MEKELLE UNIVERSITY

ETHIOPIAN INSTITUTE OF TECHNOLOGY- MEKELLE

FACALTY OF CIVIL AND ENVIROMENTAL ENGINEERING

CONSTRUCTION TECHNOLOGY AND MANAGEMENT

POSTGRADUATE PROGRAM

Investigating the Impact of Vibration Techniques on the Optimum Time and Compressive Strength of C-25 Concrete:
A Case Study of using Table and Poker Vibrators

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A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science in Civil Engineering (Construction Technology and Management)

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The undersigned have examined the thesis entitled **Investigating the Impact of Vibration Techniques on the Optimum Time and Compressive Strength of C-25 Concrete: A Case Study of using Table and Poker Vibrators,** presented by **Temesgen Tesfay,** and have proven it for the degree of Master of Science in Civil Engineering (Construction Technology and Management).

Approved by the Board of Examiners

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DECLARATION

I attest that the thesis research work titled "*Investigating the Impact of Vibration Techniques on the Optimum Time and Compressive Strength of C-25 Concrete: A Case Study of using Table and Poker Vibrators*" is my original research work and has not been presented for a degree in any other university. The material sources used in this thesis research work are duly acknowledged.

Temesgen Tesfay		January 8/ 2026
Student	**Signature**	**Date**

As research advisor, I hereby certify that I have read and evaluated this thesis research paper prepared under my guidance, by Dr. Zenagebriel G/medhn entitled "*Investigating the Impact of Vibration Techniques on the Optimum Time and Compressive Strength of C-25 Concrete: A Case Study of using Table and Poker Vibrators*" and recommend and would be accepted as a fulfilling requirement for the Master of Science in Civil Engineering (Construction Technology and Management).

Zenagebriel Gebremedhn (PhD)		January 8/ 2026
Advisor	**Signature**	**Date**

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Temegen Tesfay

ABSTRACT

The effects of vibration techniques on the ideal time and compressive strength of C-25 grade concrete are compared in this study. The study assesses two popular compaction techniques, poker vibration and table vibration, over a range of vibration durations and curing times. For concrete to be as strong, durable, and uniform as possible, proper compaction is essential, and the length and mode of vibration have a big impact on these results.

Table vibrators were used to prepare concrete specimens and subject them to controlled vibration at intervals of 5, 15, 30, 45, 60, and 75 seconds, depending on the concrete according to Indian standards. According to ACI309R-96, the ideal vibration time is 90 seconds for plastic concrete and up to 270 seconds for stiff concrete. Poker vibrators can be used at 1, 2, 3, 4, 5, and 6 seconds. The ideal vibration time is five seconds for plastic concrete and ten to fifteen seconds for stiff concrete. Compressive strength was measured at 3, 7, and 28 days for each vibration setting in order to evaluate early and long-term strength development. The goal of the study was to determine the best vibration times to improve compaction without causing bleeding or segregation, both of which have a detrimental effect on strength.

The results of the experiment show that compressive strength is directly impacted by vibration time, with each vibration technique having an ideal time range. The ideal strength for table vibrators was found to be between 30 and 45 seconds, while durations (>60 seconds) led to a decrease in strength because of segregation. Effective compaction and peak strength for poker vibrators were reached in 3 to 4 seconds, after which only slight improvements were noted.

According to the study's findings, table vibrators need longer times but might be more appropriate for particular structural components, whereas poker vibrators are more effective for quick and efficient internal compaction. The findings highlight how crucial it is to choose the right vibration techniques and times in order to optimize concrete performance. The results provide practical guidance for engineers and contractors aiming to improve quality control and structural Integrity in concrete construction projects.

Keywords: concrete, compressive strength, concrete compaction, optimum time, poker and table vibrator, vibration techniques.

ABBREVIATIONS / ACRONYMS

AASHTO M6	American Association of State Highway and Transportation Officials - Standard Specification for Fine Aggregate for Hydraulic Cement Concrete
ACI 211.1	American Concrete Institute - Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
ASTM C29	American Society for Testing and Materials - Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C33	American Society for Testing and Materials - Standard Specification for Concrete Aggregates
ASTM C70	American Society for Testing and Materials - Standard Test Method for Surface Moisture in Fine Aggregate
ASTM C127	American Society for Testing and Materials - Standard Test Method for Relative Density (Specific Gravity) and Absorption of Coarse Aggregate
ASTM C128	American Society for Testing and Materials - Standard Test Method for Relative Density (Specific Gravity) and Absorption of Fine Aggregate
ASTM C136	American Society for Testing and Materials - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C151	American Society for Testing and Materials - Standard Test Method for Autoclave Expansion of Hydraulic Cement
ASTM C184	American Society for Testing and Materials - Standard Specification for White Portland Cement
ASTM C187	American Society for Testing and Materials - Standard Test Method for Amount of Water Required for Normal Consistency of Hydraulic Cement Paste
ASTM C191	American Society for Testing and Materials - Standard Test Methods for Time of

	Setting of Hydraulic Cement by Vicat Needle
BS EN 12620	British Standards and European Norms - Aggregates for Concrete
EBCS - 10	Ethiopian Building Code Standards - Construction Materials
IS 383	Bureau of Indian Standards - Specification for Coarse and Fine Aggregates for Concrete
NRMCA	National Ready Mixed Concrete Association
SFRC	Steel Fiber Reinforced Concrete

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CHAPTER 1

1. INTRODUCTION

1.1 Research Problem Background

Concrete is a composite material commonly used in construction, defined as composed of aggregate (coarse and fine), water, cement, and sometimes chemical and/or additives. Concrete, which is used in prefabricated or cast-in-place reinforced concrete construction, should have some properties such as strength and durability. This is why materials used for producing concrete should be chosen suitable for the purpose should be suitable [1].

Concrete material is the most common building material used in today's construction industry. It is a long-life and relatively compacting can make concrete denser and stiffer, and thus have an excellent compressive strength and low permeability [2]. Without proper compacting, high-quality concrete cannot be achieved. Many years ago, consolidation was accomplished by laborers wielding a variety of spades, tampers, and similar tools. Now, nearly all concrete is consolidated with high-frequency vibrators. The purpose of compacting is to remove the air entrapped during concrete placement and to strengthen the Concrete into all the spaces including in the corners and the gaps in the reinforcing steels [2]. If the concrete is not properly compacted, the air will remain inside the pores. When it hardens, the concrete then appears with honeycomb spots or rashes.

Concrete in structures is often subjected to compaction conditions poorer than those of standard concrete specimens manufactured and quality control purposes. This may occur due to several factors, for example: The larger dimensions and often lower rigidity of the forms compared to standard, Molds, which may reduce the effectiveness of vibration; the narrow on-site spaces to be filled ,Which may filter concrete constituents, leaving voids and creating barriers that make it difficult for trapped air to escape during vibration; Differences in concrete properties resulting, for example, from variations, and mix proportions and concrete temperature during production and placement, Well as from delays in the transportation of concrete to the worksite.

Knowledge of the magnitude of the effects of on-site compaction on concrete quality is crucial not just to promote an adequate mix design and execution of concrete structures, but also to make fair decisions in cases of dispute over the quality of the supplied concrete. In practice, concrete specification has been traditionally based on prescriptive methods, in which limits are established for the composition and the compressive strength of concrete, and where quality control is essentially based on controlling its compressive strength during execution[3].

In principle, a similar approach can be used for assessing the potential durability-related properties of concrete, using correction factors for compaction applicable to such properties. This correction factor is used in the laboratory and site levels by using the table vibrator and the poker vibrator, respectively. Based on the observation at the construction material laboratory during checking the compressive strength of a cube having the same mix design, we can gauge the difference in strength. So, to solve this problem, we should optimal time of vibration in the laboratory to the site level.

1.2 Research Problem Statement

As described in the background of the problem, compaction or consolidation of concrete is one of the major properties of concrete; therefore, the vibration properties have a great impact on concrete properties. And also can a major factor in the compressive strength of concrete. Besides, based on the observation done in the construction laboratory can be vibrated using a table vibrator, which gives a fully dense concrete, and the compressive strength result is good when too comes to the site level, having a big difference in compressive strength b/c of fluctuation vibration and the cube is used for test is using tamping rod. Generally, the advantage of studying this title will be to solve the problem of poor vibration by analyzing of correction factor time from the standard of vibration to optimum time the laboratory and site level. To get good compressive strength concrete.

1.3 Research Objectives

1.3.1 General Objective

The general objective of this study is to investigate the effects of poker and table vibration techniques on the optimum time and compressive strength of C-25 concrete, to identify the most effective compaction method for improving concrete performance in terms of strength development.

1.3.2 Specific Objectives

This study specifically aims to:

1. To evaluate the effect of poker vibration on the optimum time and compressive strength of C-25 concrete.
2. To assess the impact of table vibration on the optimum time and compressive strength of C-25 concrete.
3. To determine the performance of poker and table vibrators in terms of their influence on the optimum time of concrete.
4. To determine the compressive strength results of concrete compacted using poker and table vibration techniques at different curing ages (3, 7, and 28 days).
5. To determine the most effective vibration technique for optimizing both workability and compressive strength of C-25 concrete under laboratory and site conditions.

1.4 Research Questions

This study's research questions are:

1. How does poker vibration affect the optimum time and compressive strength of C-25 concrete?
2. How does table vibration influence the optimum time and compressive strength of C-25 concrete?
3. What are the differences in optimum time between poker and table vibration techniques when applied to C-25 concrete?
4. How does the compressive strength of concrete compacted with poker vibration compare to that of concrete compacted with table vibration at various curing ages (3, 7, and 28 days)?
5. Which vibration technique, poker or table, provides better overall performance in terms of both optimum time and compressive strength for C-25 concrete?

1.5 Research Significance and Research Beneficiary

The successful completion of this research will have significance for contractors' Concrete users, students, institutions for civil engineers professions.

1. To provide necessary information regarding the physical, mechanical properties, and Application of placing and compaction of concrete production.
2. To provide good compaction and to minimize poor compaction for the current fast-growing construction industry.
3. To produce a good concrete product by studying the physical and mechanical properties of Compaction and its effect on fresh and hardened concrete properties.
4. Other researchers will use this research as a reference for further research on the Compressive strength and workability of concrete. Generally, the knowledge of this study can be used as a prospecting tool for selecting suitable compaction for the production of quality Concrete.
5. 5. Civil Engineers and Construction Professionals: The results offer insightful information about the choice of suitable vibration techniques, allowing engineers to enhance strength development, optimize overall construction quality, and improve concrete compaction practices.
6. 6. Contractors and Site Supervisors: By knowing how various vibration techniques affect concrete performance, contractors can make well-informed choices about labor productivity, equipment usage, and construction schedules.
7. 7. Concrete technologists and material researchers: The study supports additional research and innovation in concrete technology by adding to the body of knowledge on how concrete behaves under various compaction techniques.
8. 8. Infrastructure Project Planners: The findings can assist decision-makers and planners in implementing more effective procedures in infrastructure projects, particularly when durability and quality control are crucial.
9. 9. Educational Institutions and Students: To improve academic learning, universities and technical colleges can use the results as a practical reference in courses on concrete materials and construction techniques.
10. 10. Policy Makers and Regulatory Bodies: The study provides evidence-based information that can help create or update standards and guidelines pertaining to construction quality assurance and concrete compaction.

11. Local Construction Industry in Ethiopia: Particularly in regions like Tigray, the study supports the advancement of construction practices through more efficient and cost-effective methods tailored to local conditions and resources.

1.6 Research Scope

This research will study the compaction or consolidation of concrete properties. This compaction or consolidation type will be done on the laboratory and site level in the city of Mekelle. This study will only cover the optimum time using the poker vibrator and table vibrator, and the effect on the concrete compressive strength of C-25 physical properties, workability, and compressive strength of concrete at 3rd, 7th, and 28th days for C-25 and concrete grades because of time concentration.

1.7 Research Limitation

Despite the efforts made to ensure the accuracy and reliability of this research, several limitations were encountered:

1. Concrete Grade Scope: Only C-25 concrete was included in the study. Other concrete grades with different mix designs or strength requirements might not directly benefit from the findings.
2. Vibration Techniques: Only two vibration techniques were taken into consideration: table vibration and poker vibration. The comparison did not take into account other compaction methods like surface vibrators or external shutter vibration.
3. All experiments were carried out in controlled laboratory environments, which may not accurately reflect real-world site conditions where operational and environmental variables differ.
4. Limited Sample Size: The number of specimens tested was restricted due to time and resource limitations. The results' statistical reliability might have been improved with a bigger sample size.
5. Short-Term Observation: Compressive strength at 3, 7, and 28 days was the main focus of the investigation. Aspects of durability and long-term strength development were not evaluated.

6. Geographical Context: Because the study was carried out in a particular setting, the availability of labor, materials, and equipment may be unique to that area. It is advisable to exercise caution when extrapolating the findings to other regions.

Future research is encouraged to fill in these gaps for wider applicability, and these limitations should be considered when interpreting the results.

Many stakeholders in the construction sector are anticipated to gain from this study, especially in situations where concrete efficiency and quality are crucial. Among the principal beneficiaries are contractors' Concrete users, students, institutions for civil engineers professions.

1.9 Research Organization

Each of the five primary chapters that make up this thesis covers a crucial aspect of the research:

Chapter One: Introduction

The study's background, problem statement, general and specific objectives, research questions, significance, scope, limitations, and thesis organization are all presented in this chapter. It establishes the basis and justification for the study.

Chapter Two: Literature Review

This chapter examines the body of research on concrete vibration methods, workability, ideal time, and compressive strength. It draws attention to important theoretical ideas, earlier research, and knowledge gaps that this study seeks to fill.

Chapter Three: Research Methodology

The study's methodology is described in this chapter. The experiment's design, materials, sample preparation, compaction techniques (such as poker and table vibrators), testing protocols, data collection, and analysis methods are all covered.

Chapter Four: Results and Discussion

The experimental results are presented in this chapter along with a thorough analysis and discussion of the results. Tables, graphs, and interpretations are used to compare the effects of poker and table vibration techniques on compressive strength and optimal time.

Chapter Five: Conclusions and Recommendations

This last chapter summarizes the main conclusions, makes inferences based on the goals of the study, and offers helpful suggestions for researchers, policymakers, and construction professionals. There are also recommendations for additional research.

Each chapter builds on the one before it to offer a logical and cohesive flow of information that result in a thorough understanding of how vibration techniques affect the performance of C-25 concrete.as shown in Figure 1 - 1.

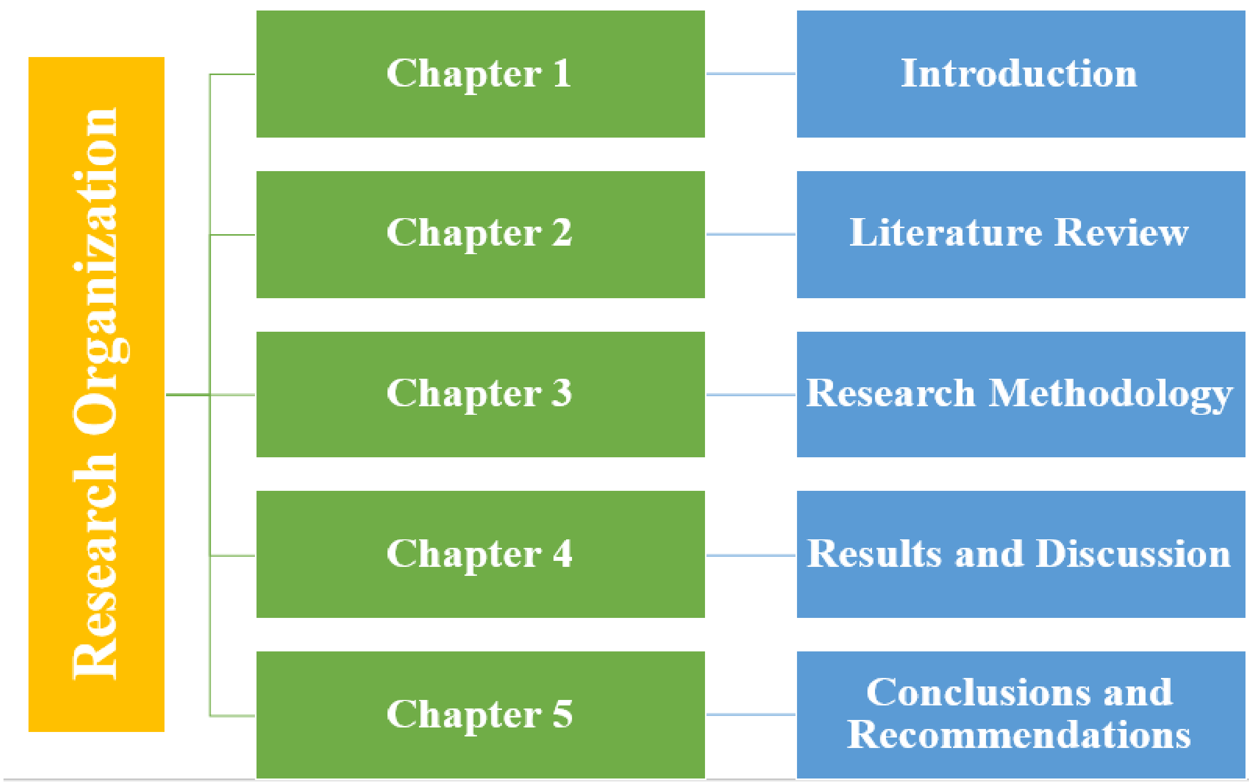

Figure 1 - 1: The research organization layout

CHAPTER 2

2. LITERATURE REVIEW

2.1 Concrete Materials

With many buildings, bridges, and water structures built to meet community needs, the construction industry is currently expanding swiftly. One material that is commonly used in construction is concrete. Concrete's popularity in the construction industry is closely associated with its benefits, especially its strength and ease of upkeep. Manufacturers are therefore compelled to compete in order to create innovative construction technology. Among the ingredients used to make concrete are Portland cement, fine, coarse, and water aggregates. The quality of the concrete is determined by the production process and the raw materials utilized. One factor used to assess the quality of concrete is its compressive strength. The compressive strength of concrete refers to its capacity to withstand force per unit area. Compaction is a technique used in the production process to improve the quality of concrete. Compaction is a crucial casting stage that has a substantial effect on the strength of the finished product. The goal of concrete compaction is to achieve maximum concrete density while simultaneously minimizing the air cavity within the concrete[4].

The components of concrete can be distributed uniformly through compaction. Internal and external concrete compactions are two different forms of concrete compaction. Vibrating internal compaction is done in a new concrete mold using a vibrator. Shaking outside the mold by vibrating the fresh concrete mold's two sides is known as external compaction. One kind of external compaction tool is the vibrating table. Vibrating fresh concrete in a cylindrical mold is how a vibrating table is used for compaction. The concrete molds' air cavity and a portion of their water content lifted as a result of the vibration. The fresh concrete is compacted when the water content is lowered, which will have an impact on the final product's quality. This study aims to ascertain the impact of water loss on concrete quality during the compaction process[4].

Vibration in the mixing process benefits the improvement of the performance of concrete. However, fewer studies are presented to discuss the effect of different vibration parameters on the properties of concrete. This study aims to investigate the effects of conventional mixing (CM) and vibratory mixing (VM) on the properties of concrete with different mix proportions[5].

With the common use of high-flow ability for its peculiarity of easily compacting for constructions, more and more studies have been carried out to evaluate the distribution pattern of steel fibers and their effect on the performance of structural members, especially in self-compacting. The present study aimed to evaluate the effect of vibration time on steel fiber distribution and behaviors of steel fiber reinforced concrete (SFRC) with different flow ability. Three different vibration times (i.e., 10 s, 30 s, and 60 s) were selected to compact SFRC specimens on the vibration table in this study. The flow ability of SFRC was represented by the varying slump from 80 mm to 200 mm[6].

SCC is characterized by high fluidity and high spread ability with stability, and also ensures good mechanical performance. These concretes were finalized initially by researchers of the University of Tokyo in the early. The concrete goes more and more towards the use of self-compacting. The SCCs are very fluid, homogeneous, and with higher stability, they are implemented without vibration. This establishes a great advantage for the realization of the constructions, and this advantage can be observed by the difference between Self-Compacting Concrete and Ordinary Concrete presented[7].

2.1.1 Cementing materials

We located numerous historical structures built from materials similar to concrete. A large number of them are mortars composed of silicate and lime. When compared to other old clay and brick structures, their mortars are extremely durable. The earliest known instance of a concrete concept dates back to the Romans in 300 BC. To be able to create a highly strong mortar that may eventually become hard, just like concrete, they mixed lime, water, and volcanic ash. Aluminate and silicate components of volcanic ash. Like cement, it may solidify by reacting with water and lime. After that time, numerous individuals have tried to develop composite mortars, which are similar to modern concrete and are made up of various binders like cement and fillers like sand. As the binder reacts with the water over time, all of the mortars solidify. Therefore, we can refer to all of these mortars as concrete and all of the binders that are used to make these mortars as cement. The English mason Joseph Aspdin has been associated with bringing cement to its current condition. Because it resembled the limestone of Portland Island in the United Kingdom, he began producing cement in 1824 and called it Portland cement. This clarifies the reason that the Portland cement we currently use has this name[8].

The addition of clay or stone containing known properties allows the components to be adjusted. The refined clinker generated by calcining adequately proportioned argillaceous and calcareous materials to incipient fusion is the raw material used to make Portland cement. During manufacture, Portland cement's final ingredients and characteristics are meticulously regulated. To meet various physical and chemical criteria, Portland cement is available in five main types as well as several customized varieties such as Type I: normal or general purpose, Type II: moderately sulfate resistant, Type III: high early strength, Type IV: low heat of hydration, and Type V: sulfate resistant [9].

Any material that can be made plastic and that gradually hardens to form an artificial stone-like material is referred to as a cementation material. Hydraulic cements, namely Portland and natural, along with lime, are the principal cementing materials used in structures. They become plastic by the addition of water, and then the mix hardens. The other principal type of cementing agents is asphalts, which are made plastic either by heating, emulsifying, or by the addition of a cutback agent. Their hardening process is different from that of a hydraulic substance, which requires a hydration mechanism to harden. This book is only concerned with one type of hydraulic cement, Portland, although natural cements will be mentioned briefly because of their historical significance[10].

In Ethiopia, Ordinary Portland cement, Portland pozzolana cement, rapid hardening Portland cement, low heat Portland cement, and sulfate resisting Portland cement are the most common types of hydraulic cement. Among those, ordinary Portland cement is extensively used in concrete construction. It is more suitable than other cements for use in general concrete construction where there is no exposure to sulfates in the soil or groundwater.

2.1.2 Aggregates

Aggregates consist of small particles, such as rocks and stones, which are divided into two grades, fine and coarse, and comprise the largest volume of concrete ingredients (typically 70%). The amount of cement used over a given area depends on aggregate size; the finer the aggregate, the larger the surface area. Also, the shape of the aggregate affects the amount of vibration required, since rough aggregate shapes hold more air than smooth[11].

These ingredients can differ or be categorized into one from the other by the size of particles, mostly of which can be used sieve analysis, these ingredients passing through a 5mm size of sieve, and may be crushed sand or river sand, we call it fine aggregate or sand. And retain in the 5mm size of sieve, we call it coarse aggregate. These ingredients have affected the compressive strength of concrete according to their shape, texture, size characteristics, and color.

2.1.3 Water for concrete

To begin the hydration process, water is needed to act as a catalyst. Water content will determine the strength, workability, and place ability of the mix. An increase in water content will improve the concrete's workability but will decrease its ultimate strength and durability[11]. So the water whit must, which can be used for concrete, must be drinkable. On the other hand, the water for concrete cannot be seawater or river water, or dirty water because they affect the compressive strength of concrete.

2.1.4 Admixture

An ingredient that is added to concrete or mortar in place of water, aggregates, or cement to regulate setting and early hardening, improve workability, or provide increased cementing qualities.

The Romans used milk and lard for early concrete and masonry, the Europeans used eggs during the Middle Ages, the Chinese used lacquer, tung oil, blackstrap molasses, polished glutinous rice paste, extracts from boiled bananas and elm soaked in water, and the Mesoamericans and Peruvi ans used cactus juice and latex from rubber plants [12].

To satisfy the demands of contemporary structures, efforts have been made for decades to produce concrete with specific desired qualities, such as high compressive strength, high workability, and high performance and durability parameters. The properties that are frequently altered are heat of hydration, accelerated or retarded setting time, workability, water reduction, dispersion and air-entrainment, impermeability, and durability factors [13].

Other than Portland cement, water, and aggregates, additives are substances added to concrete th at are added either right before or during mixing and can be categorized according to their functi on as follows; Air-entraining admixtures, Water-reducing admixtures, Plasticizers, Accelerating admixtures, Retarding admixtures, Hydration-control admixtures, Corrosion inhibitors, Shrinkage reducers, Alkali-silica reactivity inhibitors, Coloring admixtures, and Miscellaneous admixtures such as workability, bonding, damp proofing, permeability reducing, grouting, gas-forming, foaming and pumping admixture [14].

2.2 Fresh concrete

It is recent mixed concrete with a consistency of the mix such that the concrete can be transported, placed, compacted, and finished sufficiently easily without segregation and bleeding**.**

Fresh concrete refers to the state of concrete shortly after mixing and before it begins to harden. In this condition, concrete is plastic, workable, and moldable, making it easy to transport, place, compact, and finish. The quality of fresh concrete is crucial because it directly affects the strength, durability, and overall performance of the hardened concrete. Workability, which indicates how easily the concrete can be mixed, placed, and compacted without segregation; consistency, which indicates the mix's fluidity or stiffness; and cohesiveness, which guarantees the mix holds together without separating, are important characteristics of fresh concrete. The behavior of fresh concrete is influenced by variables like the water-to-cement ratio, aggregate type, mixing time, and admixtures. To prevent problems like honeycombing, segregation, and cold joints, fresh concrete must be handled and placed properly. Therefore, controlling the properties of fresh concrete is critical to achieving the desired strength and durability in the finished structure.

2.2.1 Workability

The handling, consolidation, and building sequencing decisions are influenced by the characteristics of fresh concrete. They might also have an impact on the hardened concrete's characteristics. Fresh concrete's qualities are temporary and should meet the following specifications; It must be easily mixed and transported, It must be uniform throughout a given batch, and between batches, It must keep its fluidity during the transportation period, It should have flow properties such that it is capable of filling the forms, It must have the ability to be fully compacted without segregation, It must set in a reasonable period, and It must be capable of being finished properly, either using Toweling or other surface treatment [15]

There isn't a single, widely used test procedure that can determine workability directly. Tests used to determine the consistency of vibrating and normal-weight fresh concrete are as follows the most popular test, known as the slump test, primarily assesses the consistency of concrete, the Vebe test, which is more significant for mixtures with low consistency, comes in second, and the compacting factor test, which looks at a concrete mixture's compatibility, comes in third [16].

2.2.2 Batching of concrete

There are two types of concrete batching these are weight batching and volume batching. In addition, when we use the weight batching, the measurement is weight balance in kilograms; when we use the volume batching, the measurement is using box sizes 16/18/20, 40, and 50 cm. Weight batching vs. Volume batching are as follows: Weigh batching is the more precise method of batching than volume batching, since it is difficult to find the exact volume of granular materials due to their voids. Moisture content in the aggregate should also be considered while batching. In case of fully automatic weigh batching, it can be considered, but volume batching is not suitable in such cases, Compressive strength of the same concrete mix at 7 days and 28 days is higher for the weigh batching concrete mix than the volume batching concrete mix, Weigh batching concrete mix gives a medium to very high slump, while for the same mix proportion in volume batching, the slump differs from low to high, Volume batching does not require skilled workers, but weigh batching does, and the selection of the batching method depends upon the size of the project and, concrete production rate.

2.2.3 Mixing of concrete

There are two types of mixing concrete these are hand mix and mechanical mix. The hand mix can operate by using manpower, and the mechanical mix can operate by using a mechanical mixer. In terms of hand mixing, pour the mixture into a wheelbarrow or mortar tub. Create a hollow in the center of the mixture. Pour around two-thirds of the water into the depression after measuring the necessary amount. Using a hoe, work the mixture until it achieves a consistent, workable consistency while adding water little by little [17].

In terms mechanical mixer, it’s crucial to add water to the mixer before adding the dry mix when mixing concrete by machine. Add the dry mix to the mixer after turning it on. After a minute or so of mixing, add the remaining water as needed. One bag or 50 kilograms of concrete mix can be held in a typical mixer. Pour half of the water source into the mixer after measuring the amount of water that is advised for the number of bags to be added. Until a consistent, working consistency is reached, mix for 3 to 5 minutes [17].

2.2.4 Transporting and placing of concrete

1. Transporting of concrete

Moving concrete from the mixing facility to the construction site is known as "transporting the concrete mix." Remember that not all concrete is mixed on the construction site itself, and it could take a considerable amount of travel. This most frequently occurs with ready-mixed concrete. In reality, "about two-thirds of the Portland cement produced [in the United States] is used in ready-mixed concrete". Making sure that the water-to-cement ratio, slump or consistency, air content, and homogeneity do not change from their intended conditions is the main objective when transporting concrete. There are many modes of transportation, as shown such as Wheelbarrow or motorized buggy, Truck mixer, Bucket or steel skip, Chute, Belt conveyor, Concrete pump, and Pneumatic placer [18].

2. Placing of concrete

Concrete must be moved from the truck to the formwork as soon as it gets to the working site. For simpler tasks, a basic wheelbarrow can be used. A chute that extends from the back of the truck can be used to place the concrete if it doesn't need to travel too far. Concrete can be moved over greater distances using a conveyor belt.

Concrete can be pumped from the truck to the point of deposition with the right mix design, or it can be pushed even further or dumped at a high altitude using a crane and bucket. A Tuckerbilt, which features an auger to discharge the concrete into the forms and a hopper to move the concrete to the forming beds, can be used at a precast concrete plant to cast concrete beams or panels [19].

2.2.5 Vibration (Consolidation)

Right after placement, concrete contains up to 20% entrapped air. The amount varies according to the type of mix and its slump, the placement method, form size, and the amount of reinforcing steel used. Concrete vibration can improve the compressive strength of the concrete by about 3% to 5% for each percent of air removed [11].

The purposes of concrete compaction such as reduce the air voids, increase bonding capacity between concrete compounds (aggregate and cement, and between cement and reinforcement), increase the compressive strength of concrete, increase the density of concrete, reduce the degree of absorption and increase the strength of concrete strength of weathering, and reduce the volumetric changes [20].

2.2.5.1 Types of concrete vibrators

1. **Immersion or Needle Vibrators:** The most popular vibrators for concrete are immersion or needle vibrators. It is made up of an eccentric vibrating element inside a steel tube that has one end closed and rounded. A flexible tube connects this steel tube, known as a poker, to an electric motor or diesel engine. The diameter of these might range from 40 to 100 mm. By taking into account the distance between the reinforcing bars in the formwork, the diameter of the poker is determined. Vibration ranges in frequency up to 15,000 rpm. Nonetheless, a minimum of 3000 to 6000 rpm is recommended, with an acceleration of 4g to 10g. An immersion vibrator typically operates within a radius of 0.50 to 1.0 meters. The vibrator should ideally be submerged in concrete at intervals of no more than 600 mm, or 8 to 10 times the poker's diameter. The necessary vibration duration could range from 30 to 2 minutes. Layers of concrete no higher than 600 mm should be used [21] .

2. **Extended or shutter vibrator:** To vibrate the form and concrete, these vibrators are firmly attached to the formwork at pre-established locations. Compared to internal vibrators, they use more power for a given compaction effect. As concrete advances, these vibrators must be relocated from one location to another, but they may crush up to 450mm from the face. These vibrators run between 3000 and 9000 rpm with 4g acceleration. External vibrators are more frequently utilized for pre-casting thin in-situ parts that are too thick and shaped for internal vibrators to condense [21].

3. **Surface Vibrator for concrete:** The concrete mass is directly covered by these. When the depth of concrete to be vibrated is greater than 250 mm, this is not the ideal option for compaction of shallow elements. Surface vibrators are the best tool for compacting extremely

dry mixtures. Vibrating screeds and pan vibrators are the two most widely utilized surface vibrators. This kind of vibrator is mostly used for patching and repairing pavement slabs as well as compaction of small slabs that are no thicker than 150 mm. At an acceleration of 4g to 9g, the operating frequency is around 4000 rpm [21].

4. **Concrete Vibrating Table:** The vibrating table is powered by an electric motor and is composed of a steel platform that is rigidly constructed and supported by flexible springs. At an acceleration of 4g to 7g, the typical vibration frequency is 4000 rpm. The hard concrete mixtures needed to make precast parts in factories and test specimens in the laboratory can be compacted very effectively with vibrating tables [21].

2.2.5.2 Application of a vibrator for concrete

Applications of internal vibrators: As a general rule, the radius of action of a given vibrator not only increases with the workability of the concrete, but also with the diameter of the head. A good general rule is to use as large a diameter head as practicable, bearing in mind that vibrators with diameters over 100 mm will probably require two workers to handle them. For smaller diameter vibrators, the appropriate head size will be dependent on the width of the formwork, the spacing of the reinforcement, and the thickness of concrete cover. The frequency of a vibrator is the number of vibrations per second the SI unit is Hertz (Hz). In general, high-frequency vibrators are most suited to high-slump concrete and small maximum-sized aggregates, while low-frequency vibrators are more suited to low-slump concrete and large maximum-sized aggregates. Generally, high-amplitude vibrators are most suited to low-slump/large maximum-sized aggregate concrete, while low-amplitude vibrators are most suited to high-slump concrete [21]. As shown in

Table 2 - 1

Table 2 - 1: Application of vibrator for concrete

Head Diameter (mm)	**Recommended frequency (Hz)1**	**Average amplitude (mm)2**	**Radius of action (mm)3,5**	**Rate of concrete placement (m3/h per vibrator)4,5**	**Application**
20-40	150-250	0.4-0.8	80-150	0.8-4	High slump concrete in very thin members and confined places. It may be used to supplement larger vibrators where reinforcement or ducts cause congestion in forms.
30-60	140-210	0.5-1.0	130-250	2.3-8	Concrete 100-150 mm slump in thin walls, columns, beams, precast piles, thin slabs, and along construction joints. It may be used to supplement larger vibrators in confined areas.
50-90	130-200	0.6-1.3	180-360	6-15	Concrete (less than 80 mm slump) is used in normal construction, e.g., walls, floors, beams, and columns in residential, commercial, and industrial buildings.
80-150	120-180	0.8-1.5	300-500	1-31	Mass and structural concrete of 0-50 mm slump placed in quantities up to 3 m3 in relatively open forms of heavy construction.

Exposure to vibration can cause long-term health problems such as Avoid contact with vibrating equipment or molds. Always wear ear protection. Always ensure moveable vibrating equipment is firmly clamped before operating. Always wear eye protection, and never hold molds to stop them from bouncing [22]. The difference between the table vibrator and poker vibrator is described based on their physical properties and other criteria's as shown in

Table 2 - 2.

Table 2 - 2: Difference between the table vibrator and the poker vibrator

No	Table vibrator	Poker vibrator or internal vibrator
1	It's an electrical vibrator.	It's mechanical or motor using benzene.
2	Only used in the laboratory.	Mostly, it can be used at the site level.
3	It's reliable to uniformly treat the concrete.	It cannot be uniform due to a lack of workmanship, so it can create fluctuation in compaction.
4	It can be applied to the exterior of the cube.	Can be applied internal vibrator.
5	Have no needle.	Have a needle.

2.2.5.3 Time of vibration

For poker or internal vibrator method that has been successfully used is as follows. The vibrator should penetrate rapidly to the bottom of the layer and at least 6 in. (150 mm) into the preceding layer. The vibrator should be manipulated in an up and down motion, generally for 5 to 15 sec, this time is vary depend up on the mixture or workability of the concrete for example if the concrete is plastic concrete take the time maximum of 5 sec and if the concrete is stiff workability take the time maximum 15 sec. The vibrator should then be withdrawn gradually with a series of up and down motions. The down motion should be a rapid drop to apply a force to the concrete which, in turn, increases internal pressure in the freshly placed mixture. Rapidly extract the vibrator from the concrete when the head becomes only partially immersed in the concrete. The concrete should move back into the space vacated by the vibrator. For dry mixtures where the hole does not close during the withdrawal, sometimes reinserting the vibrator within 1/2 influence radius will solve the problem; if this is not effective, the mixture or vibrator should be changed[23].

Generally, no more than 5sec of vibration should be required for each insertion to adequately consolidate the concrete with a slump greater than 3 in. [75 mm]. Longer times may be required for lower slump concrete, but the vibration time should rarely have to exceed 10 s per insertion[24].

For table vibrator optimum compaction, a minimum time of vibration is 90 seconds for mixes with a compacting factor of 0.78 (stiff mixes). This time may be reduced if more workable mixes are used there for when the mixture is plastic concrete take maximum time is 60 sec and when the concrete is stiff take the maximum time is 240sec[25].

2.2.5.4 Consequences of improper vibration

Honeycomb: Honeycomb occurs when the mortar does not fill the space between the coarse aggregate particles. Honeycomb is generally caused by using improper or faulty vibrators, improper placement procedures, poor vibration procedures, inappropriate concrete mixtures, or congested reinforcement[23].

Sand streaking: Sand streaking is caused by heavy bleeding and mortar loss along the form, resulting from the character and proportions of the materials and method of depositing the concrete. They are most likely with harsh, lean mixtures and with concrete moved horizontally with the vibrator[23].

Segregation: The mechanics of segregation come into play when the forces of gravity and vibration are given sufficient time to interact. With excessive vibration time, the cohesive forces within the concrete are overcome by gravity and vibration causes the heavier aggregates in the mixture to settle and the lighter aggregates to work upward borne by the paste matrix[23].

2.2.6 Curing of concrete

Hydration is a chemical reaction that occurs when Portland cement and water are combined. The concrete gets stronger, more durable, and denser as the cement hydrates. These characteristics increase with the degree of moisture. It takes a very long time for cement to fully hydrate. When the concrete's surface is hard, the hydration process is far from finished.

Theoretically, the hydration process continues for years. With sufficient water, the hydration process will be approximately 42% complete in 3 days, 65% complete in 7 days, and 99% complete in 28 days[26].

2.3 Harden Concrete

The performance and durability of hardened concrete in structural applications are determined by a number of significant characteristics. Strength, especially compressive strength, which indicates the concrete's capacity to withstand crushing forces, is one of the most important characteristics. This is a crucial consideration when designing structural components like slabs, beams, and columns. Although they are significantly less than its compressive strength, concrete also demonstrates tensile and flexural strength. In structures like pavements, bridges, and floor slabs, where resistance to cracking under load is crucial, flexural strength—a measure of concrete's resistance to bending—is particularly significant. Durability, or the concrete's capacity to endure environmental elements like moisture, temperature fluctuations, chemical attack, and freeze-thaw cycles over time, is another essential quality. Durable concrete is essential to long-term structural performance because it requires little upkeep to maintain its integrity and serviceability. A common problem with hardened concrete is shrinkage, which is mostly caused by gradual moisture loss. If not adequately managed, this volume reduction may result in cracking, which lowers strength and durability. Appropriate mix design, suitable curing procedures, and shrinkage-reducing admixtures can all help reduce shrinkage. In general, creating high-quality concrete that satisfies structural and environmental requirements over the course of its service life requires striking a balance between strength, durability, low shrinkage, and sufficient flexural performance.

2.4 Rebound Number and Strength of Concrete

Investigations have shown that there is a general correlation between compressive strength of concrete and rebound number; however, there is a wide degree of disagreement among various research workers regarding the accuracy of estimation of strength from rebound readings. The variation of the strength of a properly calibrated hammer may lie between ±15% and ±20%. The relationship between flexural strength and rebound number is found to be similar to that obtained for compressive strength, except that the scatter of the results is greater.

2.5 Previous Research Studies

One research was done on Jimma University the titled A Study on the Effect of Time Duration by Vibrating or Tamping Fresh Concrete on the Compressive Strength of C-25 Concrete [2]. Based on his studies, he conducted tests on the tamping rod and internal vibrator by taking the same mix design of concrete. He takes the fresh concrete samples tested by using internal vibration methods and techniques of compaction with different time durations of 1sec, 2sec, 3sec, 4sec, and 5sec. These tests were performed by using a steel rod in fresh concrete to determine the Optimum time of compaction by internal vibration on the cube test of new concrete. So he concluded this research study found that the Optimum period of compaction was 3 seconds to produce an acceptable quality of the concrete mix. Likewise, the flexural strength of the Concrete Sample, when it was tested in the laboratory on the 7th day and 28th day, the results revealed that the flexural strength improved when the vibration time increased, but the amount of water had to be reduced to obtain the desired strength. Finally, Tamping is needed to place fresh concrete in the mold correctly. Furthermore, new concrete produced should match the properties and avoid improper tamping or vibration applications. This situation must not cause differences in compressive strength of concrete [2].

2.6 Research Gap

The title of Jimma University A Study on the Effect of Time Duration by Vibrating or Tamping Fresh Concrete on the Compressive Strength of C-25 Concrete (Achalu, 2017). In this title, he is talking about the tamping rod and internal vibrator, and the strength is checking the flexural strength; he is not checking the compressive strength of concrete. And at this time tamping rod is traditional when it can be used in small projects, but in huge projects cannot be compacted using a tamping rod. And in the laboratory is compacted using a table vibrator. But in my study, I will change the tamping rod into to table vibrator b/s of the mix design is provided in the laboratory, and the compaction is conducted by table vibrator. But at the site level, the same mix design can be used poker vibrator when checking the compressive strength varies, so I want to study this correlation over time by using a standard specification to conduct the same compressive strength.

Moreover, although extensive research has been conducted on the general properties of concrete and the importance of proper compaction, there is still a limited understanding of how specific vibration techniques influence both the correlation time and compressive strength of concrete, especially in the context of commonly used grades like C-25. Most existing studies focus on either the mechanical performance of concrete or the efficiency of compaction methods individually, but few provide a direct comparison between poker vibrators and table vibrators under controlled experimental conditions.

Furthermore, little is known about the relationship between vibration duration (correlation time) and how it directly affects the development of concrete strength. In reality, vibration is frequently used arbitrarily without a scientific determination of the ideal vibration time, which can result in either excessive or insufficient compaction, both of which have detrimental impact on durability and strength. Additionally, there aren't many studies that focus on specific regions, especially Ethiopian construction practices, where the selection and application of vibration techniques are frequently determined more by habit and availability than by performance-based data.

CHAPTER 3.

3. RESEARCH METHODOLOGY

The comparison between the table vibratos and the poker vibrator is examined in this study. The materials and their sources are briefly described in the process. Furthermore, the techniques for testing the concretes, component materials at The Mekelle University Consruction Laboratory on the Main Campus. The market was consulted for the procurement of the concrete ingredients, cement, and aggregates. To verify that the coarse and fine aggregates met specifications, physical testing was done on them. This study includes the following aggregate physical tests: sieve analysis, moisture content, silt content, unit weight, specific gravity, and absorption capacity. Every test was carried out in compliance with ASTM standard test protocols. At fresh and hardened states, slump and compressive strength tests were investigated using a slump cone and compressive strength testing machine, respectively. The compressive strength for hardened concrete of all was tested at 3, 7, and 28 days using 150×150×150 cubes.

3.1 Aggregates

Throughout the inquiry, natural sand was acquired from Adigudom, 45 kilometers distant from Mekelle city, and coarse aggregates were acquired from Quiha, 10 kilometers away. Within the Mekelle University Construction Materials Laboratory, all aggregate testing was carried out. The silt content, unit weight, voids, specific gravity, particle shape and surface texture, absorption, and moisture content are among the physical characteristics of the examined aggregates.

3.2 Testing of Fine Aggregates

3.2.1 Silt Content of Fine Aggregates

Silt content in fine aggregates refers to the presence of fine clay or dust particles that are smaller than 75 microns in size. These particles are often found adhering to the surface of sand grains and can significantly affect the quality and performance of concrete. The bond between cement paste and aggregate is weakened by a high silt content, which causes the hardened concrete to be weaker, more permeable, and less durable. Additionally, it may result in shrinkage or cracking, decrease workability, and raise water demand. The sedimentation or decantation method, which involves mixing a sample of sand with water in a transparent container and letting it settle, is commonly used to determine the silt content of fine aggregates. After a specified time, the height of the silt layer is compared to the height of the total sample to calculate the percentage of silt. According to most standards, such as ASTM and IS codes, the silt content in fine aggregates should generally not exceed 6% by volume. Regular testing and control of silt content are essential to ensure the production of strong, durable, and high-quality concrete. Therefore, the purpose of this test is to identify the presence of fine silt or sand particles smaller than No. 200 (75 µm sieve) in the sand. As per the Ethiopian Standard Specification, it is advised to wash the sand or discard it if the silt content exceeds 6%. If the silt content is higher than 6%, the sand should not be utilized in the construction sector [27].

Based on the test result obtained, the sand used for this experiment had a silt content is 2.66%. Therefore, this sand was used for the research work, and all the sand properties were determined based on this sand. Amount of Sand Sample=200 gm., Amount of Water=150 ml as shown in Table 3 - 1.

Table 3 - 1: Testing silt content before washing sand from temben

Observations	**Trial 1**	**Trial 2**	**Trial 3**
Total sand and silt (cm), A	5.6	5.6	5.6
Amount of clean sand (cm), C	5.46	5.4	5.5
Amount of silt deposited above the sand (cm),	0.133	0.2	0.1
Silt content (%) = A/B *100	2.45	3.73	1.82
Average silt content,%	2.66		
Remark-Silt contents are above the ES limit of 6% and thus are not acceptable.			

3.2.2 Gradation of Fine Aggregate

Gradation of fine aggregate refers to the distribution of particle sizes within a sample of sand or other fine materials used in concrete. It is a critical factor influencing the workability, cohesiveness, and finish ability of fresh concrete, as well as the strength and durability of the hardened product. Fine aggregates are typically sieved through a standard set of sieves, and the percentage passing each sieve is recorded to produce a gradation curve. This curve is then compared to standard limits such as those in ASTM C33 or local specifications to ensure compliance. A balanced mixture of particle sizes in well-graded fine aggregate enables effective packing and lessens the need for extra cement paste to fill in gaps. As a result, strength is increased and permeability and shrinkage are decreased. Sand that is too fine (fineness modulus too low) may require more water and be less workable. Conversely, if it is too coarse (high fineness modulus), it may lead to harsh mixes and poor finish ability. Therefore, maintaining proper gradation of fine aggregate is essential for producing high-quality concrete with desirable performance characteristics in both fresh and hardened states. Therefore, Aggregates can be categorized into various groups depending on different factors, including size, origin, and weight. Fine aggregate refers to the part of the aggregate that goes through a No. 4 sieve (4.75mm) and is mostly held back by a No. 200 sieve (75μm). Fine Aggregate sample weight 2000 gm and Gradation (Sieve analysis) of fine aggregate as shown in Table 3 - 2.

Table 3 - 2: Gradation (Sieve analysis) of fine aggregate

Sieve size (mm)	Weight of sieve (gm)	Weight of sieve and Retained (gm)	Weight Retained (gm)	Percentage retained %	Cumulative (%) Retained	% of passing
10	452	507	55	2.75	2.75	97.25
5	0.536	621	83	4.15	6.90	93.10
2.36	442	589	147	7.35	14.25	85.75

1.18	415	707	292	14.60	28.85	71.15
0.6	391	902	511	25.55	54.40	45.60
0.3	364	911	547	27.35	81.75	18.25
0.15	340	615	275	13.75	95.50	4.50
Pan	297	387	90	4.50	100	0
			2000		282	
			F.M= 282/ 100 = 2.82			

The result of 2.66 for the fineness modulus (FM) falls within the acceptable range of FM values for fine aggregate used in concrete, as specified by ASTM C33 standards[28]. This means that the sand sample is appropriate for use in concrete as a fine aggregate. The FM of sand is a measurement of the average size of sand particles, calculated by adding the cumulative percentages of sand particles retained on specific sieves and dividing the sum by 100. Typically, the FM of sand ranges from 2.2 to 3.2. According to ASTM C33, [28] the fine aggregate used in concrete should have a minimum FM of 2.3 and a maximum FM of 3.1. The FM of the sand sample, which is 2.66, falls within this range, indicating its suitability for use in concrete as a fine aggregate, as shown in Figure 3 - 1.

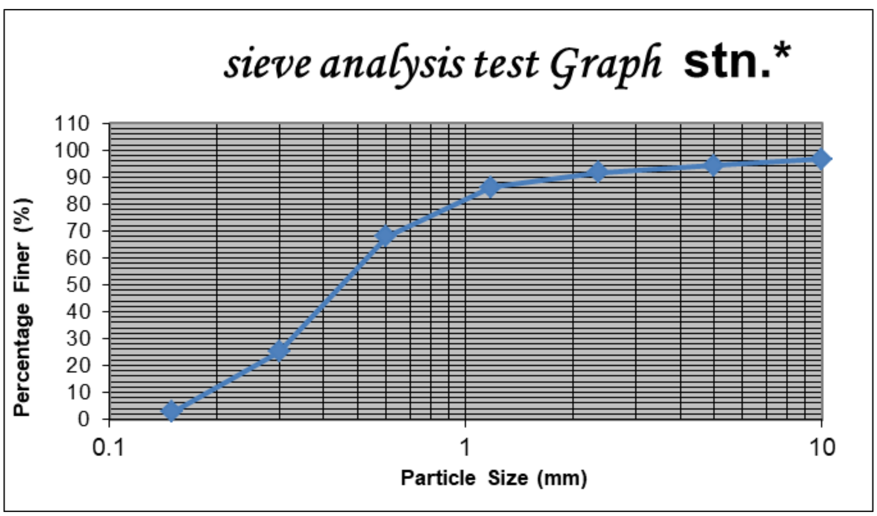

Figure 3 - 1: River sand Gradation Chart

3.2.3 Specific Gravity and Water Absorption Determination of Sand

The specific gravity of fine aggregate is the ratio of the mass of a given volume of fine aggregate to the mass of an equal volume of water. It is a measure of the density of the fine aggregate. Water absorption of fine aggregates is a measure of the amount of water that fine aggregates can absorb. ASTM C 128 describes methods for determining the specific gravity of fine aggregates. However, most specifications recommend that the water absorption of fine aggregates should not be more than 2% by weight, as shown in Table 3 - 3[29].

Table 3 - 3: Specific Gravity and water absorption determination of sand

Observations	**1**	**2**	**3**
Specimen Oven dry Weight (g) = A	492	490	491
Water Filled Pycnometer Weight (g) = B	657	657	657
Specimen+ Water+ Pycnometer Weight (g) = C	956	961	968
Specimen SSD Weight in air (g) = S	500	500	500
Apparent specific gravity (ASG) = $\frac{A}{(A+B-C)}$	2.55	2.63	2.73
Average Apparent Specific Gravity	2.63		
Bulk specific gravity = $\frac{A}{(S+B-C)}$	2.45	2.50	2.60
Average Bulk Specific Gravity	2.51		
Specific graviry = S/(B+S _ C)	2.49	2.55	2.65
Average specific gravity	2.56		
absorption capacity % = $\frac{S-A}{A} * 100$	1.63	2.04	2.73
Average absorption capacity %	1.83		

After evaluating a sample of fine aggregate made from river sand at the Mekelle University concrete laboratory, I found that the fine aggregate had an average absorption capacity of 1.83 percent, an average specific gravity of 2.56, an average bulk specific gravity of 2.51, and an average apparent specific gravity of 2.63. These findings suggest that the sample sand and fine aggregate are of a high caliber and suitable for use in the manufacturing of concrete. The quality of fine aggregates used in the making of concrete can be assessed using several different standards. A maximum absorption capacity of 2 percent is required for the fine aggregate, per the standards cited, which include ASTM C33, ACI 211.1, AASHTO M6/M80, BS EN 12620, IS 383, and the Ethiopian Standard.

3.2.4 Moisture content determination

By oven drying the fine aggregate sample for approximately 24 hours at 105°C to 110°C and then cooling it for an hour, the moisture content of the sample was ascertained. By dividing the weight difference by the oven-dry weight and multiplying the result by 100, the moisture content was determined to be 2.94 percent. The maximum permissible moisture content for fine aggregates is 3 percent, according to ASTM C566, the standard test method for total evaporable moisture content of aggregate by drying. As a result, the sample fine aggregate's moisture content falls within the range that is appropriate for fine aggregates, as shown in Table 3 - 4 and Table 3 - 5 [30].

Table 3 - 4: Moisture content of sand

Observation	**1**	**2**	**3**
Mass of wet sand, A	1000	500	800
Mass of dry sand, B	971	486	777
Moisture content (%) , $\frac{A - B}{B} * 100$	2.99	2.88	2.96
Average moisture content (%)	2.94		

Table 3 - 5: Summarized test results for the physical property of fine aggregate

No	**Physical test for fine aggregate**		**Results**
1	Silt content	sand from Temben Aby Adi	2.66 %
2	Fineness modulus		2.82
3	Specific gravity	Bulk specific gravity	2.56
		Bulk specific gravity(SSD)	2.51
		Apparent specific gravity	2.63
4	Absorption capacity		0.603

5	Moisture content	2.94 %

3.3 Testing of Course Aggregates

Testing of coarse aggregate the physical and mechanical characteristics of the coarse aggregates used in the C-25 concrete mix were assessed in this study using a battery of common laboratory tests. Particle size distribution (sieve analysis), specific gravity and water absorption, aggregate crushing value (ACV), flakiness and elongation index, and moisture content determination were among these tests. In order to achieve a well-graded mix, the sieve analysis was utilized to evaluate the aggregates' gradation and verify adherence to standard specifications. The density and porosity of the aggregates, which are essential for precise mix proportioning, were revealed by specific gravity and water absorption tests. The ACV test was used to gauge.

Because excessively flaky or elongated particles can adversely affect the workability and compaction of concrete, flakiness and elongation indices were calculated to assess the shape characteristics of the aggregates. In order to maintain the intended water-to-cement ratio and modify the mix water accordingly, the moisture content was measured. The majority of aggregates used in concrete in Ethiopia come from natural sources, like crushed rock or gravel that has had large elements crushed or screened and processed to the appropriate maximum size. By Ethiopian standards, coarse aggregates are defined as particles sized between 75- and 4.75-mm. Crushed rock, blast furnace slag, and gravel are the most common types of aggregates.

3.3.1 Unit Weight

The design standards employed determine the unit weight of coarse particles frequently used in normal-weight concrete. From many civil engineering design standards, including IS: 1350 - 1650 kg/m3, BS 1400 - 1750 kg/m3, ACI 1410 - 1680 kg/m3, and ASTM 1410 - 1680 kg/m3, Additionally Ethiopian Standards 1375–1675 kg/m3. As a result, the 1666.50 kg/m3 unit weight of coarse aggregate (compacted unit weight) from the Mekelle University concrete laboratory falls within the permissible range for normal-weight concrete unit weights and is appropriate for concrete lab work as shown in

Table 3 **- 6**.

Table 3 - 6: Unit weight of coarse aggregate (compacted unit weight)

Observation	**1**	**2**	**3**
Cylinder wt (kg)	2.968	2.968	2.968
Cylinder + loss wt (kg)	7.84	8.192	7.810
loss wt(kg), A	4.898	5.215	4.88
Cylinder volume (m^3), B		$3*10^{-3}$	
Unit weight = A/B (Kg/M^3)	1613	1738.33	1628
Average unit weight	1666.5 **kg/m^3**		

3.3.2 Gradation (sieve analysis) of coarse aggregate

Gradation of coarse aggregate refers to the distribution of particle sizes within a given sample and plays a vital role in determining the workability, strength, and durability of concrete. A well-graded aggregate contains a variety of sizes that fill the voids between larger particles, resulting in better compaction, reduced cement and water demand, and improved concrete performance. Coarse aggregates are typically graded through a series of standard sieves, and the percentage retained on each sieve is used to plot a gradation curve. This curve helps assess whether the aggregate meets specified grading limits, such as those outlined in ASTM C33 or other local standards. A uniformly graded aggregate, where most particles are of a similar size, can lead to high void content, requiring more paste to fill gaps, which weakens the concrete. On the other hand, a well-graded aggregate ensures better packing, reduces shrinkage, and enhances durability. Gap-graded aggregates, which lack certain intermediate sizes, may be used intentionally for specific purposes, such as reducing bleeding or segregation. Therefore, proper gradation of coarse aggregate is essential for achieving optimal concrete performance and efficient material use. Therefore, the sieve analysis is used to determine the particle size distribution of aggregate using sieves and to determine the fineness modulus of aggregate. The weight of the sample used is 5000 grams, as shown in

Table 3 **- 7**.

Table 3 - 7: Test result Gradation (sieve analysis) of coarse aggregate

Sieve size (mm)	**Weight of sieve**	**wt of sieve+ retained soil**	**Mass Retained (gm)**	**Percent retained (%)**	**Com. % retained**	**Percentage finer (%)**
37.5	1707	1707	0	0	0	100
28.00	1727	2406	679	13.58	13.58	86.42
20.00	1612	4376	2764	55.28	68.86	31.14
14.00	1353	2576	1223	24.46	93.32	6.68
10.00	1325	1632	307	6.14	99.46	0.54
5	1368	1391	23	0.46	99.92	0.08
2.36	0	0`	0	0	99.92	0.08
1.18	0	0	0	0	99.92	0.08
0.60	0	0	0	0	99.92	0.08
0.30	0	0	0	0	99.92	0.08
0.15	0	0	0	0	99.92	0.08
Pan	757	761	4	0.08	100.00	0

3.3.3 Specific Gravity and Water Absorption Determination of Coarse Aggregate

Sample Mekelle University tests conducted using several standards for civil engineering design coarse aggregate's bulk specific gravity (SSD form): The range of values given by the EN Eurocodes and related standards for coarse aggregates is encompassed by the average value of

2.60. The ASTM C127-15 standard test technique for relative density (specific gravity) and coarse aggregate absorption also addresses it. Consequently, this outcome is regarded as favorable[31]. Absorption capacity of coarse aggregate: The absorption capacity of 0.67% is within the range of values specified by the Indian Standard- Methods of Test for Aggregates for Concrete – Specific Gravity, Density, Voids, Absorption, and Bulking. It is also covered by the ASTM C127-15 standard test method for relative density (specific gravity) and absorption of coarse aggregate. Therefore, this result is considered good. Moisture content of coarse aggregate: The average moisture content of 0.08% is lower than the maximum limit of 2% specified by the National Ready Mixed Concrete Association (NRMCA). It is also covered by the ASTM C566-19 [32]. Standard test method for total evaporable moisture content of aggregate by drying. Therefore, this result is considered good, as shown in Table 3 - 8[33].

Table 3 - 8: Specific Gravity and Water Absorption determination of course aggregate

Observation	1	2	3
Weight of oven-dry test sample in air, gm A	1843	1283	1109
Weight of saturated surface dry test sample in air, gm B	1840	1293	1119
Weight of saturated surface dry test sample in water, gm C	1140	799.31	682
Bulk specific gravity (SSD form) = B/(B _ C)	2.61	2.62	2.56
Average	2.60		
Absorption capacity. ((B-A) /A) *100	0.33	0.78	0.90
Average absorption capacity %	0.67		

3.3.4 Moisture Content Determination of Coarse Aggregate

Prevent problems like decreased strength, segregation, or excessive shrinkage. The most popular technique is oven-drying, in which a representative after weighing a sample of the aggregate, it is dried in an oven between 105°C and 110°C until its weight remains constant. The weight of the wet and dry samples is compared to determine the moisture content. The amount of water that was initially in the aggregate is represented by the difference. The percentage of the dry weight is used to express this value. Alternatively, when quick results are needed, quicker field techniques like the speedy moisture tester may be employed. In order to guarantee consistency in concrete production and performance, routine moisture content checks are especially crucial when aggregates are kept outside and exposed to the elements. as shown in Table 3 - 9.

Table 3 - 9: Moisture content determination of coarse aggregate

Observation	1	2	3
Mass of sand in air, A	1279	1235	1473
Mass of dry sand, B	1277	1232	1470
Moisture content (%) , (A – B)/B * 100	0.16	0.24	0.20
Average moisture content (%)	**0.20**		

CHAPTER 4.

4. RESULTS AND DISCUSSIONS

4.1 Result Analysis of Compressive Strength by Table and Poker Vibration

4.1.1 The compressive strength of concrete at 3 days by Table Vibration

Concrete's three-day compressive strength is a crucial measure of early-age performance, particularly for construction projects that move quickly. Table vibration was used in this study to compact concrete specimens for 5, 15, 30, 45, 60, and 75 seconds. The findings demonstrate a direct correlation between compressive strength and vibration time. Insufficient compaction at five seconds of vibration led to poor consolidation and a higher void content, which decreased compressive strength. Strength significantly increased as the vibration duration increased to 15 and 30 seconds, suggesting improved air void removal and particle rearrangement. At 45 seconds, the compressive strength kept rising until it reached an ideal range where the concrete was well-compacted and showed no indications of segregation. At 60 seconds, the strength either stabilized or showed slight improvement; however, at 75 seconds, there was a slight reduction in strength, possibly due to over-vibration, which can cause segregation and bleeding. These findings highlight that proper control of vibration duration is essential, and an optimal range (typically between 30 and 45 seconds in this case) yields the best early compressive strength results at 3 days, as shown in Table 4 - .

Table 4 - 1: The compressive strength of concrete at 3 days by Table Vibration

Compressive strength at 3 days and table vibration for 5 seconds

No.	Description	Sample 1	Sample 2	Sample 3
1	Mass of Specimen in kg	8.261	8.419	8.347
2	Peak load in KN	216.41	209.32	198.62
3	Cross-sectional Area m^2	22.5	22.5	22.5
4	Compressive strength in MPa	9.62	9.30	8.83
5	Average Compressive strength in	**9.25**		

Compressive strength at 3 days and table vibration for 15 seconds

No.	Description	Sample 1	Sample 2	Sample 3
1	Mass of Specimen in kg	8.247	8.628	8.175
2	Peak load in KN	234.51	242.28	233.64
3	Cross-sectional Area m^2	22.5	22.5	22.5
4	Compressive strength in MPa	10.42	10.77	10.38
5	Average Compressive strength in	**10.52**		

Compressive strength at 3 days and table vibration for 30 seconds

No.	Description	Sample 1	Sample 2	Sample 3
1	Mass of Specimen in kg	8.456	8.279	8.317
2	Peak load in KN	258.76	246.25	253.58
3	Cross-sectional Area m^2	22.5	22.5	22.5
4	Compressive strength in MPa	11.50	10.94	11.27
5	Average Compressive strength in	**11.24**		

Compressive strength at 3 days and table vibration for 45 seconds

No.	Description	Sample 1	Sample 2	Sample 3
1	Mass of Specimen in kg	7.942	8.194	8.271

2	Peak load in KN	291.45	288.47	298.34
3	Cross-sectional Area m^2	22.5	22.5	22.5
4	Compressive strength in MPa	12.95	12.82	13.26
5	Average Compressive strength in	**13.01**		

Compressive strength at 3 days and table vibration for 60 seconds

No.	Description	Sample 1	Sample 2	Sample 3
1	Mass of Specimen in kg	8.329	8.461	8.514
2	Peak load in KN	261.49	254.16	273.62
3	Cross-sectional Area m^2	22.5	22.5	22.5
4	Compressive strength in MPa	11.62	11.30	12.16
5	Average Compressive strength in	**11.69**		

Compressive strength at 3 days and table vibration for 75 seconds

No.	Description	Sample 1	Sample 2	Sample 3
1	Mass of Specimen in kg	8.613	8.258	8.476
2	Peak load in KN	251.64	242.57	236.17
3	Cross-sectional Area m^2	22.5	22.5	22.5
4	Compressive strength in MPa	11.18	10.78	10.50
5	Average Compressive strength in	**10.82**		

The compressive strength of concrete at 3 days was evaluated under different durations of table vibration to determine the optimal compaction time. The results showed a gradual increase in compressive strength as the vibration time increased from 5 to 45 seconds, followed by a decline beyond that point. In particular, the average compressive strength was found to be 9.25 MPa after 5 seconds of vibration, 10.52 MPa after 15 seconds, 11.24 MPa after 30 seconds, and

13.01 MPa at 45 seconds. Nevertheless, the strength dropped to 11.69 MPa and then to 10.82 MPa at 75 seconds when the vibration time was increased to 60 seconds. These results imply that while longer vibration times improve concrete compaction and early strength development, too much vibration can cause segregation or over compaction, which would be detrimental to strength. Consequently, 45 seconds of table vibration seems to be the ideal amount of time to maximize the concrete's 3-day compressive strength, as demonstrated in Figure 4 - 1.

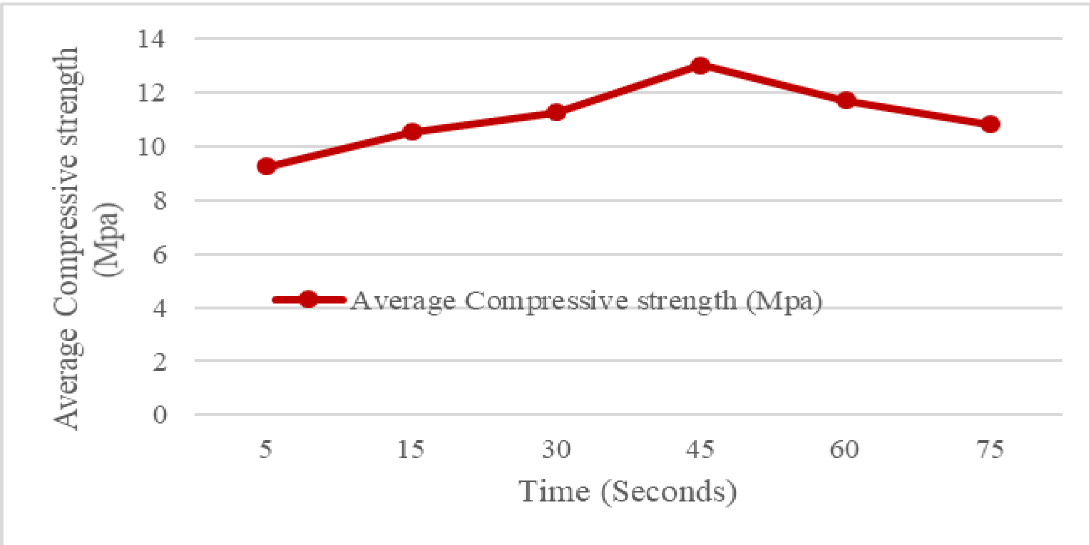

Figure 4 - 1: Average compressive strength of concrete at 3 days by Table Vibration

4.2.2 The compressive strength of concrete at 7 days by Table Vibration

For evaluating early structural capacity and forecasting 28-day performance, concrete's 7-day compressive strength serves as a crucial benchmark. Concrete specimens were vibrated on a table for 5, 15, 30, 45, 60, and 75 seconds, and they were tested after seven days. The findings showed a discernible pattern in the correlation between strength and vibration time. Due to inadequate compaction, air voids, and poor aggregate-paste bonding, the concrete showed comparatively low compressive strength at 5 seconds of vibration. The strength considerably increased as the vibration duration was extended to 15 and 30 seconds, indicating more efficient internal void reduction and consolidation. At about 45 seconds of vibration, the highest compressive strength was usually seen, indicating ideal compaction conditions. However, when the vibration time was extended to 60 and 75 seconds, a slight reduction in strength was observed. This reduction may be attributed to over-vibration, which can lead to segregation of the mix, especially the settling of coarse aggregates and bleeding of water, weakening the concrete matrix. These results indicate that controlled vibration between 30 and 45 seconds provides the most favorable balance for achieving higher compressive strength at 7 days, as shown in

Table 4 - 2.

Table 4 - 2: The compressive strength of concrete at 7 days by Table Vibration

Compressive strength at 7 days and table vibration for 5 seconds

No.	Description	Sample 1	Sample 2	Sample 3
1	Mass of Specimen in kg	8.452	8.215	8.381
2	Peak load in KN	326.51	342.69	254.74
3	Cross-sectional Area m^2	22.5	22.5	22.5
4	Compressive strength in MPa	14.51	15.23	11.32
5	Average Compressive strength in	**13.69**		

Compressive strength at 7 days and table vibration for 15 seconds

No.	Description	Sample 1	Sample 2	Sample 3
1	Mass of Specimen in kg	8.613	8.258	8.476
2	Peak load in KN	369.42	376.19	384.71
3	Cross-sectional Area m^2	22.5	22.5	22.5
4	Compressive strength in MPa	16.42	16.72	17.10
5	Average Compressive strength in	**16.75**		

Compressive strength at 7 days and table vibration for 30 seconds

No.	Description	Sample 1	Sample 2	Sample 3
1	Mass of Specimen in kg	8.613	8.258	8.476
2	Peak load in KN	374.12	381.47	348.72
3	Cross-sectional Area m^2	22.5	22.5	22.5

4	Compressive strength in MPa	16.63	16.95	16.82
5	Average Compressive strength in	**16.80**		

Compressive strength at 7 days and table vibration for 45 seconds

No.	Description	Sample 1	Sample 2	Sample 3
1	Mass of Specimen in kg	8.617	8.341	8.467
2	Peak load in KN	395.46	412.43	433.57
3	Cross-sectional Area m^2	22.5	22.5	22.5
4	Compressive strength in MPa	17.58	18.33	19.27
5	Average Compressive strength in	**18.39**		

Compressive strength at 7 days and table vibration for 60 seconds

No.	Description	Sample 1	Sample 2	Sample 3
1	Mass of Specimen in kg	8.271	8.358	8.176
2	Peak load in KN	374.18	391.79	382.49
3	Cross-sectional Area m^2	22.5	22.5	22.5
4	Compressive strength in MPa	16.63	17.41	17.00
5	Average Compressive strength in	**17.01**		

Compressive strength at 7 days and table vibration for 75 seconds

No.	Description	Sample 1	Sample 2	Sample 3
1	Mass of Specimen in kg	8.453	8.342	8.673
2	Peak load in KN	362.48	372.26	376.43
3	Cross-sectional Area m^2	22.5	22.5	22.5

4	Compressive strength in MPa	16.11	16.54	16.73
5	Average Compressive strength in	**16.46**		

The 7-day compressive strength of concrete subjected to varying durations of table vibration was examined to evaluate the influence of compaction time on strength development. The results indicate a general increase in strength with longer vibration times, up to a certain threshold. The average compressive strength was recorded as 13.69 MPa for 5 seconds of vibration, increasing significantly to 16.75 MPa at both 15 and 30 seconds. At 45 seconds, there was an additional increase, with peak strength of 18.39 MPa. The strength did, however, slightly decrease when the vibration duration was increased beyond 45 seconds, with values of 17.01 MPa at 60 seconds and 16.46 MPa at 75 seconds. According to this pattern, excessive vibration may cause segregation or decreased bonding within the matrix, even though increased vibration improves concrete compaction and strength for up to 45 seconds. Thus, a vibration time of 45 seconds seems to be ideal for obtaining the highest 7-day compressive strength, similar to the 3-day results. As shown in Figure 4 - 2.

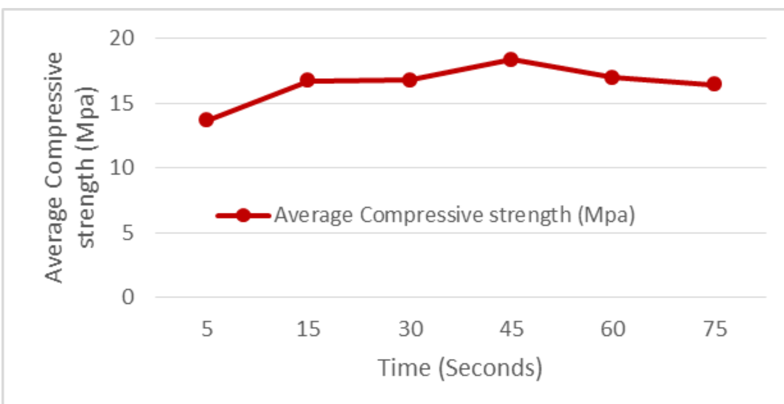

Figure 4 - 2: Average compressive strength of concrete at 7 days by Table Vibration

4.2.3 The compressive strength of concrete at 28 days by Table Vibration

The most widely accepted criterion for assessing concrete's long-term performance and structural quality is its 28-day compressive strength. In this study, C-25 concrete specimens were tested after 28 days after being compacted using table vibration for varying amounts of time: 5 seconds, 15 seconds, 30 seconds, 45 seconds, 60 seconds, and 75 seconds. The findings showed a distinct pattern in which compressive strength was directly impacted by the length of vibration.

Because of insufficient compaction, which resulted in voids and decreased the density of the hardened matrix, the concrete displayed the lowest strength at five seconds. Strength significantly increased when the vibration was increased to 15 and 30 seconds, suggesting improved paste-aggregate bonding and more efficient air removal. The highest compressive strength was typically achieved at 45 seconds of vibration, where the mix appeared optimally compacted without signs of segregation. At 60 and especially 75 seconds, a slight decline in strength was noted, which may be attributed to over-vibration. Prolonged vibration can cause segregation, where heavier coarse aggregates settle and water or cement paste migrates, disrupting the uniformity of the mix and reducing its overall strength. These findings suggest that for C-25 concrete, vibration duration of approximately 30 to 45 seconds using a table vibrator yields the best compressive strength at 28 days, ensuring both density and uniformity in the hardened concrete, as shown in Table 4 - .

Table 4 - 3: The compressive strength of concrete at 28 days by Table Vibration

Compressive strength at 28 days and table vibration for 5 seconds

No.	**Description**	**Sample 1**	**Sample 2**	**Sample 3**
1	Mass of Specimen in kg	8.613	8.258	8.476
2	Peak load in KN	518.75	521.57	514.76
3	Cross-sectional Area m^2	22.5	22.5	22.5
4	Compressive strength in MPa	23.06	23.18	22.88
5	Average Compressive strength in	**23.04**		

Compressive strength at 28 days and table vibration for 15 seconds

No.	**Description**	**Sample 1**	**Sample 2**	**Sample 3**
1	Mass of Specimen in kg	8.346	8.218	8.496
2	Peak load in KN	561.71	568.19	572.49
3	Cross-sectional Area m^2	22.5	22.5	22.5
4	Compressive strength in MPa	24.96	25.25	25.44
5	Average Compressive strength in	**25.22**		

Compressive strength at 28 days and table vibration for 30 seconds

No.	Description	Sample 1	Sample 2	Sample 3
1	Mass of Specimen in kg	8.513	8.298	8.416
2	Peak load in KN	576.16	573.24	586.13
3	Cross-sectional Area m^2	22.5	22.5	22.5
4	Compressive strength in MPa	25.61	25.48	26.05
5	Average Compressive strength in	**25.71**		

Compressive strength at 28 days and table vibration for 45 seconds

No.	Description	Sample 1	Sample 2	Sample 3
1	Mass of Specimen in kg	8.213	8.457	8.178
2	Peak load in KN	596.72	626.18	618.93
3	Cross-sectional Area m^2	22.5	22.5	22.5
4	Compressive strength in MPa	26.52	27.83	27.51
5	Average Compressive strength in	**27.29**		

Compressive strength at 28 days and table vibration for 60 seconds

No.	Description	Sample 1	Sample 2	Sample 3
1	Mass of Specimen in kg	8.419	8.559	8.646
2	Peak load in KN	569.23	578.46	586.97
3	Cross-sectional Area m^2	22.5	22.5	22.5
4	Compressive strength in MPa	25.30	25.71	26.09
5	Average Compressive strength in	**25.70**		

Compressive strength at 28 days and table vibration for 75 seconds

No.	Description	Sample 1	Sample 2	Sample 3
1	Mass of Specimen in kg	8.246	8.341	8.751

2	Peak load in KN	562.16	571.62	573.17
3	Cross-sectional Area m^2	22.5	22.5	22.5
4	Compressive strength in MPa	24.98	25.41	25.47
5	Average Compressive strength in	**25.29**		

The compressive strength of concrete at 28 days was assessed under various durations of table vibration to determine the long-term effects of compaction time. The results demonstrated a consistent trend of increasing strength with extended vibration duration up to a certain point, followed by a slight decline. In particular, the average compressive strength increased to 25.22 MPa at 15 seconds and 25.71 MPa at 30 seconds from 23.04 MPa at 5 seconds of vibration. At 45 seconds, the maximum strength of 27.29 MPa was recorded. Nevertheless, there was a slight decline in strength after this peak, with values dropping to 25.70 MPa at 60 seconds and 25.29 MPa at 75 seconds. These results imply that while moderate increases in vibration time enhance strength and compaction, excessive vibration may have a detrimental effect on the internal structure of the concrete. In order to achieve the maximum 28-day compressive strength, table vibration duration of 45 seconds is found to be the most effective, as shown in Figure 4 - 3.

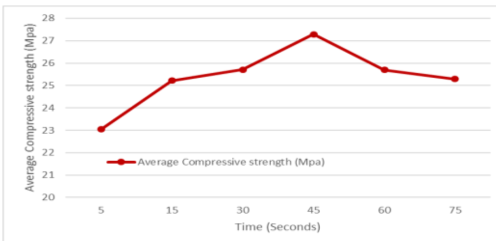

Figure 4 - 3: Average compressive strength of concrete at 28 days by Table Vibration

In conclusion, table vibration applied for 5, 15, 30, 45, 60, and 75 seconds was used to analyze the compressive strength of C-25 concrete at 3, 7, and 28 days. The findings showed that the length of vibration has a major impact on concrete's strength development. Compressive strength at all curing ages was lowest at a brief vibration time of 5 seconds, mostly because of inadequate consolidation and trapped air. Strength significantly increased when the vibration was increased to 15 and 30 seconds, suggesting more efficient compaction and a decrease in internal voids. For all curing ages, the maximum compressive strength was typically reached at 45 seconds, indicating ideal vibration that improves density and aggregate-paste bonding without causing segregation. But when the vibration time was extended to 60 and 75 seconds, the strength either slightly increased or slightly decreased, most likely as a result of segregation and bleeding from excessive vibration. Overall, the study finds that the best compressive strength for C-25 concrete at early and standard curing ages can be achieved with table vibration duration of roughly 30 to 45 seconds.

4.2.4 The compressive strength of concrete at 3 days by Poker Vibration

Early information about the rate of strength development and the efficacy of compaction techniques can be found in the concrete's compressive strength after three days. A poker vibrator was used in this study to compact C-25 concrete specimens for one, two, three, four, five, and six seconds. The results showed that the duration of poker vibration had a noticeable impact on the early compressive strength of the concrete. Due to insufficient internal compaction, which resulted in trapped air and poor consolidation, the strength was comparatively low at 1 and 2 seconds. Compressive strength significantly improved as the vibration time increased to 3 and 4 seconds, suggesting improved mix packing and more effective air void removal. The peak compressive strength at 3 days was typically observed at around 5 seconds, suggesting that this duration allowed optimal internal compaction without causing segregation. However, when the vibration time reached 6 seconds, a slight decline or plateau in strength was noticed, possibly due to over-vibration, which can disturb the aggregate distribution and lead to localized weaknesses. These findings indicate that, for early-age strength development using poker vibration, an optimal duration of 4 to 5 seconds is most effective in enhancing the compressive strength of C-25 concrete at 3 days, as shown in Table 4 - .

Table 4 - 4: The compressive strength of concrete at 3 days by Poker Vibration

Compressive strength at 3 days and poker vibration for 1 second

No.	Description	Sample 1	Sample 2	Sample 3
1	Mass of Specimen in kg	7.891	8.618	8.245
2	Peak load in KN	231.85	216.43	209.49
3	Cross-sectional Area m^2	22.5	22.5	22.5

4	Compressive strength in MPa	10.30	9.62	9.31
5	Average Compressive strength in	**9.74**		

Compressive strength at 3 days and poker vibration for 2 seconds

No.	Description	Sample 1	Sample 2	Sample 3
1	Mass of Specimen in kg	8.156	8.364	8.419
2	Peak load in KN	249.23	232.71	241.64
3	Cross-sectional Area m^2	22.5	22.5	22.5
4	Compressive strength in MPa	11.08	10.34	10.74
5	Average Compressive strength in	**10.72**		

Compressive strength at 3 days and poker vibration for 3 seconds

No.	Description	Sample 1	Sample 2	Sample 3
1	Mass of Specimen in kg	8.516	8.418	8.241
2	Peak load in KN	264.19	252.39	246.81
3	Cross-sectional Area m^2	22.5	22.5	22.5
4	Compressive strength in MPa	11.74	11.22	10.97
5	Average Compressive strength in	**11.31**		

Compressive strength at 3 days and poker vibration for 4 seconds

No.	Description	Sample 1	Sample 2	Sample 3
1	Mass of Specimen in kg	8.347	8.341	8.278
2	Peak load in KN	286.95	294.42	293.78
3	Cross-sectional Area m^2	22.5	22.5	22.5
4	Compressive strength in MPa	12.75	13.09	13.06
5	Average Compressive strength in	**12.97**		

Compressive strength at 3 days and poker vibration for 5 seconds

No.	Description	Sample 1	Sample 2	Sample 3
1	Mass of Specimen in kg	8.451	8.642	8.514

2	Peak load in KN	248.97	266.48	251.64
3	Cross-sectional Area m^2	22.5	22.5	22.5
4	Compressive strength in MPa	11.07	11.84	11.18
5	Average Compressive strength in	**11.36**		

Compressive strength at 3 days and poker vibration for 6 seconds

No.	Description	Sample 1	Sample 2	Sample 3
1	Mass of Specimen in kg	8.261	8.419	8.347
2	Peak load in KN	254.61	235.46	226.34
3	Cross-sectional Area m^2	22.5	22.5	22.5
4	Compressive strength in MPa	11.32	10.46	10.06
5	Average Compressive strength in	**10.61**		

The effect of poker vibration duration on the 3-day compressive strength of concrete was investigated to determine the optimal internal compaction time. The results show a progressive increase in strength with increasing vibration duration up to 4 seconds, followed by a decline with further vibration. In particular, the average compressive strength was 9.74 MPa at one second of poker vibration, rising to 10.72 MPa at two seconds, 11.31 MPa at three seconds, and peaking at 12.97 MPa at four seconds. Beyond this point, though, a decline in strength was noted, with values falling to 11.36 MPa at 5 seconds and 10.61 MPa at 6 seconds.

This pattern implies that excessive vibration may result in segregation or disruption of the concrete matrix, whereas shorter durations may result in incomplete compaction. In order to maximize the compressive strength of concrete after three days, a poker vibration duration of four seconds is thought to be ideal, as shown in Figure 4 - 4.

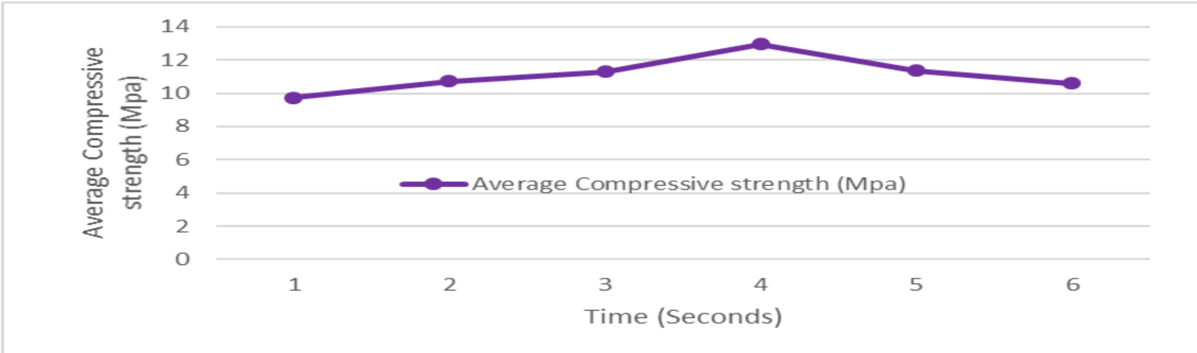

Figure 4 - 4: Average compressive strength of concrete at 3 days by Poker Vibration

4.2.5 The compressive strength of concrete at 7 days by Poker Vibration

The 7-day compressive strength of concrete serves as an important measure of early structural capacity and indicates the effectiveness of compaction techniques. In this study, C-25 concrete was compacted for 1, 2, 3, 4, 5, and 6 seconds using a poker vibrator. After seven days, the concrete's compressive strength was measured. The findings showed that relatively low compressive strengths were produced by extremely brief vibration durations, such as one or two seconds. This was attributed to insufficient consolidation, which left trapped air voids and caused poor aggregate interlocking. As the vibration time increased to 3 and 4 seconds, there was a notable improvement in compressive strength, showing more efficient air removal and better particle arrangement within the concrete matrix. The maximum strength was typically recorded at 5 seconds of vibration, suggesting optimal internal compaction. However, extending the vibration to 6 seconds did not lead to a significant gain and, in some cases, showed a slight reduction in strength, likely due to the beginning of over-vibration effects such as segregation or bleeding. These findings demonstrate that optimal poker vibration duration of 4 to 5 seconds provides the best results for enhancing 7-day compressive strength in C-25 concrete, as shown in

Table 4 - 5.

Table 4 - 5: The compressive strength of concrete at 7 days by Poker Vibration

Compressive strength at 7 days and poker vibration for 1 second

No.	Description	Sample 1	Sample 2	Sample 3

1	Mass of Specimen in kg	8.146	8.203	8.406
2	Peak load in KN	316.54	325.61	341.89
3	Cross-sectional Area m^2	22.5	22.5	22.5
4	Compressive strength in MPa	14.07	14.47	15.20
5	Average Compressive strength in	**14.58**		

Compressive strength at 7 days and poker vibration for 2 seconds

No.	Description	Sample 1	Sample 2	Sample 3
1	Mass of Specimen in kg	8.012	8.601	8.423
2	Peak load in KN	326.15	331.52	358.52
3	Cross-sectional Area m^2	22.5	22.5	22.5
4	Compressive strength in MPa	14.50	14.73	15.93
5	Average Compressive strength in	**15.05**		

Compressive strength at 7 days and poker vibration for 3 seconds

No.	Description	Sample 1	Sample 2	Sample 3
1	Mass of Specimen in kg	8.462	8.154	8.462
2	Peak load in KN	369.46	374.29	379.48
3	Cross-sectional Area m^2	22.5	22.5	22.5
4	Compressive strength in MPa	16.42	16.64	16.87
5	Average Compressive strength in	**16.64**		

Compressive strength at 7 days and poker vibration for 4 seconds

No.	Description	Sample 1	Sample 2	Sample 3
1	Mass of Specimen in kg	8.452	8.526	8.204

2	Peak load in KN	416.46	398.79	405.42
3	Cross-sectional Area m^2	22.5	22.5	22.5
4	Compressive strength in MPa	18.51	17.72	18.02
5	Average Compressive strength in	**18.08**		

Compressive strength at 7 days and poker vibration for 5 seconds

No.	Description	Sample 1	Sample 2	Sample 3
1	Mass of Specimen in kg	8.631	8.392	8.547
2	Peak load in KN	381.76	362.41	387.95
3	Cross-sectional Area m^2	22.5	22.5	22.5
4	Compressive strength in MPa	16.97	16.11	17.24
5	Average Compressive strength in	**16.77**		

Compressive strength at 7 days and poker vibration for 6 seconds

No.	Description	Sample 1	Sample 2	Sample 3
1	Mass of Specimen in kg	8.261	8.419	8.347
2	Peak load in KN	371.58	369.16	376.18
3	Cross-sectional Area m^2	22.5	22.5	22.5
4	Compressive strength in MPa	16.51	16.41	16.72
5	Average Compressive strength in	**16.55**		

The 7-day compressive strength of concrete was investigated with varying durations of poker vibration to analyze the influence of internal compaction time on medium-term strength development. The results indicated a consistent increase in compressive strength as vibration time increased from 1 to 4 seconds, followed by a slight decline with further vibration. At one second, the average compressive strength was 14.58 MPa; at two seconds, it increased to 15.05 MPa; and at three seconds, it reached 16.64 MPa. After four seconds of poker vibration, the maximum strength of 18.08 MPa was reached. Longer vibration durations, however, were associated with a decrease in strength, which dropped to 16.77 MPa at 5 seconds and 16.55 MPa at 6 seconds. These findings imply that while increased vibration enhances strength and compaction up to a certain point, excessive vibration may have negative consequences like internal disruption or segregation. In order to achieve the highest 7-day compressive strength in concrete using poker vibration, vibration duration of 4 seconds is thought to be ideal, as shown in Figure 4 - 5.

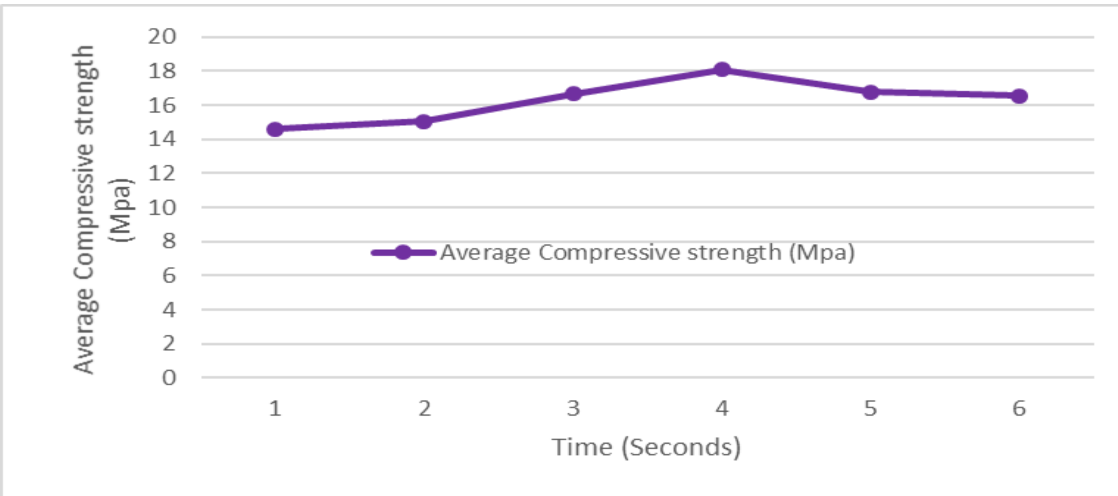

Figure 4 - 5: Average compressive strength of concrete at 7 days by Poker Vibration

4.2.6 The compressive strength of concrete at 28 days by Poker Vibration

One important measure of concrete's long-term structural performance and durability is its 28-day compressive strength. In order to evaluate the effect of vibration time on compressive strength, C-25 concrete specimens were compacted using poker vibration for different durations: 1, 2, 3, 4, 5, and 6 seconds. The findings demonstrated that the lowest compressive strengths at 28 days were produced by extremely short vibration times, such as 1 and 2 seconds. The main cause of this was insufficient internal compaction, which resulted in voids and hindered the cement paste and aggregates from properly bonding. Compressive strength dramatically increased as the vibration time was extended to 3 and 4 seconds, suggesting improved aggregate interlock and efficient air void removal. After five seconds of vibration, the highest compressive strength was usually reached, indicating an ideal balance between compaction and uniformity. At 6 seconds, a slight decline or plateau in strength was observed, which may suggest the onset of over-vibration effects such as segregation or bleeding. These results indicate that, for C-25 concrete, a poker vibration time of approximately 4 to 5 seconds is optimal for achieving maximum 28-day compressive strength, ensuring proper consolidation without compromising mix integrity, as shown in

Table 4 **-** .

Table 4 - 6: The compressive strength of concrete at 28 days by Poker Vibration

Compressive strength at 28 days and poker vibration for 1 second

No.	Description	Sample 1	Sample 2	Sample 3
1	Mass of Specimen in kg	8.309	8.298	8.164
2	Peak load in KN	529.41	542.68	539.75
3	Cross-sectional Area m^2	22.5	22.5	22.5
4	Compressive strength in MPa	23.53	24.12	23.99
5	Average Compressive strength in	**23.88**		

Compressive strength at 28 days and poker vibration for 2 seconds

No.	Description	Sample 1	Sample 2	Sample 3
1	Mass of Specimen in kg	8.513	8.247	8.163
2	Peak load in KN	536.76	564.53	543.86
3	Cross-sectional Area m^2	22.5	22.5	22.5
4	Compressive strength in MPa	23.86	25.09	24.17
5	Average Compressive strength in	**24.37**		

Compressive strength at 28 days and poker vibration for 3 seconds

No.	Description	Sample 1	Sample 2	Sample 3
1	Mass of Specimen in kg	8.649	8.234	8.561
2	Peak load in KN	560.28	571.46	576.4
3	Cross-sectional Area m^2	22.5	22.5	22.5
4	Compressive strength in MPa	24.90	25.40	25.62
5	Average Compressive strength in	**25.31**		

Compressive strength at 28 days and poker vibration for 4 seconds

No.	Description	Sample 1	Sample 2	Sample 3
1	Mass of Specimen in kg	8.346	8.271	8.416
2	Peak load in KN	618.49	599.81	608.03
3	Cross-sectional Area m^2	22.5	22.5	22.5
4	Compressive strength in MPa	27.49	26.66	27.02
5	Average Compressive strength in	**27.06**		

Compressive strength at 28 days and poker vibration for 5 seconds

No.	Description	Sample 1	Sample 2	Sample 3
1	Mass of Specimen in kg	8.246	8.615	8.421
2	Peak load in KN	588.34	572.29	570.17
3	Cross-sectional Area m^2	22.5	22.5	22.5
4	Compressive strength in MPa	26.15	25.44	25.34
5	Average Compressive strength in	**25.64**		

Compressive strength at 28 days and poker vibration for 6 seconds

No.	Description	Sample 1	Sample 2	Sample 3
1	Mass of Specimen in kg	8.416	8.519	8.341
2	Peak load in KN	561.28	572.46	543.19
3	Cross-sectional Area m^2	22.5	22.5	22.5
4	Compressive strength in MPa	24.95	25.44	24.14
5	Average Compressive strength in	**24.84**		

The 28-day compressive strength of concrete was evaluated under different durations of poker vibration to determine the long-term effects of internal compaction time. The results showed a steady increase in compressive strength as the vibration time increased from 1 to 4 seconds, after which a gradual decline was observed. In particular, the average compressive strength increased to 24.37 MPa at two seconds and 25.31 MPa at three seconds from 23.88 MPa at 1 second.4 seconds of poker vibration produced the maximum strength of 27.06 MPa, indicating the ideal compaction time. The compressive strength then gradually dropped to 25.64 MPa at 5 seconds and 24.84 MPa at 6 seconds. This pattern implies that while moderate internal vibration increases the strength and compaction of concrete, excessive vibration may result in internal flaws like segregation or loss of homogeneity, which would ultimately lower strength. Therefore, the optimal duration of poker vibration to maximize 28-day compressive strength is found to be 4 seconds, as shown in Figure 4 - 6.

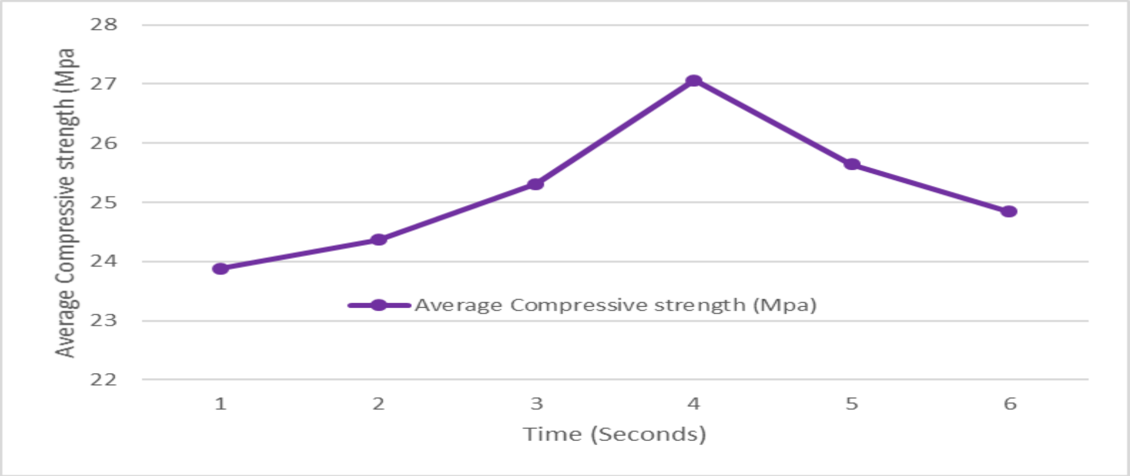

Figure 4 - 6: Average compressive strength of concrete at 28 days by Poker Vibration

In conclusion, poker vibration was used for 1, 2, 3, 4, 5, and 6 seconds to assess the compressive strength of C-25 concrete at 3, 7, and 28 days. The findings showed that vibration duration has a major impact on strength development, with a consistent trend across all curing ages. Due to inadequate internal compaction, which resulted in the presence of air voids and weak antiparticle bonding, the compressive strength remained relatively low at shorter durations (1 and 2 seconds). There were discernible improvements as the vibration time was extended to 3 and 4 seconds, with improved consolidation and a decrease in voids leading to higher strength values. Across all testing ages, the peak compressive strength was typically reached at 5 seconds of vibration, suggesting an ideal duration that offers efficient compaction without causing segregation. However, a slight decrease or plateau in strength was observed at 6 seconds, indicating that excessive vibration may start to have a detrimental effect on the structural integrity and uniformity of the concrete. Overall, the results show that a poker vibration duration of 4 to 5 seconds produces the best compressive strength performance at both early and later ages, making it the most efficient range for guaranteeing high-quality concrete in terms of durability and strength.

Finally, using poker and table vibrators, this comparative summary examines the impact of vibration technique and duration on the compressive strength of C-25 concrete at 3, 7, and 28 days. Concrete samples were compacted for 1, 2, 3, 4, 5, and 6 seconds in order to create the poker vibration. Compressive strength was low at shorter times (1-2 seconds) for all age groups. Due to inadequate internal compaction. Strength considerably increased as the duration was extended to 3–5 seconds, with peak performance typically noted at 5 seconds, which provided ideal compaction without causing segregation. A marginal strength plateau or decline was caused by a slight over-vibration at 6 seconds.

By contrast, table vibration was used for longer periods of time (5, 15, 30, 45, 60, and 75 seconds).Shorter durations (5–15 seconds) demonstrated reduced strength, similar to poker vibration. to inadequate compaction, whereas the highest strength values were obtained at durations of 30 to 45 seconds. However, strength was somewhat diminished when vibration was prolonged to 60–75 seconds, which was explained by effects of bleeding and segregation.

Overall, both approaches showed comparable trends in strength development, with over-vibration creating structural weaknesses and under-vibration failing to achieve adequate compaction. Table vibration needed a longer ideal range, whereas poker vibration worked well with shorter durations. Five seconds for poker vibration and thirty to forty-five seconds for table vibration were the most effective compaction times for optimizing compressive strength.

CHAPTER 5.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This study examined the effects of vibration duration and technique on the development of C-25 concrete's compressive strength at 3, 7, and 28 days. Specifically, table vibration (5, 15, 30, 45, 60, and 75 seconds) and poker vibration (1, 2, 3, 4, 5, and 6 seconds). The findings showed that the type and duration of vibration had a significant impact on compressive strength.

Because of possible segregation and bleeding, the best strength gains were obtained at moderate vibration times, while diminishing returns or strength reductions were seen at excessive durations. This modification was thus caused by the poker vibrators and table vibrator's incremental time lengths above the ideal time of 4 and 45 seconds, respectively. The poker vibrator demonstrated its applicability for scenarios needing quick compaction by achieving maximum efficiency in significantly shorter time frames than the table vibrator.

At all curing ages, properly vibrated specimens outperformed under- or over-vibrated counterparts, highlighting the need for precise vibration control. The study concludes that selecting the appropriate vibration technique and duration is critical to maximizing the structural performance of C-25 concrete, and poker vibration emerges as a more time-efficient way under controlled conditions. Future study may build on this work by examining various concrete grades, altering aggregate sizes, or employing hybrid vibration techniques for better compaction results.

5.2 Rrecommendations

Several important suggestions to improve construction methods and guarantee structural integrity can be made in light of the study's findings regarding the effects of vibration techniques on the compressive strength and correlation time of C-25 concrete:

Start vibration when the stinger is submerged into the new concrete vertically and quickly (i.e., about 1-foot per second), then withdraw slowly (i.e., about 4sec per foot); and, on the table vibrator is 45 sec.

Put the stinger into each portion of the new concrete. When fresh concrete is poured in layers, place the stinger about 6 inches in the previous layer, then stop vibration when the surface becomes shiny, and there are no more breaking air bubbles.

Proper attention should be taken in selecting the aggregate size and shape used for Concrete cast by vibration. The size and angularity of the coarse aggregates would affect the effort required to tamp the new concrete. The larger the size of aggregates, the greater the effort required, whiles the angular aggregates require greater effort than smooth or rounded aggregates**.**

In conclusion, the results of this study show that obtaining the appropriate compressive strength in C-25 concrete requires careful control of vibration technique and duration. Construction professionals can greatly increase the longevity, dependability, and performance of concrete structures by implementing the aforementioned suggestions.

5.3 Future Research

There are still a number of areas that need more research, even though this study has shed important light on how poker and table vibrators affect the correlation time and compressive strength of C-25 concrete. To provide a more thorough comparison across various concrete applications, future research can broaden the scope by examining additional vibration techniques, such as surface vibrators or combined vibration methods. A broader range of concrete grades (such as C-30 and C-40) could be investigated in studies to see if the trends are consistent across different strength levels. Furthermore, using sophisticated monitoring instruments and real-time compaction assessment technologies, future studies could examine the effects of vibration frequency, amplitude, and duration in greater detail. Further research is necessary to determine how environmental factors like temperature, humidity, and curing techniques affect vibration techniques' effectiveness. Furthermore, a deeper understanding of how vibration affects internal concrete structure may be obtained through the microstructures analysis of vibrated concrete using methods like X-ray computed tomography (CT) or scanning electron microscopy (SEM).

Finally, field-based case studies in real construction settings, especially in the Ethiopian context, would be beneficial to validate laboratory findings and assess the practical performance, cost-effectiveness, and user suitability of different vibration methods in large-scale projects. These areas of future research can help in developing more robust, efficient, and context-specific vibration practices for improving concrete quality and construction outcomes

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APPENDIX 1 MIXES DESIGN USING ACI METHODE

Procedures of Mix Design

The procedure for the selection of mix proportions given in this research applies to normal-weight concrete. Although the same basic data and procedures can be used in proportioning heavy, the mix design was conducted for C-25 Concrete grade cubes using the ACI method design procedures, as shown in the steps below.

Step 1 - Choice of slump 25 to 75mm.

Since the mix design is for mass concrete, the recommended slump requirement is in the range between. The slump is required to be 25 to 75mm as shown in

Slumps for various types of constructions

Types of construction	Slump (mm)	
	Maximum	**Minimum**
Reinforced foundation wall and footings	76	25
Plain footing, caissons, and substructure walls.	75	25
Beam and reinforced wall	100	25
Building columns	100	25
Pavements and slabs	75	25
Mass concrete	75	25

Step 2 - Choice of nominal maximum size of aggregate

From sieve analysis, the maximum size of aggregate was found to be 28 mm, as seen in the table above. And the nominal maximum size of the aggregate is nominal maximum size of the aggregate is determined by the smallest sieve size that retains more than 10% of the total aggregate weight. Based on the retained weights provided, the nominal maximum size of the aggregate is 20; let’s consider it as 19 mm.

Step 3 - Estimation of mixing water

It explains the approximate mixing water and non-air-entrained concrete requirements for different slumps and the nominal maximum size of aggregates. The estimated mixing water is 190 kg/m3 of concrete, as indicated based on normal maximum sizes of aggregate with a slump of 25-75, as shown in

The estimated mixing water

Slump (mm)	**Water kg/m3 of concrete for the indicated normal maximum sizes of aggregate**							
	9.5	**12.5**	**19**	**25**	**37.5**	**50**	**75**	**150**
	Non-air-entrained concrete							
25 to 50	207	199	190	179	166	154	130	113
75 to 100	228	216	205	193	181	169	145	124
150 to 175	243	228	216	202	190	178	160	-
Approximate amount of entrapped air in non-air-entrained concrete, percent	3	2.5	2	1.5	1	0.5	0.3	0.2

Step 4 - Determining water-cement ratio

The selection of the water-cement ratio by mass is given by crossing the table below. Therefore, Compressive strength at 28 days, 25mpa water cement ratio by mass for non-air entrained concrete is 0.61kg, and the target strength of the given is 28.3. By interpolation, the value of to cement ratio becomes 0.564 kg. The required mix design strength characteristic strength of 25MPa for cube F_c= 25×0.8=20MPa, since there is no previous data, the target strength = F_c+8.3MPa= 20+8.3=28.3 MPa, as shown in

Relationships b/n water water-cement ratio and compressive strength of concrete.

Compressive strength at 28 days (MPa)	Water-cement ratio by mass	
	Non-air-entrained concrete	Air-entrained concert
40	0.42	-
35	0.47	3.39
30	0.54	0.45
28.3	0.564	
25	0.61	0.52
20	0.69	0.60
15	0.79	0.70

Step-5. Determining cement content

Cement content=Water content/ (w/c) = 337Kg/m^3

Step 6 - Estimation of coarse aggregate content

The dry mass of coarse aggregate required for a cubic meter of concrete is equal to the value from Table (d) multiplied by the dry-rodded unit mass of the aggregate in kilograms per cubic meter. Table (d) - Volume of coarse aggregate per unit of volume of concrete as shown in

The estimation of coarse aggregate content

Nominal maximum size of aggregate (mm)	Volume of dry-rodded coarse aggregate per unit volume of concrete for different fineness modules of the aggregate			
	2.40	2.60	2.80	3.00
9.5	0.50	0.48	0.46	0.44
12.5	0.59	0.57	0.55	0.53
19	0.66	0.64	0.62	0.60
25	0.71	0.69	0.67	0.65
37.5	0.75	0.73	0.71	0.69
50	0.78	0.76	0.74	0.72
75	0.82	0.80	0.78	0.76

Quantity of coarse aggregate for a fine aggregate having fineness modules of 2.82 and 19mm nominal maximum size of aggregate, the reduction factor is obtained using interpolation: 0.61*1666.5kg/m3 =1016.56 kg.

Step 7 - Estimate of fine aggregate

Weight of fresh concrete for Nominal max size of aggregate 19 mm = 2345 kg/m3. Estimation of fine aggregate content as shown in

First estimate of mass of fresh concrete

Nominal max size of aggregate	**First estimate of concrete unit mass kg/m3**	
	Non-air-entrained concrete	**Air-entrained concrete**
9.5	2280	2200
12.5	2310	2223
19	2345	2275
25	2380	2290
37.5	2410	2350
50	2445	2345
75	2490	2405
100	2530	2435

Absolute volume method

To calculate the absolute volume of fresh concrete, we need to sum the volumes of air, coarse aggregate, cement, and water. However, we assume that there is no entrapped air by assuming that the air content is one percent, which is equivalent to 0.02. Assuming air = 2% = 0.020m3 as shown in.

The absolute volume method of fresh concrete

No	Ingredients	Using Absolute volume (m^3)	Result
1	Water	190/1000=0.190 m^3	0.190 m^3
2	Cement	337/(3.15*1000)= 0.107 m^3	0.107 m^3
3	Coarse aggregate	1016.56 /(2.60*1000)=0.390 m^3	0.390 m^3
4	Entrapped air 2 %	2/100 = 0.020 m^3	0.020 m^3
	Total volume	0.707 m^3	0.707 m^3
5	Volume of Fine aggregate	1-0.707= 0.293 m^3	0.293 m^3
6	Weight of fine aggregate =	$G_{FA} \times V_{FA} \times 1000$ G_{FA}=2.56, V_{FA}=0.293	750.08 Kg

Therefore, since the fine aggregate contains moisture, the water for mix should be adjusted as follows: Moisture content of Coarse aggregate=0.20%, absorption capacity = 0.67 %

Moisture content of Fine aggregate=2.94%, absorption capacity = 1.83%

Wet Coarse aggregate=1016.56 * (1+ 0.002) =1018.59 kg

Wet Fine aggregate=750.08* (1 + 0.0294) = 772.13 kg

Surface water contributed by Coarse aggregate = 0.20 – 0.67= -0.47%

Fine aggregate = 2.94 – 1.83= 1.11%

The estimated requirement of added

$$190 - \frac{1016.56\,(-0.47)}{100} - \frac{750.08\,(1.11)}{100} = 190 + 4.77 - 8.32 = 186.45\text{kg}$$

To assess the suitability of the trial batch for concrete production, we need to check the proportions of fine aggregate and coarse aggregate in comparison to common standards. The adjusted batch masses you provided are as follows: Cement: 337 kg/m³, Water: 186.45 kg, Fine Aggregate: 772.13kg, Coarse Aggregate: 1018.59 kg, and W/C (Water-Cement Ratio): 0.564.