ADDIS ABABA UNIVERSITY

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SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING

EFFECT OF SALT WATER ON COMPRESSIVE STRENGTH OF PLAIN MASS CONCRETE

A Thesis in structural engineering

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A Thesis

Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science

The undersigned have examined the thesis entitled '**Effect of Salt Water on Compressive Strength of Plain Mass Concrete** ' presented by **BIRESAW MULUYE**, a candidate for the degree of **Master of Science** and hereby certify that it is worthy of acceptance.

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UNDERTAKING

I certify that research work titled "Effect of Salt Water on Compressive Strength of Plain Mass Concrete" is my own work. The work has not been presented elsewhere for assessment. Where material has been used from other sources it has been properly acknowledged / referred.

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Biresaw Muluye

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LIST OF ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
ASTM	American Society for Testing and Materials
BS	British Standard
C.Agg	Coarse Aggregate
cm	Centimeter
ERA	Ethiopian Road Authority
F.M	Fines Modulus
g	Gram
Kg	Killo gram
L	Liter
mm	Millimeter
MPa	Mega Pascal
NaCl	Sodium Chloride
OPC	Ordinary Portland cement
ppm	Parts Per Million
SSD	Saturated Surface Dry

ABSTRACT

In this research work, the effect of salt water on compressive strength of plain mass concrete had been investigated. This paper therefore presents the results and findings of an experimental research on the effect of salt water on compressive strength of concrete. For this, fifty four (54) concrete cubes were cast; 9 cubes were cast using clean water,9 cubes were cast using a salt water sample prepared by adding 10 g sodium chloride salt per liter of clean water, 9 cubes were cast using a salt water sample prepared by adding 20 g sodium chloride salt per liter of clean water, 9 cubes were cast using a water sample prepared by adding 30 g sodium chloride salt per liter of clean water, 9 cubes were cast using a salt water sample prepared by adding 35 g sodium chloride salt per liter of clean water and the remaining 9 cubes were cast using salt water sample prepared by adding 40 g sodium chloride salt per liter of clean water. Design mix of C-25 with mix ratio 1:2.2:2.9 and 0.45 water- cement ratio was prepared for this research work. The concrete cubes were cured separately and cured for 7, 28 and 45 days. i.e. concrete cubes casted by using clean water were cured in clean water, concrete cubes casted by using a salt water samples with a concentration of 10 g ,20 g,30 g,35 g and 40 g sodium chloride salt per liter of clean water were cured in a salt water with a concentration of 10 g ,20 g ,30 g,35 g and 40 g sodium chloride salt per liter of clean water respectively. The results of the average compressive strengths of concrete cubes both mixed and cured by clean water were 25.61,37.46 and 39.58 in MPa, The results of the average compressive strength of concrete cubes both mixed and cured by salt water with a concentration of 10 g sodium chloride salt per liter of clean water were 31.28,39.07 and43.85 MPa , the result of the average compressive strength of concrete cubes both mixed and cured by salt water with a concentration of 20 g sodium chloride salt per liter of clean water were 31.87,40.59 and 43.95 MPa, the result of the average compressive strength of concrete cubes both mixed and cured by salt water with a concentration of 30 g sodium chloride salt per liter of clean water were 32.34,42.03 and 45.34 MPa, the result of the average compressive strength of concrete cubes both mixed and cured by salt water with a concentration of 35 g sodium chloride salt per liter of clean water were 34.21,42.27 and 45.53 MPa and the result of the average compressive strength of concrete cubes both mixed and cured by salt water with a concentration of 40 g sodium chloride salt per liter of clean water were 36.26,44.92 and 43.57 MPa for the hydration period of 7, 28, and 45 days respectively. From the laboratory test result, it was discovered that when we use salt water both in mixing and curing purpose in the concrete production, the compressive strength of plain mass concrete was increased.

Keywords: - Concrete Cubes, Clean Water, Salt water, Compressive Strength

CHAPTER 1 INTRODUCTION

1.1 Background of the Study

Concrete is one of the most commonly used construction material in the world. It is basically composed of three components: cement, water and aggregates. Water is an essential component of concrete. Combining water with a cementations material forms a cement paste by the process of hydration. The cement paste glues the aggregate together, fills voids within it, and allows it to flow more freely. Less water in the cement paste will yield a stronger, more durable concrete; more water will give a free-flowing concrete with a higher slump. Impure water used to make concrete can cause problems when setting or in causing premature failure of concrete structures. And it has been found that impurity in water samples used in mixing concrete can impair the strength of concrete especially the compressive strength of concrete [24]. In a similar way, water used for curing concrete can impair the strength of the concrete [24]. Impurities and deleterious substances which are largely introduced from water used in mixing concrete are likely to interfere with the process of hydration, preventing effective bond between the aggregates and matrix. The impurities sometimes reduce the durability of the aggregate [24].Excessive impurities in mixing water may affect not only setting time, concrete strength, and volume stability (length change), but may also cause efflorescence. Where possible, water with high concentrations of dissolved solids should be avoided. Salts or other deleterious substances contributed from the aggregate or admixtures are additive to those that might be contained in the mixing water. These additional amounts are to be considered in evaluating the acceptability of the total impurities that may be deleterious to concrete. There are many sources of salt water. Among these Sources, Sea is the predominant one. The primary chemical constituents of salt water are the ions of chloride, sodium, magnesium, calcium and potassium. The concentration of major salt constituents of salt water we are given in weight % of salt as 78%NaCl, 10.5% $MgCl2$, 5% $MgSO4$, 3.9% $CaSO4$, 2.3% $K2SO4$, and 0.3% KBr. It is evident from the above sodium chloride is by far the predominant salt component of seawater [20]. Sea water has a total salinity of about 3.5% (78% of the dissolved solids being Nacl and 15% $MgCl2$ and $MgSO4$).

Generally, the effects on setting are unimportant if water is acceptable from strength consideration. Water containing large quantities of chlorides (sea water) tends to cause persistent dampness and surface efflorescence. Such water should, therefore not be used where appearance is important, or where a plaster- finish is to be applied [20].

In the present investigation, the effects of salt water on compressive strength of plain mass concrete were determined. C-25 grade of concrete is used to determining the effect of salt water on compressive strength of plain mass concrete.

1.2 Statement of the Problem

Different researchers have given different conclusions about the effect of salt on the compressive strength of concrete i.e. some researchers concluded that compressive strength of concrete increases when we use salt water, while other researchers concluded that compressive strength of concrete decrease when we use salt water and some other researchers verified that compressive strength of concrete increase when we use water contains small amount of salt but decreases when water contains large amount of salt.

1.3 Objectives of the Study

1.3.1 General Objective

The general objective of this is to investigate effect of salt water on compressive strength of plain mass concrete.

1.3.2 Specific Objectives

- To know the percentage increase or decrease of compressive strength between concrete mixed and cured with different concentration of salt in water.
- To know the percentage increase or decrease of compressive strength between concrete mixed and cured by clean water and different concentration of salt in water.
- To compare the rate of gaining of compressive strength between concrete cubes both mixed and cured by different concentration of salt water and clean water.

1.4 Material and Methodology

1.4.1 Materials

The details of various materials used in the experimental investigation are as follows:-

- Coarse Aggregates: Crushed granite stone aggregate of maximum size 20mm confirming to AASHTO M43-88/ASTM C136 was used. The specific gravity were found to be 2.72 for (6-12.5mm) size of particle and 2.70 for (12.5-19.5mm) size of particle, the moisture content were found to be 1.12% for (6-12.5mm) size of particle and 1.42% for (12.5-19.5mm) size of particle, Unit weight were found to be 1594 Kg/m3 for (6-12.5mm) size of particle and 1687 Kg/m3 for (12.5-19.5mm) size of particle and absorption were found to be 0.2% for (12.5-19.5mm) size of particle and 0.5 for (6-12.5mm) size of particle.
- Sand (fine aggregate): The fine aggregate used in this investigation was Metihara river sand confirming to BS 882 was used. The specific gratuity was found to be 2.52, the moisture content was found to be 5.47%, absorption was found to be 2.04%, Unit weight was found to be 1660 Kg/m3 and silt content was found to be 4.115%.
- Cement: OPC 42.5 grade Dangote cement was used.
- Clean Water: Ordinary clean portable water free from suspended particles and chemical substances from material laboratory of Addis Ababa Institute of Technology (AAiT) was used for both mixing and curing of concrete cubes cast with fresh water.
- Salt water: Salt water is prepared by mixing sodium chloride salt and clean water according to the dosage of salt in the sample. There are five salt water samples in this research work. These are 10 g/L,20g/L,30g/L,35g/L and 40 g/L .This means, for 10 g/L there is 10 g sodium chloride salt per liter of clean water ,20 g/L there is 20 g sodium chloride salt per liter of clean water, 30 g/L there is 30 g sodium chloride salt per liter of clean water, 35 g/L there is 35g sodium chloride salt per liter of clean water, and 40 g/L there is 40 g sodium chloride salt per liter of clean water.

1.4.2 Methodology

As this paper is experimental investigation, the methodologies are as follows:-

1. Physical properties of the quarry sand and crushed aggregate were conducted. These properties are the particle size distribution based on AASHTO M6-93 for fine aggregate and AASHTO M43-88 for coarse aggregate, bulk specific gravity (SSD basis), unit weight, moisture content, absorption for both fine and coarse aggregates and also silt content of sand.
2. Mix design for C-25 was prepared. ACI211.1-91 was used for preparation of mix design [4]. After mix design of 1m3 of C-25 concrete was made, required quantity of cement, sand, coarse aggregate and water for nine cubes of (150 x 150 x 150 mm3) for each six types of mix for 7, 28 and 45 days compressive strength of concrete was determined. Out of nine cubes for each types of mix, the first three cubes used for 7 days compressive strength of concrete, the second three cubes used for 28 days compressive strength of concrete and the last three cubes used for 45 days compressive strength of concrete.
3. The water samples were divided into six parts (A-F) for mixing purpose. Sample A contained 0 g sodium chloride salt per liter of clean water ; sample B contained 10 g sodium chloride salt per liter of clean water ; Sample C contained 20 g sodium chloride salt per liter of clean water ; sample D contained 30 g sodium chloride salt per liter of clean water ; Sample E contained 35 g sodium chloride salt per liter of clean water and sample F contained 40 g sodium chloride salt per liter of natural water .
4. The required quantity quarry sand at saturated surface Dry (SSD), cement and coarse aggregate (crushed stone also at SSD condition) was measured and the water samples prepared in step 3 were spread in the mixer for each six types of mix. Each mix is differing only in mixing water. Mix one uses water sample A, mix two uses water sample B, mix three uses water sample C, mix four uses water sample D, mix five uses water sample E and mix six uses water sample F. The constituents were thoroughly mixed until a good consistency mix was obtained. The slump test was performed on each batch in accordance with provisions of BS 1881 (1996). The specimens were then cast in three layers; each layer was vibrated for 0.3 -0.45 minutes. The top surfaces of the specimens were toweled flat and molded in the laboratory for 24 hours.
5. Six curing tanks were prepared. Curing tank one contain only clean water, curing tank two contain 10 g sodium chloride salt liter of clean water, curing tank three contain 20 g sodium chloride salt per liter of clean water, curing tank four contain 30 g sodium chloride salt per

liter of clean water, curing tank five contain 35 g sodium chloride salt per liter of clean water and curing tank six contain 40 g sodium chloride salt per liter of clean water.

6. After curing tanks were prepared the concrete cubes for each mix were demolded and cured by immersion in water in the curing tanks. Curing tank one used for mix one, curing tank two used for mix two, curing tank three used for mix three, curing tank four used for mix four, curing tank five used for mix five and curing tank six used for mix six.
7. Lastly**,** the concrete samples were tested using compressive testing machine at each curing time and the compressive strength of each of these samples were recorded and analyzed.

1.5 Organization of the Thesis

This thesis is organized by five chapters. The name and their aims of each chapter are described as follows;

Chapter One: Introduction. The introduction part consists from Background of the research, Statement of the problem, Objectives of the research, Materials and methodology of the research.

Chapter Two: Literature review of the research. The literature review part consists of introduction to the literature, meaning of mixing water Sources of water used in concrete production, Function of water during the production of concrete, Quality of water for making concrete, brief definition of Saline Water and different conclusion given by different researchers on effect of Salinity on Compressive Strength of Concrete.

Chapter Three: Experimental Investigation. This chapter consists of physical tests of ingredients of concrete such as specific gravity of coarse and fine aggregates, moisture Content of coarse and fine aggregates, absorption of coarse and fine aggregates, unit weight of coarse and fine aggregates and silt content of sand and proportioning of ingredients of concrete.

Chapter Four: Result and Discussion. This chapter consists from the test result of slump, compressive strength of concrete and discussion on effect of salt water on compressive strength of concrete based on the experimental result obtained.

Chapter Five: Conclusion and Recommendation. This chapter consists from conclusion, recommendation and further studies.

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

During the construction of concrete structures, concrete may be to have properties that comprise strength, elasticity, water tightness and durability. Concrete strength comprises compressive, tensile and shear strengths. From these strength of concrete compressive strength is the predominant one. Compressive strength or compression strength is the capacity of a material or structure to withstand loads tending to reduce size, as opposed to tensile strength, which withstands loads tending to elongate. In other words, compressive strength resists compression (being pushed together). Elasticity stands for modulus of elasticity and creep. Durability of concrete is the ability of concrete to maintain its quality throughout its designed service life. Since the primary function of practically all structures is to carry loads or resist applied forces of whatever nature, concrete used for such purposes must have strength. Although in some cases other characteristics may be more important, the compressive strength of concrete is commonly considered as its most valuable property.

Concrete properties are highly influenced by the water type used and its proportion in the concrete mix. Almost any natural water that is drinkable (potable) and has no pronounced taste or odor is satisfactory as mixing water for making concrete. But in some arid areas local drinking water is saline in nature and also there is no sufficient clean water in some industrial area due to contamination of clean water by industrial wastes, and forcing the ready mixed concrete industry to review the logistics of raw material supply. A review of literature pertaining to usage of salt water for concrete shows conflicting results. There are many Researchs conducted on the effect of salt water on concrete strength especially on compressive strength. However clear cut conclusion has not established until now. Therefore laboratory tests are important to give clear cut conclusion on the effect of salt water on the compressive strength of concrete.

2.2 Mixing water

Water is an important constituent in concrete. It chemically reacts with cement (hydration) to produce the desired properties of concrete. Mixing water is the quantity of water that comes in contact with cement impacts slump of concrete and is used to determine the water to cement ratio (w/c) of the concrete mixture. Strength and durability of concrete is controlled to a large extent by its water cement ratio. Mixing water in concrete includes batch water measured and added to the mixer at the batch plant, ice, and free moisture on aggregates, water included in any significant quantity with chemical admixtures, and water added after batching during delivery or at the jobsite. Water absorbed by aggregates is excluded from mixing water.

Besides its quantity, the quality of mixing water used in concrete has important effects on fresh concrete properties, such as setting time and workability; it also has important effects on the strength and durability of hardened concrete [18].

2.3 Sources of water used in concrete production

In general, water that is fit for human consumption (potable) is acceptable for use as mixing water. However, non-potable sources of water can also be used provided the source does not negatively impact the properties of concrete. Most concrete plants have a source of municipal water that supplies potable water and this can be used as mixing water without any qualification test .In rural areas, or for portable plants set up on project sites the concrete producer may have to rely on non-potable sources such as wells, streams or other bodies of water. All concrete producers will also generate process water by cleaning mixers and plant components, also referred to as wash water. Additionally, precipitation on the site of the concrete plant generates storm water that may be collected at the plant. Environmental regulations typically require concrete plants to treat process and storm water to achieve certain characteristics like pH or solids content before discharged from the property. Process and storm water at concrete plants is referred to as water from concrete production operations in ASTM C 1602.

Process water is also generated when returned concrete is washed out in concrete reclaimed systems. These systems collect process water with the cement and aggregate fines in the form of slurry that can be re-used as mixing water in the concrete [18].

2.4 Function of water during the production of concrete

Water wets the surface of aggregates, facilitating the spreading of cement over the aggregates and makes the mix workable, initiates the hydration process of cement subsequently starts the setting and hardening process and controls the heat generation which is the biggest concern of mass concrete structures by hydration process of the cement [18].

2.5 Quality of water for making concrete

The quality of the water plays an important role in the preparation of concrete. Impurities in water may interfere with the setting of the cement and may adversely affect the strength and durability of the concrete. The chemical constituents present in water may actively participate in the chemical reactions and thus affect the setting, hardening and strength development of concrete. The suitability of water can be identified from past service records or tested to performance limits such as setting times and compressive strength and durability. Test limits are specified for mixing water with their constituents such as total alkalis, chloride and sulfate. Testing of water play an important role in controlling the quality of cement concrete work. Systematic testing of the water helps to achieve higher efficiency of cement concrete and greater assurance of the performance in regard to both strength and durability. Water is susceptible to being changed due to physical, chemical or biological reactions which may take place between at the time of sampling and analyzing Hence it is necessary to test water before used for cement concrete production [6].

Almost any natural water that is drinkable (potable) and has no pronounced taste or odor is satisfactory as mixing water for making concrete. Excessive impurities in mixing water may affect not only setting time, concrete strength, and volume stability (length change), but may also cause efflorescence or corrosion of reinforcement. Where possible, water with high concentrations of dissolved solids should be avoided. Salts or other deleterious substances contributed from the aggregate or admixtures are additive to those that might be contained in the mixing water. These additional amounts are to be considered in evaluating the acceptability of the total impurities that may be deleterious to concrete or ASTM C1602 allows the use of potable water without testing and includes methods for qualifying non potable sources of water with consideration of effects on setting time and strength. Testing frequencies are established to ensure continued monitoring of water quality ASTM C1602 includes optional limits for chlorides, sulfates, alkalis, and solids in mixing water that can be invoked when appropriate [5].

There are no standards governing the quality of water for use in mixing concrete. In most cases, water that is suitable for drinking and that has no pronounced taste or odor may be used. It is generally thought that the pH of the water should be between 6.0 and 8.0. Salt water or brackish water must not be used as mixing water, because chlorides and other salts in such water will attack the structure of the concrete and may lead to corrosion of prestressing tendons. Strands and wires used as tendons are particularly susceptible to corrosion due to their small diameter and higher stresses compared to reinforcing bars [16].

Water fit for drinking is generally suitable for making concrete. Harmful substances if present in large amounts are: salt, oil, industrial wastes, alkalis, sulphates, organic matter, silt, sewage etc. Smell, sight or taste should reveal such impurities. Water of doubtful quality should be submitted for laboratory analysis and tests. The use of seawater does not appear to have any adverse effect on the strength and durability of Portland cement concrete but it is known to cause surface dampness, efflorescence and staining. Seawater also increases the risk of corrosion of steel and its use in reinforced concrete is not recommended. In general, the presence of impurities in the curing water doesn't have any harmful effects, although it may spoil the appearance of concrete [2].

2.6 Brief definition of Saline Water

Saline water (more commonly known as salt water) is water that contains a significant concentration of dissolved salts (mainly NaCl). The salt concentration is usually expressed in parts per thousand (permille, ‰) or parts per million (ppm). The United States Geological Survey classifies saline water in three salinity categories. Salt concentration in slightly saline water is around 1,000 to 3,000 ppm(0.1–0.3%), in moderately saline water 3,000 to 10,000 ppm (0.3–1%) and in highly saline water 10,000 to 35,000 ppm (1–3.5%). Seawater has a salinity of roughly 35,000 ppm, equivalent to 35 grams of salt per one liter (or kilogram) of water [26].

2.7 Concrete

A composite materials consisting of building medium or glue i.e. cement and water in which particles of relatively inert filter materials (i.e. sand and granite aggregate) are embedded is called concrete. Properties of a concrete is improved or modified occasionally through the application of materials called admixture. The basic components constituting materials in a concrete are cement, fine and coarse aggregate (gravel or granite) and water. Admixtures are occasionally added.

2.7.1 Strength of Concrete

The maximum load or stress a concrete could withstand is referred to as its strength. The potential strength of concrete is determined by the properties and composition of its embedded material. The compressive strength of concrete is commonly used in the construction industry for the purpose of specification and quality control. A primary function of all structures is to carry load or resist applied forces of whatever nature. The proportion of water to cement, the age of the concrete, the quality as well as the mix and shape of the specimen tested determines the strength. A specimen tested for compressive strength will have a higher indicated strength if the specimen is dry before testing whereas flexural strength will be lower in a dry specimen, strength must be carefully planned, designed and controlled.

2.7.2 Compressive Strength of Concrete

The compressive strength of concretes constitutes one of its most significant and useful properties and is the most easily determined. The compressive strength of concrete is taken as the maximum compressive load it can carry per unit area. Concrete strength of up to 80N/mm2 can be achieved by selective use of the type of cement, mix proportions, method of compaction and curing conditions. Since the compressive strength constitutes an important and useful properties, it is used as a measure of overall quality of the concrete and thus as an indication of other properties relating to determination of durability.

2.8 Salinity and Compressive Strength of Concrete

The most commonly considered valuable property of concrete is its compressive strength, although in many practical cases, other characteristics such as durability, impermeability, volume and stability may in fact be more important. Yet, the overall picture of the quality of concrete is usually provided by its compressive strength. Obviously water satisfactorily used for mixing is as well suitable for curing purpose. Concrete properties are highly influenced by the water type used and its proportion in the concrete mix. From these properties of concrete compressive strength is the dominant one and highly influenced by the water type used and its proportion in the concrete mix. Due to this, many Researchs had conducted a research on the effect of salt water on compressive strength of concrete both directly and indirectly. Conclusions given by different researchers are presented as follows:

P. KRISHNAM RAJU, V. RAVINDRA et al., had aimed to adopt marine water both for mixing and curing of concrete in the construction industry as the potable water is a scarce commodity on the planet Earth. Two concrete mixes viz, M20 and M25 using ordinary Portland cement (OPC) of 53 Grade as per the Guide lines of concrete mix proportioning with a slump of 100 to 150mm were considered. The mixes were prepared with “Potable water mixing and Sea water curing” & “Sea water mixing and Sea water curing”. A total specimen of 54 cubes, 54 cylinders and 54 beams including specimens for reference concrete were cast for both the mixes and exposed to 7days, 28days and 90days period of curing in order to investigate the compressive strength behavior, modulus of rupture and flexural strength. The reference concrete is prepared with OPC using potable water mixing and cured with the same water. The study reveals that there is no reduction in compressive strength due to mixing of sea water and also due to mixing and curing with sea water compared to its target strength [7].

Preeti Tiwari, Rajiv Chandak et al., had conducted a research work on the effect of salt water on the compressive strength of concrete was investigated. This paper therefore presents the result and findings of an experimental research on the effect of salt water on compressive strength of concrete. For this concrete cubes were cast using fresh water and salt water for a design mix of M-30 1:1.8:3.31 by weight of concrete and 0.45 water- cement ratio. Half of concrete cubes were cast and cured with fresh water and remaining half cubes were cast and cured with salt water. In this research the salt water obtained by mixing 35g sodium chloride salt per liter of fresh water. The concrete cubes were cured for 7, 14 and 28 days respectively. The study reveals that there is some increase in the strength if salt water is used for casting and curing. This concrete can be used for mass concreting without any decrease in strength properties [24].

Premachand1 Mohd.Younas Mohiuddin2 M.A.Haleem3 had conducted a research work on Salinity effect on properties of M20 Grade concrete in different normality condition. For this 24 concrete cubes and cylinders were casted using fresh water and saline water concentrations of 8g, 16g and 24g NaCl salt per one liter of clean water for a design mix of M-20 concrete, and 0.55 water cement ratio. Concrete specimens were casted and cured with fresh water and remaining specimens were casted and cured with saline water .The concrete cubes were tested for 7, 14 and 28 days respectively. The study reveals that there is some increase in the strength if salt water is used for casting and curing .This concrete can be used for mass concreting without any decrease in strength properties [25].

Olutoge, F. Adeyemi1 and Amusan, G. Modupeola2 had conducted a research on The Effect of Sea Water on Compressive Strength of Concrete. On his work, 140 concrete cubes were made in two batches; half of the cubes were made using fresh water and the other half using sea water with constant water cement ratio. They were cured in fresh and sea water respectively. The curing was done for 7, 14, 21, 28 and 90days.The study concluded that there is an increase in the compressive strength of concrete for concrete specimens mixed and cured with sea water and Compressive strength of the concrete was also affected when the concrete was cast with fresh water and cured with salt water and vice-versa [22].

G Sai Teja1, Amar.B.P2, Neethu.R.Manoj3, Venkatesh E4, Prathyusha Tenepalli5 had conducted a research work on Study of Compressive Strength of Concrete Made Using Saline Water .For this Concrete samples of 150mm x 150mm were cast using saline water of four different concentrations of 4g, 10g, 30g and 60g NaCl salt per one liter of water .All the four samples were cured by total submersion in pure water. These specimens were observed for 14 days for compressive strength development before crushing with universal testing machine. The study reveals that small amounts of salinity in mixing water improve the compressive strength of concrete [13].

Donald F. Griffin and Robert L. Henry had conducted a research work on the effect of salt in concrete on compressive strength, water vapor transmission and corrosion of reinforcing steel. For this, concrete cubes prepared by using clean water and saline water contains different concentration of NaCl salt per liter of clean water with water cement ratios of 0.444 and 0.702.The concrete cubes were cured for 14 days. The study concludes that Maximum compressive strength occurs between salinities of 18 and 36 gm/kg for concrete incorporating NaCI in the mixing water [8].

Dr. Nagabhushana1, Dharmaraj Hebbal2, Nitin Akash3, S Deepak4, Mukesh Kumar5 had conducted a research work on the effect of salt water on compressive strength of concrete was investigated. For this, the concrete cubes were casted for a mix design of M-40, 1:1.30:2.63 by weight and 0.50 water-cement ratio was considered. The salt of various proportions like (25, 30, 35, 40, 45) grams/ liter of water was mixed and cured with fresh water. Some of the cubes were casted and cured with fresh water and other cubes were casted and cured using seawater. The concrete cubes were cured for 3 and 7 days. The study reveals that there is increase in the compressive strength of concrete for low levels of salt content and there is decrease in compressive strength for high level of salt content [9].

E.M. Mbadikea, A.U. Elinwab had conducted a research work on effect of salt water in the production of concrete. For this, ninety (90) concrete cubes were cast for compression strength test i.e. forty five cubes were cast using fresh water and the other forty five cubes were also cast using salt water. Similarly, a total of ninety (90) concrete beams were cast for flexural strength test i.e. forty five beams were cast using fresh water and the other forty five beams were also cast using salt water .The water cement ratio in this research is 0.47 for compressive strength test and 0.55 for flexural strength test. Water used in this research work is brack water. Brack water is water that has more salinity than fresh water, but not as much as sea water. The concrete cubes were cured at 7,21,28,60 and 90 days respectively. The study reveals that the presence of chlorides and sulphates in salt water reduces strength of concrete; the use of salt water in concrete production will reduce the strength of concrete produced to approximately 8% [10].

Obi Lawrence E. had conducted a research work on Empirical Investigation of the Effects of Water Quality on Concrete Compressive Strength. For this experiment, the water collected was of different qualities and sources and presented as salt water from Abonema, runoff water from University farm catchment and fresh water from Onumiri Spring water. The chemical compositions of these water qualities were analyzed while 48 concrete cubes were produced at a ratio of 1:2:4 using each water quality type .The cubes were cured and crushed at 7, 14, 21 and 28 days with the resulting compressive strength. It was observed that the concrete produced with salt water and run-off water had their compressive strengths gradually increased in 7days but decreased drastically at 14 and 21days age. However, concrete cubes obtained from fresh water gained appreciable strength with age. With the result of this research, it is recommended that fresh water and water without obvious concrete- inimical substances are used in concrete batching [20].

O. U. Orie[1*]and A. M. Ojaruega[2] had conducted a research work on Experimental Evaluation of Alternative Mix Water for Concrete: Case Study of Seawater and Laboratory Brine For this, A concrete mix of 1:2:4and water/cement ratio of 0.6 was adopted. The cube samples measured 150mmx150mmx150mm.The samples were cured in potable water for a period of 7, 14, 21 and 28 days at24^{0}C.The seawater and laboratory simulated saltwater contained an equal amount of salt ion concentration. The laboratory salt water was prepared with an analytical grade sodium chloride salt. The concrete cubes cast with potable water had a 28days compressive strength of 33.48 N/mm2, concrete cubes cast with the seawater had a compressive strength of 31.04N/mm2, and while the laboratory brined concrete cubes had a compressive strength of 25.26N/mm2. The results showed that the laboratory prepared salt water samples had the least compressive strength. Compared with the control samples, there was a strength reduction of 7.29% and 24.55% in the compressive strength of the seawater and laboratory saltwater samples respectively. Comparing the concrete cubes made with sea water with that of laboratory brined samples revealed a reduction of 18.62%in compressive strength of the laboratory brined concrete. Seawater therefore has a lesser reducing effect on the compressive strength of concrete than brine [23].

Falah M. Wegian had conducted a research work on Effect of seawater for mixing and curing on structural concrete. In this article, the effects of mixing and curing concrete with seawater on the compressive, tensile, flexural and bond strengths of concrete are investigated. For this, Concrete mixes were prepared by varying coarse aggregates, cement proportions and types. Six groups of concrete mixes were mixed and cured in fresh water, six groups were mixed and cured in seawater, while four groups were mixed with fresh water and cured in seawater. The compressive strength and subsequently the other related strengths of concrete were shown to increase for specimens mixed and cured in seawater at early ages up to 14 days, while a definite decrease in the respective strengths was observed for ages more than 28 days and up to 90 days. The reduction in strength increases with an increase in exposure time, which may be due to salt crystallization formation affecting the strength gain [12].

Haseeb Khan[1], Tabish Izhar[2], Neha Mumtaz[3], Abdul Ahad[4] had conducted a research work on Effect of Saline Water in Mixing and Curing on Strength of Concrete. For this, The effects of sodium chloride (NaCl) solutions as mixing and curing at concentrations of 1g/l,2g/l,4g/l,6g/l and 8g/l.Atotal of 72concretecubes,using metal mould of 150 X 150 X 150mm size, were cast with, chemicals and fresh water.12 cubes of concrete were mixed and cured in fresh water. 60cubes were mixed and cured in sodium chloride. The compressive strength of the cubes determined through crushing at 7, 28 and 48 days respectively. These cubes were cured for 7, 28 and48 days and were tested for compressive strength respectively. For this concrete cubes were cast for a design mix of M-30, 1:1.46: 2.64 by weight and 0.42 water cement ratio. From the results it can be said that, there was an increase in the compressive strength of concrete cubes at early ages which were cast and cured with saline water at different concentration (1g/l, 2g/l, 4g/l, 6g/l and 8g/l) as compared with the concrete cubes cast and cured with tap water. The strength increase at 7 days and decrease at 28 days and 48 days [15].

Oladapo. S. A, Ekanem. E. B had conducted a research work on effect of sodium chloride (Nacl) on concrete compressive strength. For this experiment, a total of sixteen cubes were cast**.** The water used for mixing was drinkable water free from organic matters and other impurities that may lead to weakness in concrete strength for control groups and Sodium Chloride was however introduced as a strange material in the concrete in proportion of the cement used as 0, 2, 4, 6, 8 and 10 percentages by weight for non-control groups. The concrete cubes were cured at 7, 14, 21 and 28 days respectively. The study conclude that sodium chloride could be used as additive in plain concrete work at between 2 and 6 percentages if there is need to improve/increase the compressive strength of concrete [21].

In general researchers give five main conclusions. The first conclusion said that compressive strength of concrete increases when we use salt water , the second conclusion said that compressive strength of concrete decrease when we use salt water , the third conclusion said that compressive strength of concrete increase when we use water contains small amount of salt but it decreases water contains large amount of salt and the fourth conclusion said that compressive strength of concrete increases when we use salt water contains a sodium chloride of 2%-6% of cement but if the sodium chloride salt in water beyond 6% of cement the compressive strength of concrete decreases and the last conclusion said that Maximum compressive strength occurs between salinities of 18 and 36 gm/kg for concrete incorporating NaCI in the mixing water.

Due to this there is no clear cut conclusion on the effect of salt water on the compressive strength of concrete. So effect of salt water on compressive strength of concrete was investigated again.

CHAPTER 3 EXPERIMENTAL INVESTIGATIONS

This investigation aims at studying the effect of salt water on the compressive strength of concrete.

3.1 Mix design

Mix design is the proportion of ingredients that would produce a workable concrete mix that is durable and of required strength and at a minimum cost.

Quality concrete: mix design of concrete is very helpful to achieve better strength, durability, homogenous and impervious structures by deciding the relative proportions of ingredients of concrete having in mind that the fresh concrete is workable.

Economy of Cement consumption**:** Due to the high price of cement mix design helps to save cement quantity and lower cement content also results in lower heat of hydration and hence reduces shrinkage cracks.

Best use of available materials**:** Site conditions often restrict the quality and quantity of ingredient materials. Concrete mix design offers a lot of flexibility on type of aggregates to be used in the mix design. Mix design can give an economical solution based on the available materials if they meet the specified requirements. This can lead to save in transportation costs from longer distances [14].

3.1.1 Silt content of sand

River sand is used and its silt content was carried out to check its suitability for mixing. According to the Ethiopian Standards, if the silt content of sand is more than 6%, it shall not be used for construction [1]. The results obtained are shown in table 1. As it can be seen from table one below 4.115% < 6% so, the sand is suitable for mixing.

Table 3-1: Silt content of sand

Samples	Amount of silt deposited above the sand (A)	Amount of clean sand (B)	Silt(%)=A/B*100
1	15	350	4.29
2	13	330	3.94
Average			**4.115**

3.1.2 Sieve analysis

In the construction industry of Ethiopia, the manuals used for the sieve analysis and other laboratory tests are AASHTO and ASTM and therefore; I used these manuals for particle size distribution of aggregates.

3.1.2.1 Sieve analysis of Sand

River sand is used and sieve analysis was carried out to whether it meets the BS standards and the result is given in table 3-2 below.

Table 3-2 : Particle size distribution of natural sand BS 882

Weight of Sand	Sample				
	500				
AASHTO Sieve Size mm	Weight Retained	%. Retained	% pass	BS 882	
				Lower	Upper
9.5	0	0	100	100	100.0
4.75	1.4	0.28	99.72	89.0	100.0
2.36	53	10.6	89.12	60.0	100.0
1.18	103.8	20.76	68.36	30.0	100.0
0.600	162.2	32.44	35.92	15.0	100.0
0.300	134.3	26.86	9.06	5.0	70.0
0.1500	35.2	7.06	2	0.0	15.0
0.075	8.6	1.72	0.28		
Passing 0.075(pan)	1.4	0.28	0		
Total sum	**500**	**100**		FM	**2.96**

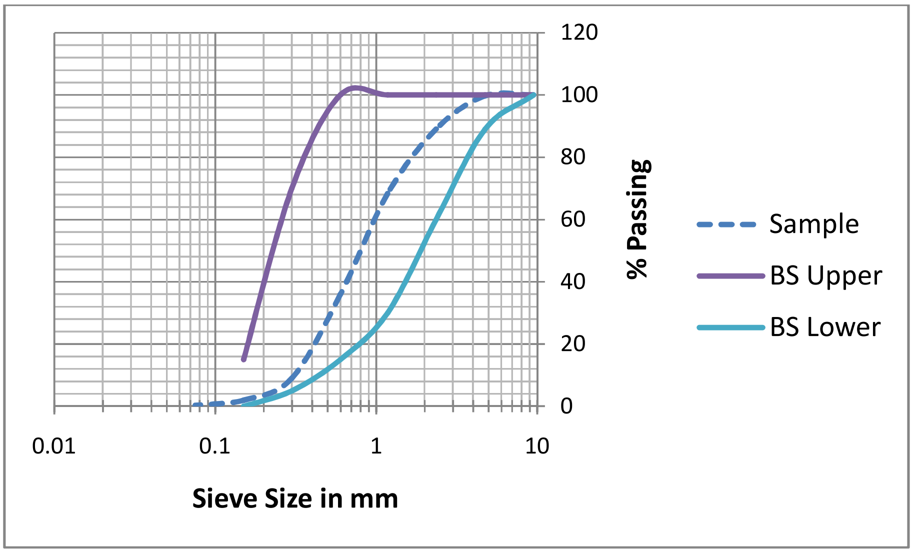

Figure 3-1: Particle size distribution of sand

As it can be seen from the above figure, the gradation of sample of sand used is within the upper and lower limit of BS standard. It is therefore, satisfactory to be used for the concrete preparation.

3.1.2.2 Sieve analysis of Aggregates

A crushed aggregate of maximum size 20mm is used. Two sizes of aggregates (6-12.5 and 12.5-19.5mm) were blend and sieve analysis was carried out and proportioned to meet the AASHTO or ERA standards and the result is given in table 3-3 below.

Table 3-3: Particle Size distribution of Crushed aggregate (6-12.5mm) AASHTO M43-88/ASTM C136

Weight Of Aggregate	Sample 1			Sample 2			
	2039			2064			
AASHTO Sieve Size (mm)	weight Retained	% Retained	% pass	weight Retained	% Retained	% pass	% passes Avg.
19.0	0	0	100	0	0	100	100
10.00	33	1.62	98.38	124	6.0	94	96.19
4.75	1685	82.64	15.74	1598	77.4	16.6	16.17
Passing 0.075(pan)	321	15.74	0	342	16.6	0	0
Total Sum	2039	100.00		2064	100.00		

Table 3-4: Particle Size distribution of Crushed aggregate (12.5-19.5mm) AASHTO M43-88/ASTM C136

Weight Of Aggregate	Sample 1			Sample 2			
	2086			2084			
AASHTO Sieve Size (mm)	Weight Retained	%. Retained	% pass	Weight Retained	%. Retained	% pass	% passes Avg.
25	0	0	100	0	0	100	100
19.0	1575	75.5	25.5	1398	67.0	33	29.25
10.00	511	24.5	0	675	32.39	0.61	0.305
4.75	0	0	0	11	0.61	0	0
Passing 0.075(pan)	0	0	0	0	0	0	0
Total Sum	2086	100		2084	100		

Table 3-5: Combined gradation of coarse aggregate AASHTO N43-88 OR ASTM C 136

AASHTO Sieve Size (mm)	% pass of 12.5-19.5mm Aggregate	% pass of 6-12.5mm Aggregate	Combined result %	Specification ERA STS 8402-3		AASHTO M43-88	
				Lower	Upper	Lower	Upper
25	100	100	100	100	100	100	100.0
19.0	29.25	100	97	80	100	90	100.0
10.00	0.305	96.19	37.75	10	40	20	55.0
4.75	0	16.17	3	0	4	0	10.0
% proportion	62	38	100.0				

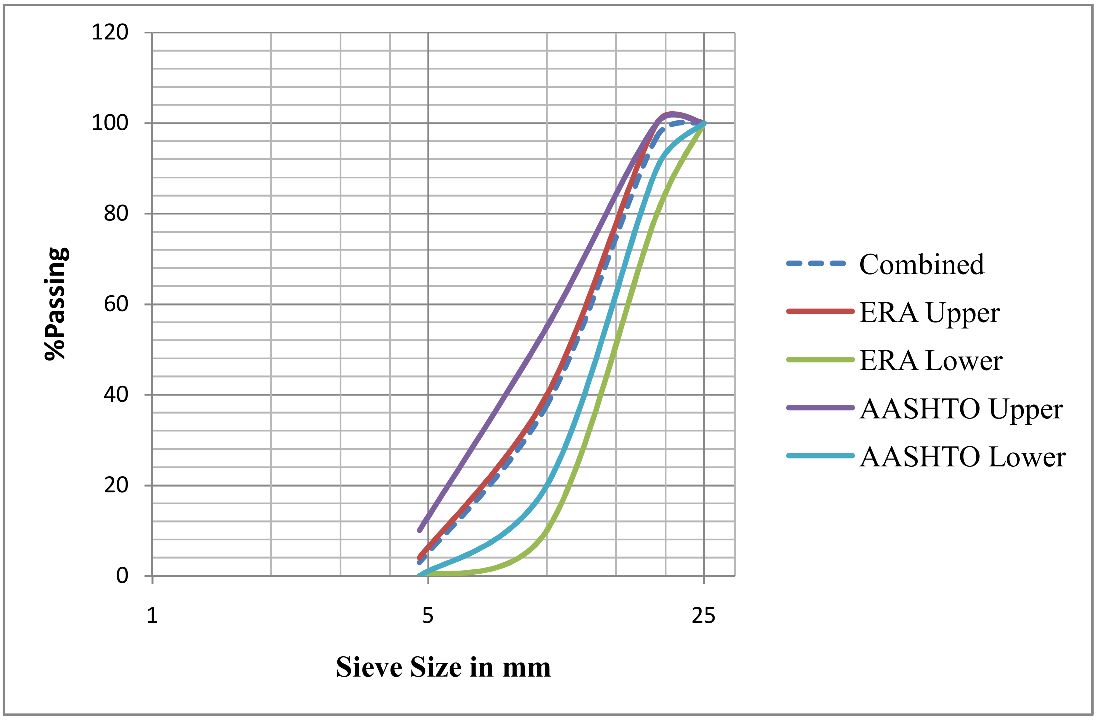

Figure 3-2: Particle Size distribution of aggregate

As it can be seen from the above figure, the gradation of sample of crushed aggregate used is within the upper and lower limit of the standards [3, 11]. It is therefore, satisfactory to be used for the concrete preparation.

3.1.3 Specific gravity

The specific gravity of a substance is the ratio between the weight of the substance and that of the same volume of water. This definition assumes that the substance is solid throughout. Aggregates, however, have pores that are both permeable and impermeable; whose structure (size, number, and continuity pattern) affects water absorption, permeability, and specific gravity of the aggregates [17, 19].

3.1.3.1 Specific gravity of fine aggregates

The specific gravity of the fine aggregate was determined using 3 different pycnometers so that the average can be taken. For each test, 500gm of oven dried fine aggregate was used. The results are presented in Table 3-6.

Table 3-6: Specific gravity of fine aggregate (sand)

Trial No.	Mass SSD sand sample in gm (A)	Mass of pycnometer + water in gm (B)	Mass of pycnomete +water + sand in gm (C)	Specific gravity = [A/(A+B-C)]
1	500	1351.6	1650.3	2.48
2	500	1352.4	1654.1	2.52
3	500	1352.5	1657.2	2.56
Average				2.52

3.1.3.2 Specific gravity of coarse aggregate

The specific gravity of the fine aggregate was determined using two different samples and the average value can be taken.

The results obtained for aggregates (6-12.5mm) and (12.5-19.5) are shown in Table 3-7 and Table 3-8 respectively.

Table 3-7: Specific gravity of coarse aggregate (6-12.5mm)

Samples	Weight of Saturated - Surface Dry sample in air(B)	Weight of saturated sample in air (c)	Specific gravity(in SSD base)=B/B-C
1	5065	3209	2.73
2	5011	3135	2.67
Average			**2.7**

Table 3-8: Specific gravity of coarse aggregate (12.5-19.5mm)

Samples	Weight of Saturated - Surface Dry sample in air(B)	Weight of saturated sample in air (c)	Specific gravity(in SSD base)=B/B-C
1	5078	3233	2.75
2	5036	3164	2.69
Average			**2.72**

3.1.4 Absorption

Absorption is a measure of the amount of water that an aggregate can absorb into its pore structure. Pores that absorb water are also referred to as water permeable voids.

3.1.4.1 Absorption of fine aggregates sand

The Absorption of fine aggregates sand was determined by taking 500gm of sand in SSD base. The results are presented in Table 3-9.

Table 3-9: Absorption of fine aggregate (sand)

Trial No	Mass of SSD sand Sample in (g)	Mass of oven dry sand	Absorption (%)
1	500	490	2.04

3.1.4.2 Absorption of coarse aggregates

The Absorption of coarse aggregates was determined by taking 5000 g of coarse aggregate in SSD bases. The results are presented in Table 3-10.

Table 3-10: Absorption of coarse aggregate

Types of aggregate	SSD mass (g)	Mass of oven dry	Absorption (%)
(12.5-19.5)	5000	4990	0.2
(6-12.5)	5000	4975	0.5

Table 3-11: Specific gravity and unit weight of materials

Materials	Bulk specific gravity (SSD basis)	Unit weight (Kg/m^3)
Cement	3.15	1400
Natural Sand	2.52	1660
Crushed Aggregate(6-12.5mm)	2.70	1594
Crushed Aggregate (12.5-19.5mm)	2.72	1687

3.1.5 Moisture content of aggregate

The moisture content of aggregates was determined by taking 500gm of fine aggregate and 2 Kg of coarse aggregates. The results are presented in Table 3-12 and Table 3-13 for fine aggregate and coarse aggregates respectively.

Table 3-12: Moisture content of sand

Trial No	Weight of Sample (g)	Oven dry weight (g)	Moisture content (%) =(A-B/B)*100
1	500	468.7	6.68
2	500	479.6	4.25
Average			5.47

Table 3-13: Moisture content of aggregates

Types of aggregate	Weight of sample (g)	Oven dry weight (g)	Moisture content (%)
(6-12.5 mm)	2000	1972	1.42
(12.5-19.5 mm)	2000	1978	1.12

3.1.8 Mass of Materials

3.1.8.1 Mass of materials to be used in the mix without adjusting aggregate moisture

Table 3-14: Mass of materials per m3 of concrete

Materials	Mass (Kg)	Volume (m3)
Aggregate 6.5-12.5mm	369.49	137
Aggregate 12.5-19.5mm	638.02	233
Natural Sand	724.9	286
Cement	423.00	134
Water	190	190
Air		20
Estimated Concrete Density	2345.41	1000

3.1.8. 2 adjusted materials to be used in the mix after adjusting aggregate moisture

Table 3-15: Adjusted mass of materials per m^3 of concrete

Materials	Mass (Kg)
Aggregate 6.5-12.5mm	374.74
Aggregate 12.5-19.5mm	645.18
Natural Sand	764.2
Cement	423.00
Water	156
Air	
Estimated Concrete Density	2363.12

The volume of concrete for one mix of each of A-F (0g/L, 10g/L, 20g/L, 30g/L%,35g/L and 40g/L) i.e. 11 cubes for compressive strength test out of 11 cubes 2 cubes are considered for wastage , is 0.0371m^3 therefore the mass of each materials for each mix is as shown in table 3- 16.

Table 3-16 : Quantities of materials used for each mix

Materials	Mass (Kg)
Aggregate 6.5-12.5 mm	13.9
Aggregate 12.5-19.5 mm	24.0
Natural Sand	28.4
Cement	12.9
Water	5.8

3.1.9 Amount of sodium chloride in water used for mixing and curing purpose

The concrete cubes mixed by using clean water, also cured by using clean water but concrete cubes mixed by using salt water , also cures by using salt water. The amount of salt in one liter of water is common for mixing and curing purpose. As it can be seen from table 3-16 the required amount of water used for mixing purpose is 5.8 Liter for each mix. The required amount of water used for curing purpose is 55.615 Liter for each mix.

Table 3-17 : Amount of sodium chloride salt used for mixing and curing

Concentration of NaCl salt (g/L)	Amount of salt used for mixing (g)	Amount of salt used for curing (g)
0	0	0
10	58	556.2
20	116	1112.3
30	174	1668.5
35	203	1946.5
40	232	2224.6
Total	**783**	**7508.1**

3.2 Slump and Compressive strength test

3.2.1 Slump test

A concrete mix ,either produced at a ready mix plant or on site, must be made of the right amount of cement, aggregate and water to make the concrete workable enough for easy compaction and placing and strong enough for good performance in resisting stress after hardening. If the mix is very dry, then its compaction will be so difficult and if the concrete is very wet, the concrete is likely to be weak. During mixing the mix might vary without the change very noticeable at first. For instance, a load of aggregate may be wetter or drier than that is expected or there may be variations in the amount of water added to the mix. These all necessitate a check on the workability and strength of concrete right away producing it.

Slump test is the simplest among the available concrete tests with regard to workability and is most widely used on construction sites. In the slump test, the distance that a cone full of concrete slumps down is measured when the cone is lifted from around the concrete. The slump can vary from nil on dry mixes to complete collapse on very wet case. One drawback with this test is that, it is not helpful for very dry mixes.

There are three kinds of slumps. These are:

1. True slump- where the concrete just subsides, keeping its shape approximately
2. Shear slump – where the top half of the cone shears off and slips sideways down an inclined plane.
3. Collapse slump – where the concrete collapses completely.

The first one is associated with workable mix while the other two are usually associated with harsh mixes that lack cohesion [17].

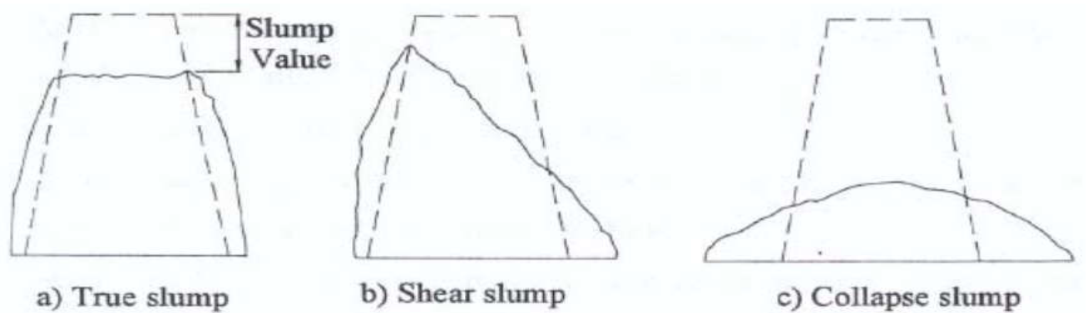

Figure 3-3: kinds of slumps

3.2.1.1 Apparatus used

- Standard slump cone – 300mm high with a bottom diameter of 200mm and top diameter of 100mm
- A steel tamping rod, 600 mm long with a diameter of 16 mm that has at least one end rounded
- Measuring tape or ruler
- Steel float
- Water proof base plate, about 450*450mm square
- Cleaning rags

3.2.2 Compressive strength

The major goal of concrete structure is to carry loads coming to them. These loads may be dead, live, earthquake, wind or snow types or their combination. The concrete produced must not fail under the action of any of such loads. The most common test for hardened concrete involves taking a sample of fresh concrete and putting it into a special cube molds so that when hardened ,the cubes can be tested to failure in a special machine in order to measure the strength of concrete. The results obtained from compression tests on hardened concrete cubes are used to check that its strength is above the minimum specified and to assess the control exercised over the production of concrete. The strength of concrete specimen is affected by many factors such as; water-cement ratio, degree of compaction and curing temperature. Care should be taken, in preparing samples for testing. When water-cement ratio goes up above a certain level, the strength will decrease correspondingly. Compaction reduces the amount of entrapped air and therefore increases the strength of concrete (for each 1% air entrapped there will be about5% to 6%loss of strength). Curing temperature affects the hydration of cement and hence, the duration of the strength gain (cubes kept at about 10oc will have their 7-day strength reduced by 30%and their28-day strength reduced by 15%). This calls for proper cure of test cubes at a recommended temperature 20^0c [17].

3.2.2.1 Apparatus used

- Mixer
- Cubical mold (15*15*15) cm
- Vibrator
- Spatula and
- Compressive strength testing machine

3.2.2.3 Calculation

$$\sigma = \frac{P}{b * d}$$

Where,

σ = Compressive strength (MPa)

p =Maximum applied load (kN)

b = Breadth (m) and d = Width (m)

CHAPTER 4 RESULT AND DISCUSSION

4.1 RESULTS

4.1.1 Results of slump test

The results of slump tests are shown in table 4-1 below.

Table 4-1: Slump and water used for each concentration of salt

Concentration of Salt (g/L)	Slump (mm)	Amount of water Used (L)	W/C ratio
0	40	5.8	0.45
10	55	5.8	0.45
20	65	5.8	0.45
30	75	5.8	0.45
35	80	5.8	0.45
40	65	5.8	0.45

4.1.2 Result of test for Compressive strength

The results of the experiments on the compressive strength of concrete with the concentration increase of sodium chloride salt of water from 0g/L to 40g/L for 7, 28 and 45 curing days are shown in table 4-2 and graphs of their respective values in figures 4-1.

Table 4-2: Results of Compressive Strength of concrete

Concentration of Salt (g/L)	Samples	Compressive strength(Mpa) curing time		
		7	28	45
0	1	23.72	37.85	39.45
	2	26.63	36.96	41.17
	3	26..49	37.56	38.12
	Average	**25.61**	**37.46**	**39.58**
10	1	31.20	38.62	44.82
	2	30.76	36.31	43.38
	3	31.87	42.29	43.35
	Average	**31.28**	**39.07**	**43.85**
20	1	30.12	41.51	45.32
	2	31.54	41.58	42.98
	3	33.94	38.69	43.56
	Average	**31.87**	**40.59**	**43.95**
30	1	32.27	42.16	45.32
	2	32.98	42.73	46.02
	3	31.76	41.20	44.67
	Average	**32.34**	**42.03**	**45.34**
35	1	33.55	40.79	45.16
	2	34.60	42.22	43.53
	3	34.49	43.81	47.89
	Average	**34.21**	**42.27**	**45.53**
40	1	36.23	44.64	42.79
	2	36.13	45.64	44.40
	3	36.41	44.49	43.53
	Average	**36.26**	**44.92**	**43.57**

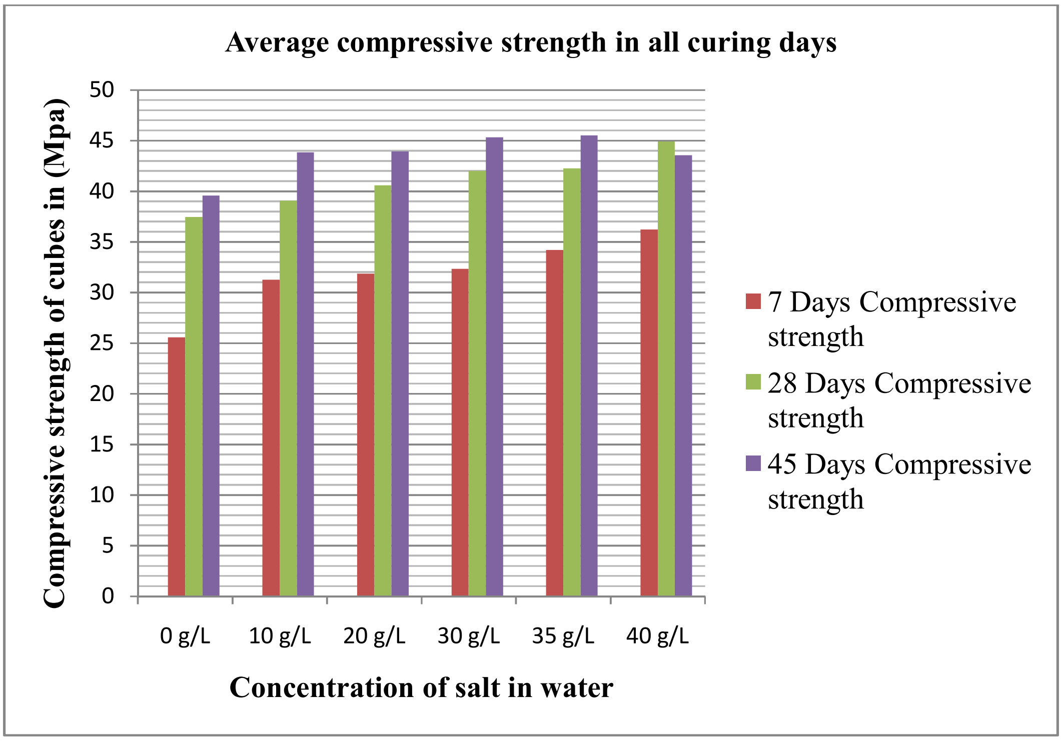

Figure 4-1**:** Summary of average Compressive Strength of concrete

4.2 DISCUSSION

4.2.1 Compressive strength of concrete

As can be seen from table 4-2 and figure 4-1 above the compressive strength of concrete is increased with the increase of concentration of salt in water for all curing days.

The percentage increase in average compressive strength of concrete as the concentration of salt in water increases from 0g/L to 10g/L, 0g/L to 20g/L , 0g/L to 30g/L,0g/L to 35g/L,& 0g/L to 40g/L is 22.14%, 24.44%, 26.28%, 33.58% & 41.58% for 7 days curing time respectively. The percentage increase in average compressive strength of concrete as the concentration of salt in water increases from 0g/L to 10g/L , 0g/L to 20g/L , 0g/L to 30g/L,0g/L to 35g/L,& 0g/L to 40g/L is 4.29%, 8.36%, 12.20%, 12.84%& 19.91% for 28 days curing time respectively and the percentage increase in average compressive strength of concrete as the concentration of salt in water increases from 0g/L to 10g/L , 0g/L to 20g/L , 0g/L to 30g/L,0g/L to 35g/L,& 0g/L to 40g/L is 10.79%, 11.04%, 14.55%, 15.03%& 10.08% for 45 days curing time respectively. Even though there is an increase in compressive strength of concrete with an increase of salt in water, the percentage increase in compressive strength of concrete in 7days curing time is much larger than 28 and 45 days curing time.

There is no percentage increase in average compressive strength of concrete for water sample of 40g/L when the curing time is changed from 28 to 45 days and the percentage increase in average compressive strength of concrete for water samples of 0g/L, 10g/L, 20g/L, 30g/L, 35g/L & 40g/L when the curing time changed from 7 to 28 days is 46.27%, 24.90%, 27.36%, 29.96%, 23.56% & 23.88% and the percentage increase in average compressive strength of concrete for water samples of 0g/L,10g/L,20g/L,30g/L& 35g/L when the curing time changed from 28 to 45 days is 5.66%, 12.23%, 8.28%, 7.88% & 7.71%. This shows that the rate of the strength gain in clean water cubes is fast as compared with the salt water cubes when the curing time is changed from 7 to 28 days but the rate of strength gain in clean water cubes is slow as compared with the salt water cubes when the curing time is changed from 28 to 45 days.

CHAPTER 5 CONCLUSIONS AND RECCOMENDATIONS

5.1 Conclusion

Researchers have contradicted ideas on the effect of salt water on compressive strength of concrete. In this research work, the effect of salt water on compressive strength of plain mass concrete had been investigated experimentally. The research was conducted by varying the concentration of sodium chloride salt from 0g to10g, 20g, 30g, 35g and 40g per liter of clean water both in the mixing and curing purpose. The 0g/L water sample was the control group while the other five water samples were non- control groups. For this, fifty four (54) concrete cubes were cast for six water samples; 9 cubes for each water samples, each of three cubes for 7, 28 & 45 days compressive strength test. By comparing both the result of compressive strength of concrete in each curing time for concrete cubes both mixed and cured by using clean water with that of concrete cubes both mixed and cured by using salt water and also by comparing the results of compressive strength of non-control concrete cubes each other in each curing time; the following conclusions were obtained;

1. The compressive strength of concrete cubes both mixed and cured by using salt water were higher than that of concrete cubes both mixed and cured by using clean water in all curing days.
2. The compressive strength of concrete cubes both mixed and cured by using 10g, 20g, 30g and 35g sodium chloride salt per liter of clean water were increased when the curing time changed from 7 to 28 days and 28 to 45 days, but the compressive strength of concrete cubes both mixed and cured by using 40g sodium chloride salt per liter of clean water were decreased when the curing time changed from 28 to 45 days.
3. The rate of the strength gain for concrete cubes both mixed and cured by using clean water was fast as compared with concrete cubes both mixed and cured by using salt water when the curing time changed from 7 to 28 days, but the rate of the strength gain becomes slow when the curing time changed from 28 to 45 days.
4. The maximum 7 and 28 days compressive strength of concrete were occurred when we use 40g sodium chloride salt per clean water, but the maximum 45 days compressive strength of concrete were occurred when we use 35g sodium chloride salt per clean water.
5. The 45 days compressive strength of concrete cubes both mixed and cured by using 40g sodium chloride salt was smaller than that of the 45 days compressive strength of concrete cubes both mixed and cured by all other salt water samples.

5.2 Recommendation for further studies

1. Studies should be carried out for long term compressive strength test for further comparison among the concretes produced from different concentration of salt in water.
2. Studies should be carried out for the durability of reinforced concrete structures.
3. Studies should be carried out for different types and properties of cement, fine and coarse aggregates.
4. Studies should be carried out for large amount of sodium chloride salt in water.
5. Studies should be carried out for concrete cubes mixed by using clean water but cured by salt water.
6. Studies should be carried out for concrete cubes produced from different percentage of salt in cement.

REFERENCES

[1]. Abebe Dinku,construction materials laboratory manual, Addis ababa university Department of civil Engineering, June 2002

[2]. Abiduselam Hassen, Workshop practice and Excursion materials, unpublished lecture note, Wollo University, 2010/2011.

[3]. American Association of State Highway and Transportation Officials, "Standard Specifications for Transportation Materials and Methods of Sampling and Testing: part II – Methods of Sampling and Testing", Thirteenth Edition, AASHTO, 444 North Capitol St., N.W., Suite 225 Washington, D.C. 20001, July1982

[4]. American Concrete Institute (ACI) "Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete." ACI 211.1-91, ACI Committee 211, 2002

[5]. American Concrete Institute (ACI) "Building code Requirements for Structural Concrete." ACI 318-08, ACI Committee 318, 2008

[6]. Akinsola Olufemi Emmanuel1, Fatokun Ajibola Oladipo1 & Ogunsanmi Olabode E2 , Journal of Sustainable Development, Investigation of Salinity Effect on Compressive Strength of Reinforced Concrete , vol. 5, No.6, May 24, 2012.

[7]. B.G.RAVI TEJA, effect of sodium chloride on compressive strength of concrete containing sugarcane bagasse ash, Gitam University, Gitam Institute of technology, 2014

[8]. Donald F. Griffin and Robert L. Henry, Technical Repot R306, The effect of salt in concrete on compressive strength, water vapor transmission and corrosion of reinforcing steel, July 22, 1964

[9]. Dr. Nagabhushana1, Dharmaraj Hebbal2, Nitin Akash3 , S Deepak4, Mukesh Kumar5 , International Research Journal of Engineering and Technology , Effect of Salt Water on Compressive Strength of Concrete , volume .04 Issue:05 May 2017

[10]. E.M. Mbadikea, A.U. Elinwab , Nigerian Journal of Technology, Effect of Salt Water in the production of Concrete , Vol. 30, No. 2, June 2011

[11]. Ethiopian Road Authority Manual (ERA) “Concrete for Structures” Standard Technical Specification-2002

[12]. Falah M. Wegian, Journal of IES, Effect of seawater for mixing and curing on structural concrete, Vol. 3, No. 4, November 2010

[13]. G Sai Teja1, Amar.B.P2, Neethu.R.Manoj3, Venkatesh E4, Prathyusha Tenepalli5, International Journal of Civil and Structural Engineering Research, Vol. 2, Issue 1, pp: (76-78), Month: April 2014 - September 2014

[14]. Guidelines on quality control and quality assurance of ready mix concrete, RMCMA, 2008

[15]. Haseeb Khan[1], Tabish Izhar[2], Neha Mumtaz[3], Abdul Ahad[4], Effect of Saline Water in Mixing and Curing on Strength of Concrete, Volume 2 Issues 5 –MAY 2016

[16]. JAMES K. WIGHT and JAMES G. MACGREGOR, REINFORCED CONCRETE Mechanics and Design, SIXTH EDITION

[17]. Journal, FM 5-472/NAVFAC MO 330/AFJMAN 32-1221(I)

[18]. National Ready Mix Concrete Association (NRMC), Concrete in practice, Silver spring, MD, 2000

[19]. Nigus G/Egziabher, comparison of concrete properties produced using mugher, messebo and diredawa cements, Addis Ababa university school of graduate studies, October 2005.

[20]. Obi Lawrence E, International Journal of Constructive Research in Civil Engineering, Empirical Investigation of the Effects of Water Quality on Concrete Compressive Strength, Volume 2, Issue 5, 2016

[21]. Oladapo. S. A, Ekanem. E. B, International Journal of Engineering Research & Technology, Effect of Sodium Chloride (NaCl) on Concrete Compressive Strength, Vol. 3 Issue 3, March – 2014.

[22]. Olutoge, F. Adeyemi1 and Amusan, G. Modupeola2, The Effect of Sea Water on Compressive Strength of Concrete, Volume .3 Issue 7, July 2014.

[23]. O. U. Orie1* and A. M. Ojaruega[2], Nigerian Journal of Technology, Experimental Evaluation of Alternative Mix Water for Concrete, Vol. 34 No. 3, July 2015

[24]. Preeti Tiwari 1 , Rajiv Chandak 2 , R.K. Yadav 3, Journal of Engineering Research and Applications , Effect Of Salt Water On Compressive Strength Of Concrete , Vol. 4, Issue 4(Version 5), April 2014

[25]. Premachand1 Mohd,YounasMohiuddin2 M.A.Haleem3, Journal of Advance in Science and Technology, Experimental study on Salinity effect on properties of M20 Grade concrete in different normality condition, Vol .11,issue No.22,may 2016.

[26]. Water Encyclopedia. (2012). Earth: Retrieved from www. Saline water .com

APPENDIX A

Appendix A contains tables of concrete mix design for C-25 concrete.

Table A-1: References for the specification of parameters used for mix design

CONCRETE MIX DESIGN FOR C-25 Trial No.1		
Specified compressive strength by cube : 25 Mpa		
Required Slump 25-75 mm		
Parameter	Specification	Reference
Type of Cement	OPC (Dangote)	
Maximum Cement content	≤ 550 Kg/m3	ERA STS 8404 CLAUSE (d)
Maximum Water /Cement ratio	0.5	ERA STS 8404 CLAUSE (c)
Water/Cement ratio	0.45	ACI 211.1-91 table A1.5.3.4(a)
Required cube compressive strength in Mpa	25	ERA STS 8404-1
Standard deviation in Mpa	5	ACI table 2.8-1
Design cube compressive strength in Mpa	30	
The maximum nominal size of coarse aggregate in mm	20	
% of Air in non-air entrained	2%	ACI 211.1-91 table A1.5.3.3
Cement content in in Kg/m3	347	
Water in Kg/m^3	156	

Table A-2: Results of physical test of ingredients and its proportion

Ingredients	Specific Gravity	Absorption (%)	Volume (m3)	Unit Wt.(Kg/m3)	Mosisture Content (%)	% Proportion (Coarse & Fine aggregate)	% Proportion of coarse aggregate (10-20mm& 5-10mm) to obtain the desired grading	Combined Specific Gravity of Coarse Aggregate
Cement	3.15	0	134	1400				
Aggregate (10-20mm)	2.72	0.2		1687	1.12	36.17	62	2.7124
Aggregate (5-10mm)	2.7	0.5		1594	1.42	21	38	
Natural Sand	2.52	2.04		1660	5.47	42.83		
Air	1	0	20					
Water	1	0	156					
Total			310			100	100	

Table A-3: Required mass and volume of ingredients

Volume of Sand & Coarse Aggregate = 656		
Sand Proportion in mix (%) = 42.83		
Sand to Aggregate Ratio = 0.749		
Ingredients	Mass (Kg/m3)	Volume (m3)
Aggregate (5-10 mm & 10-20 mm)	1007.51	
Aggregate (5-10 mm)	369.49	137
Aggregate (10-20 mm)	638.02	233
Natural Sand	724.9	286
Cement	423	134
Water	190	190
Air		20
Estimated Concrete Density	2345.41	1000

Table A-4: Adjusted materials used to in the mix

Materials	Mass
Aggregate (5-10)	374.74
Aggregate (10-20)	645.18
Natural Sand	764.2
Cement	423
Water	156
Air	
Estimated Concrete Density	2363.12

Table A-5: Adjusted mass for the trial batch

<table>
<tr><td rowspan="2">Materials</td><td>Trial Batch
54 Cubes (for Compressive) &
12 Cubes (for Waste & Slump)</td><td>Total Volume (m3)
0.0371</td></tr>
<tr><td colspan="2">Individual Mass in Kg for Batch</td></tr>
<tr><td>Aggregate(5-10mm)</td><td colspan="2">13.9</td></tr>
<tr><td>Aggregate(10-20mm)</td><td colspan="2">24</td></tr>
<tr><td>Natural Sand</td><td colspan="2">28.4</td></tr>
<tr><td>Cement</td><td colspan="2">12.9</td></tr>
<tr><td>Water</td><td colspan="2">5.8</td></tr>
</table>

APPENDIX B

Appendix B contains tables of results of cube compressive strength of 54 cubes.

Table B-1: Compressive strength of cubes prepared by using clean water sample

Date Specimens were cast : 19/07/2010							
Description of test Specimens : Cube test							
Maximum Size of C.Agg =20 mm ; F.M of Sand =2.96 & Salt Content of Water = 0 g/L							
Spec No.	Days Cured	Weight (Kg)	Area (mm2)	Load (KN)	Stress (Mpa)	% fc'	Date Tested
A1	7	8.080	22500	533.6	23.72		26/07/2010
A2		8.090	22500	599.1	26.63		26/07/2010
A3		8.125	22500	596.1	26.49		26/07/2010
Average		**8.098**	22500	**576.27**	**25.61**		
A4	28	8.160	22500	851.7	37.85		17/08/2010
A5		8.085	22500	831.6	36.96		17/08/2010
A6		8.165	22500	845.1	37.56		17/08/2010
Average		**8.137**	22500	**842.80**	**37.46**		
A7	45	8.145	22500	887.7	39.45		04/09/2010
A8		8.115	22500	926.2	41.17		04/09/2010
A9		8.225	22500	857.8	38.12		04/09/2010
Average		**8.162**	22500	**890.57**	**39.58**		

Table B-2: Compressive strength of cubes prepared by using a salt water sample contains 10 g NaCl salt per liter of clean water

Date Specimens were cast : 19/07/2010							
Description of test Specimens : Cube test							
Maximum Size of C.Agg =20mm;F.M of Sand =2.96 & Salt Content of Water =10 g/L							
Spec No.	Days Cured	Weight (Kg)	Area (mm2)	Load (KN)	Stress (Mpa)	% fc'	Date Tested
B1	7	8.072	22500	702.0	31.20		26/07/2010
B2		8.080	22500	692.2	30.76		26/07/2010
B3		8.085	22500	717.1	31.87		26/07/2010
Average		**8.079**	22500	**703.77**	**31.28**		
B4	28	8.175	22500	869.0	38.62		17/08/2010
B5		8.170	22500	817.0	36.31		17/08/2010
B6		8.155	22500	951.4	42.29		17/08/2010
Average		**8.167**	22500	**879.13**	**39.07**		
B7	45	8.090	22500	1008.6	44.82		04/09/2010
B8		8.060	22500	976.1	43.38		04/09/2010
B9		8.115	22500	975.4	43.35		04/09/2010
Average		**8.088**	22500	**986.7**	**43.85**		

Table B-3: Compressive strength of cubes prepared by using a salt water sample contains 20 g NaCl salt per liter of clean water

Date Specimens were cast : 19/07/2010							
Description of test Specimens : Cube test							
Maximum Size of C.Agg =20mm ;F.M of Sand =2.96 & Salt Content of Water =20 g/L							
Spec No.	Days Cured	Weight (Kg)	Area (mm2)	Load (KN)	Stress (Mpa)	% fc'	Date Tested
C1	7	8.065	22500	677.7	30.12		26/07/2010
C2		8.045	22500	709.8	31.54		26/07/2010
C3		8.090	22500	763.6	33.94		26/07/2010
Average		**8.067**	22500	**717.03**	**31.87**		
C4	28	8.035	22500	933.9	41.51		17/08/2010
C5		8.115	22500	935.8	41.58		17/08/2010
C6		8.025	22500	870.4	38.69		17/08/2010
Average		**8.058**	22500	**913.37**	**40.59**		
C7	45	8.030	22500	1019.6	45.32		04/09/2010
C8		8.185	22500	956.6	42.98		04/09/2010
C9		8.070	22500	980.1	43.56		04/09/2010
Average		**8.095**	22500	**985.43**	**43.95**		

Table B-4: Compressive strength of cubes prepared by using a salt water sample contains 30 g NaCl salt per liter of clean water

Date Specimens were cast : 20/07/2010							
Description of test Specimens : Cube test							
Maximum Size of C.Agg =20mm ;F.M of Sand =2.96 & Salt Content of Water =30 g/L							
Spec. No.	Days Cured	Weight (Kg)	Area (mm2)	Load (KN)	Stress (Mpa)	% fc'	Date Tested
D1	7	8.045	22500	726.1	32.27		27/07/2010
D2		8.045	22500	742.1	32.98		27/07/2010
D3		8.095	22500	714.8	31.76		27/07/2010
Average		**8.061**	22500	**727.67**	**32.34**		
D4	28	8.13	22500	948.7	42.16		18/08/2010
D5		8.035	22500	963.3	42.73		18/08/2010
D6		8.04	22500	927.1	41.20		18/08/2010
Average		**8.068**	22500	**946.37**	**42.03**		
D7	45	8.065	22500	1019.7	45.32		05/09/2010
D8		8.115	22500	1035.6	46.02		05/09/2010
D9		8.025	22500	1005.1	44.67		05/09/2010
Average		**8.068**	22500	**1020.13**	**45.34**		

Table B-5: Compressive strength of cubes prepared by using a salt water sample contains 35 g NaCl salt per liter of clean water

Date Specimens were cast : 20/07/2010							
Description of test Specimens : Cube test							
Maximum Size of C.Agg =20mm ;F.M of Sand =2.96 & Salt Content of Water =35 g/L							
Spec. No.	Days Cured	Weight (Kg)	Area (mm2)	Load (KN)	Stress (Mpa)	% fc'	Date Tested
E1	7	8.060	22500	754.9	33.55		27/07/2010
E2		8.135	22500	778.5	34.60		27/07/2010
E3		8.110	22500	776.0	34.49		27/07/2010
Average		**8.102**	22500	**769.8**	**34.21**		
E4	28	8.115	22500	917.7	40.79		18/08/2010
E5		8.125	22500	949.9	42.22		18/08/2010
E6		8.015	22500	985.8	43.81		18/08/2010
Average		**8.085**	22500	**951.13**	**42.27**		
E7	45	8.080	22500	1016.2	45.16		05/09/2010
E8		8.095	22500	979.4	43.53		05/09/2010
E9		8.070	22500	1077.7	47.89		05/09/2010
Average		**8.082**	22500	**1024.43**	**45.53**		

Table B-6: Compressive strength of cubes prepared by using a salt water sample contains 40 g NaCl salt per liter of clean water

Date Specimens were cast : 20/07/2010							
Description of test Specimens : Cube test							
Maximum Size of C.Agg =20mm ; F.M of Sand =2.96 & Salt Content of Water =40 g/L							
Spec No.	Days Cured	Weight (Kg)	Area (mm2)	Load (KN)	Stress (Mpa)	% fc'	Date Tested
F1	7	8.094	22500	815.2	36.23		27/07/2010
F2		8.060	22500	812.9	36.13		27/07/2010
F3		8.105	22500	819.4	36.41		27/07/2010
Average		**8.086**	22500	**815.83**	**36.26**		
F4	28	8.13	22500	1004.5	44.64		18/08/2010
F5		8.06	22500	1026.9	45.64		18/08/2010
F6		8.10	22500	1001.3	44.49		18/08/2010
Average		**8.097**	22500	**1010.9**	**44.92**		
F7	45	8.185	22500	963.6	42.79		05/09/2010
F8		8.115	22500	999.0	44.40		05/09/2010
F9		8.200	22500	979.4	43.53		05/09/2010
Average		**8.167**	22500	**980.67**	**43.57**		