction Industry Development Policy. While only some scant experience may have been gained especially on Contract Audit over the past four solid years, there is much to be desired, however, from the implementation of Construction Audit in the local context.

Construction Audit has to be executed in a well-structured process quality management system for it to be successful and responsive to desired need of the Industry. An ISO 9001-certified (Natarajan, 2017) wok environment can be well-adapted to lead the activities of this working unit within the Ministry.

CONSTRUCTION AUDIT IMPLEMENTATION STRATEGY

As noted in the previous sections, Construction Audit as a multi-disciplinary,

multi-phenomena targeted process and, likewise, it calls for a well-organized, synchronized and fully informed process handling for its successful implementation. It also needs the cooperation and joint operation of a variety of government and private institutions in order to craft, design, implement, monitor, and evaluate the various stages of the Construction Audit Process both at System- and project levels.

The concept of Construction Audit entails working at Industry level, thus covering a variety of stakeholders including Industry leadership and management (political appointees and employed professionals at institutional and organizational levels) along with all their duties and responsibilities, construction- and related companies and a variety of other players (please see Fig. 1), and further, audit of policy and legal instruments that have been crafted to manage the Industry. Several other Governments bodies also involve in a variety of public and private construction projects one way or another and their operational modalities need also be examined to create a conducive working environment for the Industry to meet the ultimate DPSRAC goals. The involvement of such establishments also calls for their being part of the Construction Industry Audit Policy Development and Implementation Strategy, monitoring, and evaluation process.

Likewise, Construction Audit when addressing Projects calls for working on a variety of institutions, agencies and establishments, including government and private alike, as well

as professional-, skilled and other work-force groups as to the qualities and project-related safety and a large variety of issues.

It was initially conceived to house the Construction Audit body in the a Government institution responsible for leading and managing the Industry while the ultimate goal has been to establish an autonomous National Construction Audit body that will be accountable to a higher body. This initial phase of developing the Construction Audit concept and strengthening institutional and legal framework to that effect will be an incubation phase whose period will essentially depend on the maturity level of the actors in that body and the Government's intention to create such an independent body.

The Construction Audit implementation strategy, therefore, is to be based on addressing all stakeholders and players at different levels (Shifferaw, 2019). In light of such development, therefore, the following institutions and establishments can form part of the operational aspect of the Construction Audit process besides the body indicated in the Ethiopian Construction Industry Development Policy:

- Auditor General
- Ministry of Finance and other relevant Ministries
- Regional- and the Two-Cities Administration
- Regional and Two-Cities Construction Bureaus and other relevant Regional institutions
- Public Procurement Agency
- Financial institutions
- Institutions of Higher Learning and Industry-related Training Establishments
- Mass media agencies
- And other institutions involved in the development of the Country

They will cooperate on the design of the Construction Industry operational formats including reporting ones. While the Ministry of Urban Development & Construction currently makes Construction Audit part of its Organizational Structure, it will responsible for carrying our Construction Audit or facilitate such grounds for others to involve, it should also establish a working, effective and strong unit that deals with the audit mission. With particular reference to the Office of the Audit General, however, it has got a very special role in that it will be in a position to conduct performance audit of the Ministry of Urban Development & Construction in the latter's quest to conduct all elements of the audit process without directly involving in the auditing of the Construction Industry Development Policy document – a process that is beyond its mandate.

Besides assembling a variety of stakeholders as noted above, a legal framework and institutional arrangement become mandatory in conducting Construction Audit. Indeed, this had been a formidable hurdle when a previous attempt was made in 2009 to audit a Government development project[1] by the then-newly established Construction Audit Directorate of the formed Ministry of Construction.

CONCLUDING REMARKS

Construction Audit, well synchronized with a

strong Research & Dissemination, will enhance the quality of the Country's Construction Industry Policy and legal framework such that the key Industry actors and players will have conducive environment for operation. In fact, these two grand assignments will have impactful positive consequences on

the Industry's DPSRAC goals and, subsequently, on Project delivery qualities and other key critical measurements for project success.

A well-planned Construction Audit process will create a basis of nurturing identification of proven practices, KPIs for the Industry and Projects, supplying a variety of inputs for policy makers and implementers in order to help them establish legal frameworks for policy implementation and its improvement when this is especially synchronized with Research & Dissemination.

Construction Audit is mainly a mission for identifying both good and not so-good practices and ideas in the Sector and provides fact-based, unbiased reports that will help improve the performance of the Construction Industry by way of instilling development, Productivity, Sustainability, Resilience, Adaptability and Competitiveness' into this largest employing Industry and, thus, contributing to social stability.

It is, therefore, recommended that a legal- and institutional framework be enacted in order to take further the implementation of Construction Audit at national level.

[1] Name withheld for reasons of privacy.

Acknowledgements

The Author is greatly indebted to the facilitation of this work by the Office of the State Minister for Construction, Federal Ministry of Urban Development & Construction, where he has been assuming the responsibility of an Advisor for Capacity Building, Technology Transfer and Policy matters under the financial grant from the World Bank.

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SOAKED CALIFORNIA BEARING RATIO VALUE DETERMINATION FROM LABORATORY DYNAMIC CONE PENETROMETER TEST FOR ADDIS ABABA RED CLAY SOIL

Ashenafi Mulugeta[1] and Samuel Tadesse[2]

ABSTRACT

The California Bearing Ratio (CBR) test is the most widespread method of determining the bearing strength of pavement materials and is fundamental to pavement design practice. Almost all road construction manuals of Ethiopia recommend CBR tests for flexible pavement constructions. However, most of low volume roads such as roads built under Universal Rural Road Access Program (URRAP) have been designed, constructed and maintained without performing the required CBR tests. One of the cited reasons is that CBR is an expensive test.

Hence, this study is aimed to introduce the simplest and cheapest way of determining the required CBR values indirectly using DCP tests.

In this study DCPI (Dynamic Cone Penetrometer Index) values obtained from the laboratory prepared samples were correlated with soaked CBR values for Addis Ababa red clay soils. In laboratory both CBR and DCP tests were conducted on soil samples remolded in standard CBR molds. The tests were performed for both soaked and un-soaked conditions. Besides, the appropriate soil index tests were conducted for all of the samples.

The data analysis was made using statistical software called SPSS, and a good correlation was obtained between soaked CBR and soaked DCP values and change in moisture content with coefficient of determination 72.9%.

Key words: Clay soil, Correlation, Soaked CBR, Laboratory DCP

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INTRODUCTION

The developments of new roads, enhancement of existing roads are part of infrastructures boom in Ethiopia. In road construction, pavement design is a crucial stage, which has to be performed carefully in order to be economical and increase the service period of the road. During pavement design, the most important things to be considered, especially for the design of flexible pavements are traffic volumes, subgrade strength and weather condition.

Subgrade strength is determined majorly using CBR values, which play a key role in fixing flexible pavement thicknesses. Besides, suitability of road embankment filling materials is mainly determined by their CBR values.

When compared with the road network of the country the availability of CBR machines in Ethiopia are negligible. Hence, most of low volume roads of the country, such as roads built under URRAP have been constructed without carrying out this test. This could not happen if this expensive testing method had been replaced by another simplified method.

One of the cheapest and easiest ways to indirectly determine CBR values is to conduct DCP tests and derive CBR values from the already developed empirical equations. Here in Ethiopia, all published empirical equations with their own limitations, are applicable only for DCP tests conducted in the field. Other African countries for example Malawi and South Africa had already included laboratory DCP test procedures in their road design and construction manuals [1]

Hence, this study introduces DCP tests conducted in laboratory and tries to find a way to determine soaked CBR values by generating an empirical equation from laboratory DCP tests.

EXISTING CORRELATIONS BETWEEN LABORATORY DCP AND CBR

T. Al-Refeai and A. Al-Suhaibani[14] conducted correlations between the values of laboratory DCP and laboratory CBR under un-soaked conditions using different soil types ranging from clay to gravely sand. The developed correlations are shown in Table 1

Another study, which was carried out in Malawi, provides an approximate guide to the relationship between the laboratory DCP values and laboratory CBR values for different kinds of soils at different moisture content. Table 2 , which was drafted from the Malawi pavement design manual, shows the relation between laboratory DCP and CBR[10].

Table 1: Correlation between Laboratory DCP and Laboratory CBR[14] .

Sample	USCS	Model	R^2
S2	SP	log CBR = 3.16 - 1.36 log DCP	0.81
S5	SP-SM	log CBR = 3.57 - 1.86 log DCP	0.83
S2+S5		log CBR = 3.24 - 1.50 log DCP	0.71
S4	SM	log CBR = 3.05 - 1.73 log DCP	0.85
S7	SM	log CBR = 2.70 - 1.35 log DCP	0.87
S4+S7		log CBR = 2.80 - 1.46 log DCP	0.85
S3	ML	log CBR = 2.51 - 1.15 log DCP	0.93
S9	CL	log CBR = 2.55 - 1.31 log DCP	0.96
S3+S9		log CBR = 2.54 - 1.23 log DCP	0.93

Table 2: Approximate relationship between laboratory DCP and CBR values at different moisture contents (for different kinds of soils of Malawi) [10].

Material Classification	CBR and DCPI values at moisture content					
	Soaked		OMC		0.75OMC	
	CBR	DCP	CBR	DCP	CBR	DCP
NG80	80	3.7	95	3.2	150	2.2
NG65	65	4.5	90	3.8	145	2.5
NG45	45	5.7	70	4.2	110	3.0
NG30	30	8.0	60	4.7	95	3.2
NG25	25	9.1	55	5.0	85	3.5
NG15	15	14.0	50	5.4	80	3.6
NG10	10	19.0	35	7.0	60	4.6

However, in Ethiopian road construction sector, laboratory DCP tests have not yet been practiced; hence the authors of this study couldn't find any publication which correlates laboratory CBR with laboratory DCP for both soaked and un-soaked conditions of local soils.

MATERIALS AND METHODS

MATERIALS

This study was made based on the Addis Ababa red clay soils. The predominant red clay sources of Addis Ababa were identified based on the previous studies conducted on the same soil type of the city[6,13]. Accordingly, twenty four disturbed red clay soil samples were collected from North and North West parts of the city, specifically from Shiromeda, Semen Mazegajia, and Asco areas. The soil index test results are summarized in Table 3.

METHODS

CBR and DCP tests are performed in laboratory by remolding the samples in standard CBR molds at their optimum moisture content and maximum dry density. From a single sample four remolded specimens are prepared using a similar initial condition, (i.e. similar moisture content, dry density, and compaction effort). From these paired remolded samples two of them are used to conduct the un-soaked tests while the remaining two are soaked for four days to conduct tests under soaked condition.

CBR TEST

One point CBR test is performed using the test procedure of AASHTO T-193. This test is made for both un-soaked and soaked conditions. The un-soaked CBR test is conducted on one of the paired samples immediately after remolding the sample and the soaked CBR test is conducted on the remaining remolded sample after soaking it for four days. Moisture contents are determined for both un-soaked and soaked samples

Table 3: Soil index properties

Site designation	Asco	Semen Mazegajia	Shiro Meda
Specific gravity	2.58 - 2.63	2.55-2.64	2.6-2.64
Liquid limit (%)	47-60	58-63	60-65
Plasticity index (%)	16-27	26-31	25-27
Maximum dry density (gm/cc)	1.53 - 1.64	1.46-1.59	1.53-1.63
Optimum moisture content (%)	19.8-25	22.9-26.73	27.4-29
AASHTO Soil classification	A-7-5 & A-7-6	A-7-5	A-7-5

DCP TEST

This test follows the test procedure presented under ASTM D6951-03 except here the penetration is performed on remolded samples in laboratory. Remolding the samples is performed in standard CBR molds. The DCP is directly placed at the surface in the center of the remolded sample with the same surcharge load used in CBR tests. The DCP test is then started by sliding the hammer while measuring the soil resistance to penetration in terms of mm/blow. Similar to the CBR tests, the un-soaked DCP test is conducted on one of the paired samples immediately after remolding the sample and the soaked DCP test is conducted on the remaining remolded sample after soaking it for four days. Here also moisture contents are determined for both un-soaked and soaked samples. During calculating the DCPI, the first blow is usually ignored due to the fact that the imprint area of the cone tip is smaller than that of the subsequent blows.

TEST RESULTS AND DISCUSSION OF THE STATISTICAL ANALYSIS

Table 4: summary of laboratory CBR and laboratory DCP test results.

Site designation	CBR (%)		DCPI (mm/blow)	
	Un-soaked	Soaked	Un-soaked	Soaked
Asco	40.5-85.4	4.5-17.5	5-15	11-41
Semen Mazegajia	74.6-90.4	4.98-11.5	5-6	14-40
Shiro Meda	55.3-76.4	12.5-14.3	7-12	14-21

The analysis of this study was made by developing different kinds of models. Since the purpose of this study is to determine soaked CBR values from DCP tests, in all models soaked CBR is presented as a dependent variable and other test variables together with the DCPI values are presented as independent variables.

From the developed models, strong relationships were obtained between Soaked CBR, soaked DCP, change in DCP and Change in DCP moisture contents. The values of CBR and DCP were mainly affected by the change in moisture content, this is expected because finer soils such as red clay soils are influenced by the change in moisture content. Soaked CBR is negatively correlated with soaked DCP, change in DCP and change in DCP moisture. Obviously, the higher CBR values show the stronger material which demands more blows for DCP, which in return indicates lesser DCP values.

Among the developed models, the highest coefficient of determinations was obtained from multiple linear empirical equations and they are presented as follows:

$(CBR)_s = -0.46(\Delta DCP) + 0.15(DCP)_s + 14.54$ (1)

$R^2 = 73.3\%$ SE= 2.15

$(CBR)_s = -0.53(\Delta\omega)_{DCP} - 0.22(DCP)_s + 19.49$ (2)

$R^2 = 72.9\%$ SE= 2.16

where

$(CBR)_s$ = Soaked CBR

$(DCP)_s$ = Soaked DCP

(ΔDCP) = Soaked DCP- Un-soaked DCP and

$(\Delta\omega)_{DCP}$ =the difference between the water

contents before and after soaking of the remolded samples for DCP tests

Eq.(1) has a higher Coefficient of determination than Eq.(2). However, it demands a longer test procedure than Eq.(2). For Eq. (1), un-soaked DCP tests should be conducted to obtain the change in DCP variable (ΔDCP). Whereas, Eq.(2) requires only to conduct soaked DCP tests. The change in DCP moisture content can be computed by recording the moisture contents before and after soaking the sample while conducting the soaked DCP tests. Hence, although Eq.(2) has a slightly lesser coefficient of determination than Eq.(1), for the sake of simplicity of test procedure, Eq.(2), with R^2= 72.9% and standard error of regression = 2.16, is recommended as the best empirical equation of this study.

VALIDATION OF THE DEVELOPED EQUATION

In order to validate the proposed empirical equation, three additional samples were randomly taken from three sites and similar to the other twenty one samples, all the required tests were performed. The results of the predicted and observed soaked CBR values are presented in Table 5.The soaked CBR values were predicted using the proposed regression model given by Eq. (2). It is found that the observed soaked CBR values and the predicted CBR values are close to each other.

Table5: Validation of the developed empirical equation

Sample number	Site designation	$(DCP)_s$(mm/blow)	$(\Delta\omega)_{DCP}$(%)	Laboratory Soaked_CBR (%)	Predicted Soaked CBR (%)	Variation (%)
10	Asco	26	7.9	8.6	9.6	-11.1
15	Semen Mazegajia	23	2.4	15.8	13.2	16.5
34	Shiro Meda	19	7.5	10.8	11.3	-4.9

CONCLUSION

The developed relationship is useful to the Civil Engineer in estimating strength parameters of soil from results of very fast and easier DCP test. The results of the regression analysis of this study show that satisfactory relationships of soaked CBR with soaked DCP, change in DCP and change in DCP moisture content may be established. The following empirical equation was developed with 72.9% coefficient of determination and 2.16 standard error of regression based on 21 samples;

$$CBR)_s = -0.53(\Delta\omega)_{DCP} - 0.22(DCP)_s + 19.49$$

Hence, using the developed relationship, one can indirectly determine soaked CBR values from DCP tests conducted in laboratory. Furthermore, the developed empirical equation can be used to determine CBR values at any percentage of moisture content as far as DCP tests are also conducted at the same moisture content.

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Implementation of Construction Health and Safety regulations, Their Effects on Workers Job Performance and Mitigation Measures in Building Project Sites of Hawassa City

Tadewos Awugchew wudineh[*]

Abstract

Health and safety (HS) issues have always been a major problem and concern in the building construction industry. The HS regulations are stated to eliminate hazards and reduce the consequential risks. However, the importance of the regulations seems to be overlooked in building project sites of Hawassa City. Accordingly, many companies do not follow the regulations as construction workers are injured and killed by construction accident. This paper aims to identify factors that affect implementation of CHS (Construction Health and Safety) regulations, their effects and mitigation measures on workers job performance in building project sites of Hawassa City. To reach this objective a review of literature as well as the Ethiopian CHS regulations has been undertaken. Mainly a five point Likert scale questionnaire was distributed to contractor's, consultant's and client's respondents in building sites of Hawassa City. Statistical analysis was used to summarize, interpret the data and to find the significances of the responses. In addition, interviews were carried out with project managers and Engineers. Accordingly, the findings indicate that the top factors which affect the implementation of CHS regulation are; availability and development of a clear HS policy and review, HS inspections by top management, conducting HS training and orientation, provision of safe working environment and employment of trained HS officers. The study revealed that implementation or non-implementation of CHS regulations has effect on the worker's productivity, job satisfaction, rate of accidents and cost greatly. Thus, the suggestion to minimize the impact on worker's job performance are; developing of a clear HS policy, management commitment towards implementation of HS regulations, HS education and training and conducting regular HS inspections. It was concluded from the study that good implementation of CHS regulations is the results from administrative and management commitment which calls for more attention to be paid to improve the implementation of CHS regulations in building project sites of Hawassa City.

Key Words: Building Construction, Health, Regulations, Safety

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1. Introduction

The construction industry being a significant factor for the development of the whole economy of a nation and encompasses significant portion of the labor force, its safe operation will be of paramount importance. It is important to know the existing situation and the gaps of Occupational Safety and Health. The knowledge helps to maintain sustainable development that safeguards both the work force and the immediate environment (Seifedin, 2014). In the construction industry, the risk of a fatality is five times more likely than in a manufacturing based industry (Davis V, 2009).In light of its importance in the economy, the construction industry is recognized to be the most hazardous industry (Rowlinson and Stephen, 2003).

Ethiopia has ratified about more than 20 ILO (International Labor Organization) conventions, including core conventions such as: OSH Convention, No. 155. The country had a regulation on OSH since the 1940's. It is unfortunate to note that although Ethiopia has HS regulations to date there is poor implementation of HS regulations in the construction sites (Seifedin, 2014). This manifest itself on construction sites as numerous accidents / injuries and even death to occur.

The above situation suggested the need for the present study, which was aimed to identify the factors that affect implementation of CHS regulations, their effects and mitigation measures in building construction sites of Hawassa City. Outcomes from this study provided a set of factors that can be used to guide CHS regulations implementation as well as it contributes to the body of knowledge in the subject of HS in the building industry sector.

2. Problem Statement

Recently, the Ethiopian Construction Industry has experienced considerable growth in construction activities and envisioning reducing poverty since the country is developing cities across the nation. This will increase employment opportunities for wide range of laborers both skilled and unskilled. Even in 2009 E.C job opportunity has been created for more than 1.2 million peoples in the construction sector of the country but the HS management and practice do not grow equally with the construction speed. The number of workers died in the construction sites of Addis Ababa for example has increased by 3 times in 2009 E.C than that of 2005 E.C (MoLSA, 2018). Similarly, urbanization in Hawassa City is growing fast by constructing many civil engineering infrastructures, thousands of daily laborers will be employed in the construction sites. These labor-intensive construction methods will result in high accidents and fatalities rates. As a result, a dozen of daily laborers get different serious injuries. Many, in fact, lose their life (Tariku, 2016).

Unfortunately, many companies do not follow regulations as construction workers are more likely to be killed by construction accident than any other type of employment (Davis, 2009). Legislations exist in Ethiopia but only on paper leaving the safety and wellbeing of construction workers at the mercy of employers. The need for up-to-date regulations and identifying factors on HS is of critical importance for the purposes of identifying areas of required action and for setting priorities for policy initiatives on improving HS. The available research on HS regulations remains incomplete and few literature relating directly

to the HS

regulations on construction sites in Ethiopia. Similarly, prior studies conducted in the area of HS in construction industry in Hawassa are very few. Therefore, this study is aimed at studying the factors that affect implementation of HS regulations, their effects on workers job performance and mitigation measures in building project sites of the Hawassa City.

3. Research Objectives

The aim of the study is to assess the factors affecting implementation of CHS regulations, their effects & mitigation measures in the building construction project sites of Hawassa City.

In order to achieve the general objective, the following specific objectives are set:

1. To assess the existing construction health and safety regulations of Ethiopia.

2. To identify factors that affect implementation of construction health and safety regulations in building construction project sites in Hawassa City.

3. To identify effects of implementation of construction health and safety regulations on the workers job performance in building construction project sites in Hawassa City.

4. To propose mitigation measures to avoid or reduce health and safety impacts on the workers job performance in building construction project sites in Hawassa City.

4. Methodology

The research started with gathering information through literature review in which factors, effects and mitigation measures in implementation of CHS regulations in general were identified and FDRE Constitution, FDRE National OSH policy and strategy, C155 occupational HS convention, Civil code of Ethiopia, Labor Proclamation, Building Proclamation, Public Health Proclamation and directives are reviewed to assess the existing Ethiopian CHS regulations.

From the literature reviewed, relevant information that could aid the study objectives were reviewed. Closed questions required the respondents to rate (using Likert Scale) their opinions on issues relating to implementation of CHS regulations in their projects. There are different factors classified in different groups and those which have similarity have been merged. Only 12 groups and 71 factors are considered; Administrative and management commitment, role of government and engineering societies, project nature, historic, human and psychological factors, organizational structure, HS inspections, HS meetings, records and reports, incentives, HS education and training, economic investment, medical and welfare facilities and technical group factors. Positive effects and consequences which result from non- implementation of CHS regulations were reviewed from various literatures and the mitigation measures in the literature review were used to design the questionnaire.

The sample size was limited to eighteen building project sites in Hawassa City. In order to supplement one by the other the methodolo-

gy combined both quantitative and qualitative types of data. A total of eighty-seven questionnaires were distributed to the respondents. Out of these seventy-six valid questionnaires were received: thirty-seven from contractors, twenty-seven from consultants and twelve from clients. Nine interviews were carried out in order to get construction managers and Engineers viewpoints. The data collected using closed-ended questions of the questionnaire were analyzed using descriptive statistics. Analysis was made by determining the mean score, percentages and Chi- square test (equation 1) using the Statistical package for social sciences (SPSS) software and top results on CHS factors, effects and mitigation measures were presented through tables.

5. Construction Health and Safety Regulations in Ethiopia

Article 89 of the FDRE constitution says that the "government shall endeavor to protect and promote the health, welfare and living standards of the working population of the country". The FDRE national occupational safety and Health policy is drafted also to address and guide implementation of preventive measures to create safe and healthy working environment in Ethiopia. The policy required employers to provide safe workplaces, safe equipment, free of charge personal protective equipment to workers, emergency medical services, develop health and safety policy and record accidents. As per the policy, workers are obliged to cooperate with employers and relevant government organizations in order to establish occupational safety and health services.

According to Article 2548(1) Civil Code of Ethiopia "The employer shall take measures as are required by the special circumstances of the work to safeguard the life, physical integrity, health and moral standing of the employee. He shall in particular arrange the premises and keep up the equipment in his undertaking with this object in view, in accordance with the general practice and technical requirements." Art. 2549 also describes about "Accidents arising from work" and states "The employer shall be liable for accidents which the employee suffers arising from his work." There is legal provision stipulated in the Civil Code Proclamation No. 165/1960 which states that the employer shall be liable for diseases which the employee contracts arising from his work and the employee may at any time claim that he has contracted a disease arising from his work.

The Labor Proclamation (No. 377/2003) provides guidance through general provisions stating preventive measures, Occupational Injuries (Articles 95-112) obligations of employers (Article 92), obligation of workers (Article 93) and prohibitions. Article 92(5), Article 105 and 106 of the proclamation states that employers shall care for the medical examination and hospital and pharmaceutical services.

Article 11 of FDRE public health proclamation No. 200/2000 states that employers shall ensure the availability of OSH services to his employees and the use of any machinery or instrument which generates excessive noise is prohibited. Article 12 of the proclamation states that "Any person shall collect waste in especially designated place and in a manner which does not affect the health of the society.

The responsibilities of the building officers and designers regarding HS are stipulated in the building proclamation No.624/2009. Article 30 and 31 entails that any building shall be designed and constructed in such a way that it shall not impair the HS of people moving around, other constructions and properties. In any excavation work related to building, the owner of the site shall take adequate precautionary measures to ensure that the HS and stability of any property and service is maintained. In addition the proclamation contains firefighting and fire protection provisions (Article 44) and punishment provisions (Article 53).

Ethiopian Building Code standard (EBCS 14:2014) on occupational health and safety provides standards on preventive and protective measures during working at height, excavation work, formwork, concrete work, demolishing works and using ladders and scaffolding. According to the code a contractor should prepare safety plan, site layout plan, provide safety signs, PPE and emergency route and exits.

The FDRE OSH directive, issued by the Ministry of Labor and Social Affairs (MOLSA), establishes the duties of employers, rights and duties of workers, responsibilities of the labor inspectorate, and mandatory conditions on overcrowding, sanitation, fire safety, and preparedness. It provides guidance on mandatory employer responsibilities and details provisions for ambient working conditions and hazards. In addition the minister adopted a directive on the prohibition of activities for young workers, woman & pregnant workers.

The desire by employers to reduce and control HS effects relies for its effectiveness on the knowledge of HS regulations and a willingness to take action to reduce it. This alone is insufficient, unless it is covered by legal sanctions in the event of negligence leading to injury or illness. A number of legislations reviewed above are helpful to govern site operations and in minimizing hazards. It is clear that there are some similarities between these legislations.

6. Results and Discussion

The factors identified in the literature review were distributed to respondents to measure for their degree of impact on implementation of CHS regulations in building construction sites of Hawassa City. These factors are coded and entered into SPSS and the descriptive statics of the top factors are presented in Table 1. The results obtained from respondents on the effects of implementation and non-implementation of CHS regulations and on the suggested mitigation measures are stipulated in Table 2, Table 3 and Table 4 respectively. Based on data from interview, all respondents agreed that identifying the critical factors that affect implementation of health and safety regulations is crucial. According to the interviewees it can be said that the majority of the contractors, consultants and clients are reluctant to implement construction health and safety regulations at construction sites and identifying these factors can help to improve the situation.

According to respondents; it was obtained that the availability and development of a clear HS policy & conduction of review was the most important factor as it has the first rank among all factors with mean equals to 4.54 for contractors, 4.52 for consultants and 4.83 for clients. This factor is more important for contractors and clients. This agreement between all target groups shows that workers in the building construction sites are not aware of

the HS policy. Having HS policy will help to create awareness on the HS aims and objectives of the company. FDRE OSH directive declares that 'the employer shall set out in writing their respective workplace HS policy and arrangements'.

Table 1: Top factors that affect implementation of CHS regulations

Factors that affect implementation of health and safety regulations in building construction sites of Hawassa city	Contractor		Consultant		Client		Total	χ^2 test
	Mean	Rank	Mean	Rank	Mean	Rank		
HS awareness of company's top management and support	3.95	12	4.70	1	4.25	9	7	.000***
Availability and development of a clear HS policy & conduction of review	4.54	1	4.52	2	4.83	1	1	.000***
Provision of HS working environment	4.27	3	4.44	4	4.17	11	4	.000***
Issuing & implementation of in-house HS rules	4.00	10	4.37	7	4.42	6	8	.020**
Employment of trained HS officers	4.24	4	4.15	11	4.75	2	5	.000***
Employment of skilled labor	3.95	11	4.15	10	4.08	12	9	.000***
Development of HS committee	4.22	5	4.26	9	4.50	5	6	.000***
Issuing of construction HS regulations	4.16	6	3.96	14	3.67	27	10	.131
HS inspection by top management	4.38	2	4.30	8	4.33	8	2	.000***
Conducting HS training and orientation	4.08	7	4.52	3	4.67	3	3	.000***

*P<0.1 ** P<0.05 *** P<0.01

Table 2: Mean, χ^2 test and rank of effects of implementation of CHS regulations

The positive effects of the implementation of construction health and safety regulations on workers job performance	Contractor		Consultant		Client		Total	χ^2test
	Mean	Rank	Mean	Rank	Mean	Rank		
Improved workers morale & relations	3.89	5	3.85	6	4.08	4	5	0.000***
Workers stress reduction	3.81	6	4.04	4	3.75	6	6	0.000***
Improved workers health and safety	3.46	7	3.67	7	3.17	9	8	0.000***
Increased job satisfaction of workers	4.46	3	4.33	3	4.17	3	3	0.000***
Reduced absenteeism of workers	4.38	4	4.00	5	3.33	8	4	0.000***
Increased productivity of workers	4.49	2	4.44	1	4.42	1	1	0.221
Lower employee turnover	3.43	8	3.59	8	3.92	5	7	0.000***
Avoiding the cost of accidents	4.59	1	4.37	2	4.33	2	2	0.000***
Reduced medical expenses	3.16	9	3.30	9	3.42	7	9	0.000***

*P<0.1 ** P<0.05 *** P<0.01

Table 3: Mean, χ^2 test and rank of effects of non- implementation of CHS regulations

The effects of non-implementation of CHS regulations on workers job performance	Contractor		Consultant		Client		Total rank	χ^2test
	Mean	Rank	Mean	Rank	Mean	Rank		
Less worker commitment	3.92	6	3.96	6	4.08	4	6	0.191
Workers dissatisfaction	4.22	4	4.11	5	3.92	5	4	0.000***
Increased workers absenteeism	3.89	7	3.89	7	3.58	7	7	0.000***
Increased workers turnover	3.24	9	3.22	10	2.92	11	10	0.003***
Less workers' productivity	4.62	1	4.56	1	4.50	1	1	0.008***
Aggression amongst workers	3.27	8	3.26	9	3.17	9	9	0.027**
Poor employee health, physical injuries and disabilities	4.16	5	4.15	4	3.83	6	5	0.000***
Workers stress	3.19	11	3.52	8	3.08	10	8	0.014**
Poor quality work outputs	3.22	10	3.04	11	3.33	8	11	0.002***
Higher rate of accidents	4.51	2	4.41	2	4.00	3	2	0.000***
Increased accident costs and litigation	4.32	3	4.30	3	4.17	2	3	0.001***

*P<0.1 ** P<0.05 *** P<0.01

Similar regulations are stated in Labor Proclamation, FDRE national OSH policy and strategy and ratified conventions. This result is in line with Seifedin (2014) and Tariku (2016) that almost none of the respondents in Addis Ababa and Hawassa agree to the statements that their company has a written HS policy.

HS inspection by top management has been

Table 4: Mean, chi square test (χ^2 test) and rank of mitigation measures to avoid or reduce impacts on workers job performance

Mitigation measures to avoid or reduce impacts on workers job performance that result from non-implementation of CHS regulations	Contractor		Consultant		Client		Total Rank	χ^2test
	Mean	Rank	Mean	Rank	Mean	Rank		
Development of a clear HS policy	4.30	1	4.48	1	4.42	1	1	0.008***
Management commitment towards implementation of HS regulations	4.24	2	4.26	2	4.33	2	2	0.091
Communicating HS regulations	3.51	9	3.59	9	3.33	9	9	0.000***
HS education and training	4.16	3	4.19	3	4.08	5	3	0.006***
Development of HS committee	3.92	5	4.00	5	3.92	6	5	0.000***
Conducting regular HS inspections	4.05	4	4.15	4	4.17	4	4	0.841
Provision of emergency preparedness program	3.81	8	3.81	7	3.75	7	7	0.000***
Provision of job hazard analysis	3.86	6	3.93	6	4.25	3	6	0.108
Accident reporting & investigation	3.08	10	3.07	10	3.17	10	10	0.000***
Conducting HS meetings	3.84	7	3.70	8	3.58	8	8	0.033**

*P<0.1 ** P<0.05 *** P<0.01

with mean equals to 4.38. It has been ranked by consultant's and client's respondents in eighth position with mean 4.30 and 4.33 respectively. Top managers should be accountable for HS inspections within their company. The interviews conducted also reveal the fact that top managers didn't give emphasis for the implementation of HS inspections in their building construction project sites. The results in this study agreed with the results of Fang et .al (2004), in China, which reported that the safety on sites can be improved effectively by providing that HS inspection as a continuous improvement tool to benchmark HS at site. This result is in line with Seifedin (2014) in which 82% respondents disagree and 8% respondents agree for the availability of regular site inspection in the company. Conducting HS training and orientation has been ranked in the third position. In Hawassa city, both consultants and clients highly agree on the necessity of HS training for the implementation of CHS regulations. In the other side contractors less agree on the influence of this factor. This is because contractors are not willing to give HS training because of the myths cost of safety is high. FDRE health and safety directive and Article 92(2) of the FDRE Labor Proclamation require the employer to appoint a part time or full-time safety officer.

ranked by contractors in the second position

Competent persons are required to assist the employer in meeting his obligations under health and safety regulations.

Influence of most top factors on implementation of CHS regulations responded by contractor's, consultant's and client's respondents (Table 1) shows that, there is a very strong positive association at 0.000 and the result was statistically significant at $p< 0.01$. Based on the results obtained from SPSS, the top three group factors were administrative and management commitment, HS education and training and economic investment.

Implementation of HS regulations should not be seen as a regulatory burden as it offers significant opportunities and benefits to the construction companies. Table 2 illustrates that contractor's (59.5%), consultant's (55.6%) and client's respondents (58.3%) rate increased productivity of workers as a most important positive effect. Okereke (2007) revealed that the benefit of implementing the HS program can increase the productivity in construction site. Rate of accidents and accident cost can be avoided by implementing CHS regulations and it is because of that contractor's respondents (81.1%), consultant's respondents (59.3%) and client's respondents (58.3%) rate avoiding the cost of accidents and litigation as a most important positive effect. Table 2 and Table 3 that show that effects on implementation and non-implementation CHS coincide each other and the results are reversible for both.

In the chi-square test (Table 2), the values appear similarly and the response percentages are also close to each other for most of them. Higher percentage of positive response on the effect of implementation of CHS regulations on workers job performance shows that the contractor's, consultant's and client's respondents are aware of the importance of implementation of CHS regulations. Increased productivity of workers is not significant to the test. Effects other than increased productivity of workers are significant at $p<0.01$. The respondents answer on less workers' productivity, aggression amongst workers, groups and employee burnout, physical and emotional stress on workers and have significant relation at $p< 0.05$. The respondents answer on Workers dissatisfaction, increased workers absenteeism, increased workers turnover, poor employee health, increased accident costs and litigation, physical injuries and disabilities less worker commitment and higher rate of accidents have significant relation at $p< 0.01$ (Table 3).

Development of a clear HS policy, management commitment towards implementation of HS regulations, HS education and training, Conducting regular HS inspections and Development of HS committee are rated as a most important mitigation measures (Table 4). The chi- square test in Table 4 shows that the responses on conducting HS meetings are significant at $p<0.05$. The responses on communicating health and safety regulations, development of a clear health and safety policy, health and safety education and training, development of health and safety committee provision of emergency preparedness program and accident/incident reporting & investigation program are significant at $p<0.01$.

7. Conclusions

This research through the review of regulations assessed the existing Ethiopian CHS regulations. The research identified factors affecting implementation of CHS regulations, their effects on workers job performance & suggests mitigation measures to avoid or reduce CHS impacts on the workers job performance in building project sites of the Hawassa City. A list of 71 factors were identified from various literatures that set the basis for a questionnaire survey and interview. These factors were grouped into 12 parent factors. Descriptive statistics for each factor was calculated and used to rank the factors. The χ^2 test was used to assess the agreement among rankings and it was found to be significant for most of the factors, effects and mitigation measures.

The study shows that the administrative and management commitment group factor is the most important group factor. The most prominent factor in the administrative and management commitment group were shown to be availability and development of a clear HS policy & conduction of review. Results of the HS training and education factor indicated that a strong relation exists between 'conducting HS training and orientation' and implementation of CHS regulations. Role of government in issuing CHS regulations, role of insurance companies, and system of inspection and HS meetings, records and reports will help to secure compliance with onsite construction HS regulations. On the other hand, one of the vital conclusions from the study is that implementation of construction HS regulations appears to be significantly influenced by the organizational structure.

The findings show that respondents were quite aware of the effects of implementation and non-implementation of CHS regulations as it is revealed that there was a greater agreementon increase productivity of workers, avoiding the cost of accidents and litigation, increased job satisfaction of workers, reduced absenteeism of workers, improved workers morale and relations, workers stress reduction, lower employee turnover, improved workers HS and reduced medical expenses upon implementation of HS regulations. The most rated mitigation measures by the respondents were; development of a clear HS policy, management commitment towards implementation of HS regulations, HS education and training and conducting regular HS inspections.

8. Recommendations

In order to improve the implementation of CHS regulations in building construction sites of Hawassa City, the concerted effort and commitment of owners, management and employees of construction companies, consultants as well as government is necessary.

- Contractors shall concentrate to employ competent safety officer/engineer.

- The regulations on safety are too scattered in lots of documents hence government and all regulatory bodies should come out with a well compiled and concise document.

- Ministry of Construction should make the cue for its members to embrace HS matters by providing the relevant training and induction programs.

- Contract documentation and strict procurement procedures (present safety certificate as a pre-requisite to awarding contracts) if made mandatory for every building construction project, will make project-clients more proactive to issues of health and safety.

- Finally, all parties in construction project must contribute their rightful parts towards implementation of CHS regulations.

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PRE-FABRICATED CONCRETE CONSTRUCTION AS AN ALTERNATIVE FOR THE ETHIOPIAN HOUSING CHALLENGES

(A forgotten companion)

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ABSTRACT

Traditional on-site construction, as a common method, has been criticized because of its inherent drawbacks; such as, long construction time, low productivity, weather sensitivity, wastage of resource, environmental pollution, poor safety, etc. To mitigate the mentioned challenges, prefab concrete has been introduced as an alternative system to promote sustainability in the performance of the construction industry. Prefab system seems to be the focus area that the construction industry should attempt to take in Ethiopia. The significance of this research is to emphasize that the prefabricated concrete technology which is currently at its infant stage in our country is a best alternative considering the two governing parameters of time and cost.

The main objective of the research is to examine the impact of prefabricated concrete technology on cost and time in building projects. The study focused on comparing the in-situ construction system with that of prefabricated concrete technology. To address the stated objective the methodology employed was desk study, interview, site observation and case study. To understand which system is worth considering, discounted payback period was used to arrive at the final decision. To that effect, the findings indicated that the prefab construction system happened to be costly by a margin of 14.2%-25.4% than that of the cast in-situ practice. However, since the construction time of the cast in-situ system is more than 422%-605% the saving in time using prefab concrete system which undoubtedly disproved the cast in-situ less initial cost manifestation through a quick turnover period to recover the money spent. There is a significant gap on the payback period between the two construction systems. Thus, by converting this in to monetary value, the study revealed that the prefab concrete building recovers the investment cost in a very early period than that of the cast in-situ. The solid reason behind is that, "Time is Money."

Key words: In-situ construction, Prefab system, Time, Cost saving, Payback period

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1. INTRODUCTION

Prefab is defined as a concept that uses standardized structural components produced away from the construction site and the components are transported to the site for assembly (Harrop, L., 2004). Worldwide, the construction industry is changing rapidly with the introduction of new system of construction and adaptive technologies (Blismas, N., 2006). The production of prefabricated building components was started in our country in the 1980's (Bayou, K., 2017). However, our local practice is very far away from the contemporary industry realities on the ground. Lack of a practical insight to make a choice between precast and conventional methods might be one of the factors. The construction industry in our country heavily relies on cast in-situ system involving extensive use of on-site mixed concrete which is a cause for wastage and on-site construction activates are described as "labor intensive, dangerous and polluting" (Seyoum, A., 2015) . Prefab concrete construction method until now has not grown to the expected level. The main objective of the study is to investigate the impact of prefab concrete construction on cost and time. The main focus area is on cost effectiveness of prefabricated products by converting the time saved using prefabricated concrete into reaches in revenue coupled with its intrinsic value of assured quality by the concept of "time is money".

2. STATEMENT OF THE PROBLEM

Generally, the Ethiopian construction industry exercises very traditional practices and is resistant to change. Since prefab construction is perceived as a costly method by a large segment of the society there is a profound need to conduct industrial researches. To address the existing knowledge gap, efforts are needed to raise the level of awareness within the construction industry and the user at large. Moreover, there is an assumption that, prefab construction is typically less economical than in-situ construction, without considering the indirect cost, saved by construction speed, quality, and unaccounted for overhead costs. In Ethiopia, the actual average on site wastage of concrete which comes from different activities is approximately 13% (Seyoum, A., 2015) and (Yibeltal, A., Admassu, K., 2017). There are other costs incurred in cast in-situ method which are not recurrent in prefab. According to (Koshe, W., 2016), in Ethiopia, only 8.25% projects are completed on the targeted completion time. The rest 91.75% of projects face delay ranging from 25%-352% of contract time. But the data collected from PBPPE shows that there is an average of 5.6% deviation from actual time. Therefore, this research aims at revealing how much this technology can impact cost and time in the Ethiopian construction industry.

3. RESEARCH OBJECTIVE

The general objective of this research is to investigate the impact of prefabricated concrete building system on cost and time of construction and to compare direct and indirect costs of prefabricated construction system with that of the in-situ construction system.

4. RESEARCH METHODOLOGY

The research is aimed at investigating the impact of prefabricated concrete construction system with that of the cast in-situ practice. The methods used for the research are: desk study, interview, site observation and

case studies to compare the two systems. Site observation was held to record the labor and machinery productivity and the interview was on how to conduct the work schedule and method, rental rate, detail cost of materials and labor. All of those results are used directly or indirectly for the case studies. The details of the building parts which are used in prefab construction were collected from Prefabricated Building Part Production Enterprise (PBPPE). Getting these details helped to estimate the quantities required and the cost of the prefab construction work. The research pursued quantitative result analysis using descriptive statistics. To perform the quantitative analysis, two case studies were analyzed which were built with prefabricated concrete elements for their structural parts. In order to address the objectives, all cost components that result from the in-situ construction system of the sampled construction companies and all cost components from PBPPE's latest projects are considered as a base. A representative cost value is arrived at by calculating the mean of the last completed building projects of each in-situ construction company. In addition, the detailed work schedule and construction time that could take to finish the relevant activities is analyzed to compare the time impact. The payback period is calculated by counting the number of years it will take to recover the cash invested on a project. Payback period in capital budgeting refers to the period of time required to recoup the funds expended in an investment, or to reach the break-even point (Cudney G., 2018).

5. RESULTS AND DISCUSSIONS

CASE STUDY ONE: Comparative Study of Precast and Cast In-situ Buildings

It's B+G+8 ICT incubation center laid on 1117m^2 located along the road from Yarer to Gorro. The contract price is 26,745,618 Birr for the structure. The quantity of prefab item elements produced per day and duration for erection are listed in the table below.

Table 1: Total duration for the production and erection of prefab concrete system

No	Item	Qty (Pcs.)	Elements produced/ day	Total production time (Days)	Daily output for erection (Pcs/ day)	Duration for erection (Days)
1	Footing (f1) 250x250x-135cm	8	2	4.0	8	1.0
2	Footing (f2) 200x200x80cm	38	2	19.0	8	4.75
3	Footing (f3) 160x160x80cm	2	4	2.0	8	0.25
4	Footing (f4) 120x120x80cm	3	4	1.30	8	0.37
5	Initial column. C-30-1W,	75	6	12.5	16	4.70
6	1-storey column,C30 ,3m	589	10	59.0	16	37.0
7	Slab 420x420cm	401	9	45.5	12	33.4
8	Slab 420x120 (Cantilever)	205	4	51.0	12	17.0
9	Edge Girder17x22x420 cm	63	6	10.6	16	4.0
10	Staircase flight 290x125cm	18	1	18.0	8	2.25
11	Staircase flight 175x125cm	9	2	4.50	8	1.10
12	Staircase landing 165x135	18	1	18.0	8	2.25
13	Shear wall 386x338x25cm	84	3	28.0	6	14.0
	TOTAL	1513		232.0		
				116		**122**

Note: The rates indicated in Table1are taken directly from the bid documents which include the costs of production, transportation erection and overhead expenses. The production was started in parallel with site mobilization so that 50% of the production time is not in the critical activity.

To summarize, a building having 1117 m^2 of built up area, required a total construction cost including overhead of Birr 26,745,618. If this is divided by the built up area for a general estimate, the construction unit cost amounts to Birr 23,944.1 /m^2. Working days required for production are 116 and for erection 122. Considering the deviations from the contract time due to logistics, crane maintenance and material shortage of 5.6 % the overall time needed is pushed to a total of 252 days to complete the mentioned building.

i. In-situ contractor's cost data: For the structural parts including foundation it consumes a total of 2168m^3 of concrete. From the collected data the mean price of cast in-situ contractor's cost for 1m^3 of concrete is 4028 Birr/m^3 .The average overhead and profit margin for the companies are 13% and 10.3%; respectively.

Table 2: Major work items and costs for a B+G+8 building with the cast in-situ system

Major Work item	**Unit**	**Qnty**	**Unit cost (Birr)**	**Total cost of concrete (Birr)**
As dried base concrete	M^3	2,168.0	4028	8,732,704
Reinforcement steel bar	Kg	164,307	31.4	5,159,234
Rebar Cut and fix in position	Kg	164,307	5.50	903,688.5
Formwork	m^2	11,890	40.24	478,454.0
Scaffolding which supports slab soffit, stair, landing	m^2	11,170	19.65	219,490.0
Labor cost for Form work shuttering ad striking	m^2	11,890	55.00	653,950.0
Cost of chiseling	m^2	10,788	18.00	194,184.0
Plastering material cost	m^2	12,400	64.00	793,600.0
Cost of plasterer (3 coat)	m^2	10,788	40.00	431,520.0
Cost of equipment and tools take 10% labor & material costs				79,3600.0
Total cost				**17,646,184.5**
Add 13% overhead cost				**19,940,188.5**

The building rests on 1117m^2 and the construction cost using cast in-situ concrete is 19,940,188.5 Birr and for precast concrete 26,745,618 Birr. This has an inflated cost of 6092.7 Birr/m^2 of work resulting in a 25.4 % increment.

ii. Analysis of required time for construction

A detailed analysis was conducted to record the average productivity of labor and crews to deliver each activity, waiting time until structures get full strength and all costs related to cast in-situ system and are discussed independently. Table 3 illustrates all major activities, total quantity for the works and the daily outputs.

Table 3: Estimating the average construction time for the same building using cast in-situ system

	Major activities	Unit	Average daily output	Total quantity	Required duration (day)
1	2 steel fixer and 2 assistant and 4 daily labors can fix 0.5 tons of steel / day	Tone	0.5	164.30	328.6 (10 days lag)
2	One carpenter and one assistant can fix and strike 25 m2 form work per day	m^2	25	11,890	475.6
3	A 9 man concrete gang can place 16 m3 of concrete / day	m^3	16	2168.0	135.5
4	Waiting period to precede next floor. Until it get its strength	Day	21	9 suspended floors	189.0
5	2 man crew can chisel an average of 120 m2/day	m^2	120	10788	90 (10 days lag)
6	A 4 man plastering crew can plaster 27 m2 for three coats	m^2	27	10,788	399.5
	TOTAL				1220
	Deviation from contract time 25%				1525
					4.8 years

Note: - As discussed earlier, in Ethiopia, 91.75% projects face delays ranging from 25%-352% of contract time (Koshe, W., 2016). For this analysis, the favorable list worst scenario of 25% delay is considered from the actual contractual time. So that in 26 working days per month; the precast building method required 9.7 months: whereas, the cast in-situ method needs 1525 days (4.8 years) which consumed 605 % more time than that of the pre-cast method.

iii. Overall Cost and Time Comparison Between Prefab and In-situ Construction Systems

Based on the discounted payback period method: Payback period in capital budgeting refers to the period of time required to recoup the funds expended in an investment, or to reach the break-even point. DPP considers the time value of money by discounting the cash inflows of the project for each period at a suitable discount rate. The average discount rate in Ethiopia for the last ten years was 11%. The formula to calculate payback period of a project depends on whether the cash flow per period from the project is even or uneven (Irfanullah, 2019). In cases where cash inflows are uneven, it needs to calculate the cumulative net cash flow for each period by using the following formula:

Discounted Payback Period

Discounted Payback Period = (A+B)/C ....Eqn 1

Where: A = Last period with a negative discounted cumulative cash flow;

B = Absolute value of discounted cumulative cash flow at the end of the period A; and

C = Discounted cash flow during the period after A.

Summary Case Study One

Since Ethiopia does not have a standardized rental price; a rental rate/m^2 of similar sized building is adopted from within a 2km radius of the new building. Since the rental price varies from building to building and floor to floor the average rate was made use of.

Also for both building methods, the common gross area is considered to be rented all the year round. The total built up area excluding the basement is 1,117 m^2* 9 floors = 10,053 m^2. Per the survey made, the average rental rate around the location of the building area is 110 Birr/m^2.The possible revenue is 110 Birr/m^2*10,053m^2= 1,105,830 Birr/month, which is 13, 269,960 Birr/year. With a 10% increment in rental every 2 years the annual revenue is given in Table 4.

Table 4: Annual revenue if the building is rented

Year	Yearly revenue (Birr)	Cumulative revenue (Birr)
1	13,269,960	13,269,960
2	13,269,960	26,539,920
3	14,596,956	41,136,876
4	14,596,956	55,733,872

A building constructed with prefab concrete incurs additional expense of 6,805,427 Birr relative to the cast in-situ method which is 25.4% more. But with regard to time, cast in-situ method takes 3.9 years more to complete the project. In this case, for simplicity, it is better to analyze the return in saved time by early completion of the project from the rental income. Then, after deducting 6,805,427 Birr from the total net income looks the following.

(2*13,269,960)+(1.9*14,596,956)=54,274,136.4 Birr

54,274,136.4 - 6,805,427 = 47,468,709.4 Birr.

This shows that the project has a return of over 47,274,136.4 Birr revenue as a result of early completion of the construction.

Case Study Two: Comparative Study on a G+2 Building

Due to page limitation, case study two results are presented with the vital summaries only. It is a G+2 pre-casted concrete dormitory building having 835m^2 area located along the road from Ayat square to Macedonia. The priced bill of quantity for the dormitory building using reinforced pre-fab concrete elements is estimated as per a preliminary building plan is 6,878,298.75 Birr; for which a total of 418 different pre-cast elements were used. If the same building is constructed with cast in-situ construction method the total cost of the building for the structural part would be 5,901,012 Birr considering wastage and all the overhead costs. This is less by 14.2% compared to prefab concrete building. But for the prefab building 138 days were enough for erection; whereas, for the cast in-situ it required 583 days; exceeding the prefab method by 445 days.

Comparison of Both Buildings by Using Discounted Payback Method

One of the major disadvantages of simple payback period is that it ignores the time value of money (Irfanullah, 2019).To counter this limitation, discounted payback period was devised, and it accounts for the time value of money by discounting the cash inflows of the project for each period at a suitable discount rate. To calculate the discounted payback period of the investment, multiply the actual cash flows by present value factor and the cumulative sum is considered to find out whether the project has fully recovered the incurred cost or not.

A prefab project having an initial investment of 26,745,618 Birr is required to generate 13,269,960 per year with 10% increment every 2 years. For the cast in-situ building the investment cost is 19,940,188 and generates equivalent revenue when it comes to function. For the latter method, the cash outflow is equally distributed over its period of construction of 4.8years. The research considers only the costs required to deliver the buildings not lifetime costs; like, operation, depreciation and maintenance. The table below shows the cash flow and the time needed to recover the cost incurred.

Table 5: Expected payback period for prefab and cast in-situ buildings using equation 1 (Case 1)

Year	Expected cash flow for Prefab building				Expected cash flow for Cast in-situ building			
	Cash flow CF	PV factor $1/(1+i)^n$ PV	Discounted cash flow CF*PV	Cumulative discounted cash flow	Cash flow CF	PV factor $1/(1+i)^n$ PV	Discounted cash flow CF*PV	Cumulative discounted cash flow
0	-26,745,618	1.00	26,745,618	-26,745,618	-4,154,206	1.00	-4,154,206	-4,154,206
1	13,269,960	0.9009	11,954,907	-14,790,711	-4,154,206	1.00	-4,154,206	-8,308,412
2	13,269,960	0.8264	10,966,295	-3,824,416	-4,154,206	1.00	-4,154,206	-12,462,648
3	14,596,956	0.7513	10,966,693	7,142,277	-4,154,206	1.00	-4,154,206	-16,616,824
4	14,596,956	0.6830	9,969,721	17,111,998	-3,323,364	1.00	-3,323,364	-19,940,188
5	16,056,652	0.6209	9,969,764	27,081,762	13,269,960	0.6209	8,239,318	-11,700,870
6	16,056,652	0.5644	9,062,374	36,144,136	13,269,960	0.5644	7,489,565	-4,211,305
7	17,662,317	0.5131	9,062,535	45,206,671	14,596,956	0.5131	7,489,698	3,278,393
8	17,662,317	0.4665	8,239,471	53,446,142	14,596,956	0.4665	6,809,480	10,087,873

The discounted payback period for both techniques is calculated by using equation 2.

DPP = 2 + = 2.35 Years DPP = 6 + = 6.56 years

The same was done for case study two using the above procedure and the DPP is:

DPP= 2+ = 2.22 Years Discounted Payback Period = 3+ = 3years

In order to understand the comparison made easily, results are shown in the following two graphs.

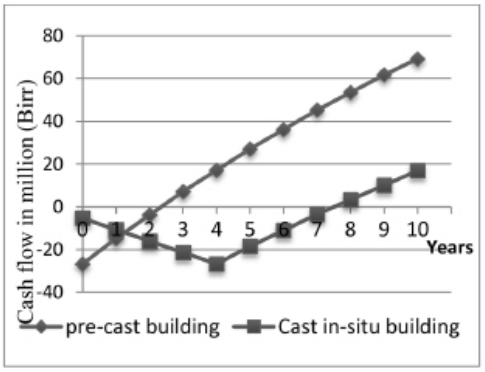
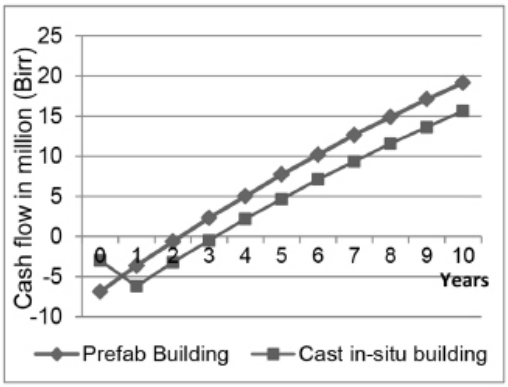


Figure 1: Discounted cash flow for case study



1 Figure 2: Discounted cash flow for case study 2

The graphs show that the cast in-situ construction system stays in a negative cash flow for 6.6 years for case 1 and 3 years for case two. While the prefab concrete construction system recoups the incurred cost in lesser years. The two case studies revealed that the prefab concrete construction recovers the project cost and reach the break-even point in an earlier period than that of the cast in-situ system.

6. CONCLUSION

The very objective of this research was to investigate the impact of prefab concrete construction on cost and time in comparison with the conventional cast in-situ method giving

emphasis on the comparison of time and cost of both systems. The case studies revealed that, on average, the prefab concrete construction system is 14.2%-25.4% expensive than the in-situ concrete construction and the latter takes 422%-605% more time relative to the prefab construction system. It should be taken into consideration that, although the measurement and comparison using the time parameter is direct, the implications of the outcome are more complex. This is because; reducing project delivery time affects all the other governing parameters indirectly. All these are ascribed to shorter construction time needed for prefab construction relative to the cast in-situ system.

By using the payback period method the researchers concluded that, the cast in-situ concrete system takes more time to recover the investment/incurred cost as compared to the prefab concrete system. A selected B+G+8 building, was constructed using the two system in parallel and the prefabricated building took 9.7 months; whereas, the cast in-situ took 4.8 years to complete structural parts alone. By considering the time value of money the prefab building can pay back the investment cost after 2.35 years; whereas, the equivalent cast in-situ building can recover after 6.56 years. A second case study has also demonstrated a similar outcome. Thus, having in mind the time value of money one can clearly understand which one could be the best alternative for a given project.

As discussed in the cost benefit analysis, it is obvious that completing the project in the earlier time possible will help the owner earn a quick positive cash flow. When clients decide on selecting construction work systems it is better to consider quick delivery of the project rather than considering list bidder. The governing factor in cost as clearly demonstrated with the help of the two case studies is that, however high the direct cost of prefab construction is the quicker completion time will bring about an earlier positive cash flow on investment. Hence, it is a better choice and decision.

7. RECOMMENDATIONS

With the research outcome in the background the following recommendations are forwarded.

- Firmly standing with the research findings it is suggested that, new entrants to the construction sector are advised to use prefab concrete construction system for all its inherent advantages.
- A policy framework, awareness creation and sensitization towards understanding the advantages of prefab concrete construction system are highly needed.
- Introducing incentive scheme to encourage stakeholders to invest on a prefab

concrete industry and construction is a step forward.

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