EFFECT OF SUGAR AND SLAG CEMENT IN CONCRETE

A Thesis

Submitted in partial fulfillment of requirements for the award of the degree of

MASTERS OF TECHNOLOGY

IN

CIVIL ENGINEERING

With specialization in

STRUCTURAL ENGINEERING

Under the supervision of

Mr. Chandra Pal Gautam

By**:**

Ankush Panwar

142667

To

Department Of Civil Engineering

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

WAKNAGHAT, SOLAN – 173234

HIMACHAL PRADESH INDIA

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CERTIFICATE

This is to certify that the work which is being presented in the project **"EFFECT OF SUGAR AND SLAG CEMENT IN CONCRETE"** in partial fulfillment of the requirements for the award of the degree of Master of technology in Civil Engineering with specialization in **Structural Engineering** and submitted in Civil Engineering Department, Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by **ANKUSH PANWAR** during a period from July 2015 to June 2016 under the supervision of **Mr. CHANDRA PAL GAUTAM** Assistant Professor, Civil Engineering Department, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of my knowledge.

Date: -

Dr. Ashok Kumar Gupta	Mr. Chandra Pal Gautam	………………….
Professor & Head of Department	Assistant Professor	External Examiner
Civil Engineering Department	Civil Engineering Department	
JUIT Waknaghat	JUIT Waknaghat	

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I also take the opportunity to thanks all my friends who have directly or indirectly helped me in my project work.

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Place: JUIT Waknaghat (H.P) Ankush Panwar

Date: 142667

ABSTRACT

Concrete blocks are mostly used for covering or coating on a structure or material, load bearing purposes all around the world. This project gives special importance or value to the effect of sugar on strength of concrete. This Project work determines the effect of admixtures (sugar) on the compressive strength of concrete block. Based on books and literature the main function of sugar is to increase the initial setting time of concrete. Usually three different percentage of sugar admixtures are taken as 0.0, 0.06, and 0.08% by weight of cement. The compressive strength of concrete blocks increased by 16.02% at 28 days as compared to ordinary concrete blocks. The use of sugar is to delay setting of cement. But, addition of sugar has inevitable implications not only on setting time but also on compressive strength of cement paste. So, its effect needs to be well-understood for better control over its use. Test samples prepared by using 53 grades OPC cement and sugar in increasing proportion did not show a fixed result.

On the other hand use of slag cement considerably increased the compressive strength, tensile strength and the flexural strength of the concrete. Usually three different percentage of slag cement was taken as 0%, 30% and 50%.the result showed that there was an increase of 20% increases in the compressive strength and a considerable increase in the tensile strength of the concrete mix.

Keywords: Slag Cement, Sugar, Compressive Strength, Tensile Strength, Flexural Strength

Place: JUIT Waknaghat (H.P) Ankush Panwar

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LIST OF ABBREVATIONS

ACV	Aggregate Crushing Value
C&DW	Construction and Demolition Waste
CA	Coarse Aggregate
CTM	Compression Testing Machine
f **'ck**	Target average Compressive Strength in N/mm^2
f **ck**	Characteristic Compressive Strength in N/mm^2
f **'st**	Split Tensile Strength in N/mm^2
FA	Fine Aggregate
FCM	Fresh Concrete Mix
FM	Fineness Modulus
HSC	High Strength Concrete
IS	Indian Standard Specifications
NA	Natural Aggregate
OPC	Ordinary Portland cement
RA	Recycled Aggregate
RCA	Recycled Aggregate Concrete
S	Standard Deviation
Sc	Specific Gravity of Cement
SG	Specific Gravity
SSD	Saturated Surface Dry Density
WCM	Waste Concrete Mix

CHAPTER 1 INTRODUCTION

1.1 General Introduction

Most plain and reinforced concrete structures are designed on the principle that the effective concrete areas shall be stressed in compression only. Consequently the compressive strength becomes the most important quality of the concrete and its accurate determination is the most outstanding problem for the engineering profession. Since, the first uses of concrete, attempts have been made to ascertain its compressive strength. However, the problem of interpreting and correlating the secured result is far more difficult than it appears to a casual inspector and the significance of the compressive test becomes a very difficult answer in definite terms. The compressive strength of concrete is one of the most important and useful properties of the concrete. In most structural applications concrete is employed primarily to resist compressive stresses. In those cases where strength in tension or in shear is of primary importance, the compressive strength is frequently used as a measure of these properties. Therefore, the concrete making properties of various ingredients of the mix are usually measured in terms of the compressive strength. Compressive strength is also used as a qualitative measure for the other properties of hardened concrete. No exact quantitative relationship between compressive strength and flexural strength, tensile strength, modulus of elasticity, wear resistance, fire resistance or permeability have been established nor are they likely to be. However, approximate and statically relationships, in some cases, have been established and these give much useful information to engineers. It should be emphasized that compressive strength gives only an approximate value of these properties and that other tests specifically designed to determine these properties should be useful if more precise results are required. For instance, the indicated compressive strength increases as the specimen size decreases, where as the modulus of elasticity decreases. The modulus of elasticity in this case does not follow the compressive strength. The other case where the compressive strength does not indicate the useful property of concrete is when the concrete is subjected to freezing and thawing. Concrete containing about 6%of the entrained air which is relatively weaker in strength is found to be more durable than dense and strong concrete.

The compressive strength of concrete is generally determined by the testing of cubes and cylinders made in laboratory or field or cores drilled from hardened concrete at site or form the non-destructive testing of the specimen or actual structures. Strength of concrete is its resistance to rupture. It may be measured in a number of ways, such as, strength in comparison, in tension, in shear or in flexure. All these indicate strength with reference to a particular method of testing. When concrete fails under the compressive load the failure is the mixture of crushing and shear failure. The mechanics of failure is the complex phenomena. It can be assumed that the concrete in resisting failure generates both cohesion and internal friction. The cohesion and internal friction developed by concrete in resisting failure is related to more or less a single parameter i.e. w/c ratio.

Concrete is the premier construction material across the world and the most widely used in all types of civil engineering works, including infrastructure, low and high rise buildings, defense installations, environmental protection facilities . The use of sugar and Slag cement in concrete opens a whole new range of possibilities in increasing the compressive strength of the structure. The utilization of Sugar and Slag cement is a good solution to the problem of low strength in the buildings, provided that the desired final product will fit the standards. The studies on the use of easily available admixture have been going on for 50 years.

1.2 Background

Concrete is a manmade building material that looks like stone. Combining cement with aggregate and sufficient water makes concrete. Water allows it to set and bind the materials together. Different mixtures are added to meet specific requirements. Concrete is normally reinforced with the use of rods or steel mesh before it is poured into moulds. Interestingly, the history of concrete finds evidence in Rome some 2000 years back. Concrete was essentially used in aqueducts and roadway construction in Rome. It is said that the Romans used a primal mix for their concrete. It consisted of small gravel and coarse sand mixed with hot lime and water, and sometimes even animal blood. To trim down shrinkage, they are known to have used horsehair. Historical evidence states that the Assyrians and Babylonians used clay as the bonding material. Even ancient Egyptians are believed to have used lime and gypsum cement for concrete. Lime mortars and gypsums were also used in building the world-acclaimed pyramids. However, Romans are known to have made wide usage of concrete for building roads. It is interesting to learn that they built some 5,300 miles of roads using concrete. Concrete is a very strong building material. Historical evidence also points that Romans used Pozzalana, animal fat, milk and blood as admixtures for building concrete. Concrete has been proved to be a leading construction material for more than a century. It is estimated that the global production of concrete is at an annual rate of 1 m3 per capita. The global consumption of natural aggregate will be in the range of 48.3 billion metric tons after 2015.

1.3 Materials Used

The materials being used in the project mainly increases the compressive strength of the concrete. These materials are used so as to maintain the maximum desired strength. Almost all civil engineering works are site work based but the procedure to perform these works are derived in a controlled lab i.e. parameters temperature, humidity are controlled, hence in actual practice desired quality may not be achieved and also many a times , it may not be possible to follow exact set of procedure. Concreting in hot weather i.e. above 100°F accelerates the early hydration of cement and produce concrete having high strength at early ages, but the later strength is reduced considerably. Further, the rapid evaporation of water causes plastic shrinkage (cracks developed before the concrete has hardened) in concrete and subsequent cooling would cause tensile stresses and cracking. Similarly, concreting in cold weather is also detrimental. If water of plastic concrete sets , then overall volume of concrete increases and also delays the setting and hardening of the concrete as no water is available for chemical reaction, ultimately resulting large volume of pores and hence low strength is gained. Hence in order to maintain the standard condition, admixtures are used. Retarders are admixture that extend the hydration induction period, thereby lengthening the setting times.

1.3.1 Sugar:

Sugar is a carbohydrate, a substance composed of carbon, oxygen and hydrogen. It is that in old monuments in Gandikota at Kadapa district Andhra Pradesh, where holding the stone was achieved by mortar with combination of lime, sand and jiggery juice. It can be useful when concrete used in hot weather, when the normal setting time of concrete is shortened by the higher surrounding temperature such as Gujarat, Rajasthan etc. Very small dosage of the order of 0.05 to 0.1 per cent of the mass of the concrete is enough. 0.05 per cent of sugar can delay initial setting time by about 4 hours. Sugar disrupts the setting process by preventing the hydration reaction between water and cement – a key ingredient of the concrete mix containing calcium, silicon and aluminum oxides. Dry concrete mix contains cement together with coarse aggregate – usually sand or crushed gravel. When water is added it reacts with the cement’s components to make a thick paste which hardens to bind the aggregate together. Throwing sugar into the mix interferes with the hydration process, although the exact mechanism is still a bit of a mystery. One theory is that the sugar molecules coat cement particles and prevent them clumping together to form a smooth paste. Another suggests that the sugar reacts with aluminum and calcium in the cement to make insoluble complexes. These interfere with the hardening process and leave less Al and Ca available to react with the water. Some sugars work better than others (white refined sugar works well, while the milk sugar lactose only has a moderate retarding effect), and salt acts in a similar way. The cement hydration process itself is not fully understood, and there are likely to be several interactions at play. The more sugar you mix in, the longer the concrete takes to set, and if the sugar concentration exceeds 1% of the cement mixture it will refuse to harden altogether. While this effect can be useful, it does have its downsides. Because sugar is not usually considered hazardous, dry concrete mix can easily become contaminated while it is being transported. The compressive strength of concrete blocks increase to a desirable extent using sugar.

Figure. 1.1 Sugar

1.3.2 Slag Cement:

Concrete made with slag cement provides higher compressive and flexural strengths compared with straight Portland cement concrete. Improved strengths make it easier to achieve specified safety factors of the concrete mixture and can provide engineers with a tool to optimize concrete element designs. It provides enhanced material properties allowing producers to optimize concrete mix designs. Owners may realize decreased life cycle costs. Slag cement is most widely used in concrete, either as a separate cementitious component or as part of blended cement. It works synergistically with Portland cement to increase strength, reduce permeability, and improve resistance to chemical attack and inhibit rebar corrosion. Portland Slag Cement, commonly known as PSC, is blended cement. Slag is, essentially, a non-metallic product comprising of more than 90% glass with silicates and alumino-silicates of lime. At JSW Cement, we use superior quality slag produced at our steel manufacturing plant, conforming to IS: 12089 standards for producing PSC. It is created with a combination of up to 45- 50% slag, 45% – 50% clinker, and 3-5% gypsum. PSC has been voted as the most suitable cement for mass construction because of its low heat of hydration.

Figure 1.2 Slag Cement

PSC's inherent chemistry gives it several advantages over ordinary cement. Apart from being more environment-friendly, it offers;

- Ultimate compressive strength
- Excellent resistance to Chloride & Sulphate attacks
- Low risk of cracking
- Improved workability
- Better compatibility with all types of admixtures
- Ease of pumping
- Better resistance against alkali-silica reaction
- Minimized shrinkage cracks

1.4 Main Objective of the Project

The main objective of the project mainly surrounds around increasing the strength of the concrete structure. The sugar as an additive increases the strength as well as increases the initial setting and final setting time. Whereas the slag cement increases the compressive strength as well as the flexural strength of the concrete. The main objective of the project is to;

- To increase the compressive strength of the concrete.
- To increases the flexural strength and the tensile strength of the concrete structures.
- To make a cost efficient and more durable and workable concrete mix that can have a long life and strength as compared to a normal mix concrete.

1.5 Organization of the Thesis

The work of the project was noted down into chapters and a brief data was collected. This thesis work has been organized in five chapters as follows:

Chapter 1 Introduction

It presents various aspects of Sugar and Slag cement. This chapter also discusses objective, scope, and the methodology adopted for this investigation.

Chapter 2 Literature Review

A review of recent literature on behavior of Sugar and Slag Cement has been discussed on the basis of which the need of the present investigation.

Chapter 3 Materials Used

It describes the properties of the materials used in the test specimens, the sizes and the number of specimens, testing methods and the associated instrumentation.

Chapter 4 Methodology

The analyses of the results, the related discussion and salient observations from the testing have been included in a sequential manner. Results and discussion pertaining to material tests have been presented first and those of the strength tests have been presented later.

Chapter-5 Work Performed

The significant conclusions obtained from experimental investigations of this study have been integrated and presented in a logical sequence and recommendations for further research made.

At the end, references used in this document are present.

2.1 Review of Papers

[1]**Refer to paper by *Jaibeer Chand and *Sangeeta Dhyani on EFFECT OF SUGAR ON THE COMPRESSIVE STRENGTH OF CONCRETE Accepted: 4 July 2015;**Concrete blocks are mostly used for covering or coating on a structure or material, load bearing purposes all around the world. This paper gives special importance or value to the effect of sugar on strength of concrete. This experiment determines the effect of admixtures (sugar) on the compressive strength of concrete block. Based on books and literature the main function of sugar is to increase the initial setting time of concrete. Concrete is most widely used man made construction material in the world and obtain by mixing cement, sand, aggregates and water, and sometime admixtures is required in suitable proportions. The strength, durability and other characteristics of concrete depends up on the properties of its ingredients, on the proportion of mix, the method of compaction and other control during placing, compaction and curing. Concrete block has its superior properties like binding, strength and durability, but it cannot be used in all places due to different weather conditions in different countries. Variation in weather condition and sessions causes changes in the initial setting time of concrete. Retarder and Accelerator are used to increase and decrease the initial setting time of concrete especially in winter sessions and summer sessions respectively. With the help of different type of admixture used such as Retarder- sugar and gypsum etc. and Accelerator- calcium chloride (cacl2) etc. According to various review papers and research papers sugar is good admixture to retard (or increase) the initial setting. Usually three different percentage of sugar admixtures are taken as 0.0, 0.06, ands0.08% by weight of cement. Finally compressive strength and workability of concrete were computed out. The compressive strength of concrete blocks increasing it by 16.02% at 28 days as compared to ordinary concrete blocks.

[2]**Refer to paper by *J Paya,* J Monzo, *MV Borrachero, L Diaz-Pinzon and LM Ordonez. ON SUGAR USAGE AND ITS PROPERTIES FOR REUSING IN CONCRETE PRODUCTION Accepted: 2002;** sugar bagasse is an industrial waste which is used worldwide as fuel in the same sugar industry. The combustion yields ashes containing high amounts of unburned matter, silicon and chemically, physically and mineralogical characterized, in order to evaluate the possibility of their use in a cement replacing material in the concrete industry. Determination of parameters such as carbon content (by thermal analysis methods), presence of crystalline materials (by x-ay diffractometry), granulometric distribution. The reuse of waste materials for concrete production is a worldwide practice.

One of the types of waste for producing cement replacing materials and concrete components materials is agricultural waste. The addition of concrete of ashes from combustion of rice husks is a frequent practice because of the pozzolonic activity of the ashes towards lime. Agricultural wastes are being tested for concrete production. One of the most interesting materials is the ash obtained from the combustion of sugar cane bagasse. The bagasse is produced as a fibrous residue after crushing and juice extraction. Thus this paper represents the preliminary study on the characterization of the sugar basagge with high content of unburned substances (Greater than 10%) and the study of its pozzolonic reactivity. Sugar is a carbohydrate, a substance composed of carbon, oxygen and hydrogen. It is that in old monuments in Gandikota at Kadapa district Andhra Pradesh, where holding the stone was achieved by mortar with combination of lime, sand and jiggery juice. It can be useful when concrete used in hot weather, when the normal setting time of concrete is shortened by the higher surrounding temperature such as Gujarat, Rajasthan etc. Very small dosage of the order of 0.05 to 0.1 per cent of the mass of the concrete is enough. 0.05 per cent of sugar can delay initial setting time by about 4 hours. Usually three different percentage of sugar admixtures were taken as 0.0, 0.06, ands0.08% by weight of cement.

[3]Refer to paper by *Giridhar, *Kadapa, *Kishore Kumar Reddy ON EFFECT OF SUGAR ON STRENGTH PROPERTIES OF CONCRETE Accepted: 30 October, 2013: Concrete is an inevitable material in the human being's life, because of its superior characteristics like strength and durability, but in certain situations it can't be used in all places because setting time of concrete. Retarders are used in the concrete composition to improve the setting time and also to increase the temperature of the composition with different type of admixtures. It is observed that an old Monuments in Gandikota at Kadapa dist, where bonding between the stones was achieved by mortar with combination of lime, sand and jaggery juice. Concrete made with admixtures like sugar and jaggery can be utilized in particular situations. Usage of these admixtures will decrease the segregation and bleeding. Sugar is a carbohydrate, a substance composed of carbon, oxygen and hydrogen. Jaggery is made from the product of sugar cane. So, both are useful to add as an admixtures in the concrete composition. Cement was replaced by Sugarcane Bagasse Ash (SCBA) in the production of mortar and concrete as 0, 5, 10, 15 and 25%. Based on the experimental results, it was accomplished that, as the replacement ratio increases, workability and significant strength values were increased. White sugar was used from 0 to 1% by weight of cement in the concrete preparation. Compressive strength was marginally improved, but maximum strength was obtained at 0.06% for 28 days. In the process of manufacturing the sandcrete brick of size 450mm x150mm x225mm, 0.1 and 0.2% of sugar was added by weight of cement into the brick manufacturing. The compressive strength was increased by 17 and 9% respectively. Molasses has been procured from three different sugar industries and added two percentages of 0.4 and 0.7% by weight of cement into the concrete as admixture. Setting time was increased when dosage increases. Similar types of trends were observed in the compressive strength of concrete with 0.4% molasses based admixture. Setting of cement extended due to the incorporation of sugar by weight of cement up to certain extent of 0.15%, exceeding this limit of incorporation, it has been acted as accelerator up to 0.3% and the optimum percentage of sugar added into the concrete was 0.15%. 20% of SCBA added into the clinker, which resulted higher compressive strength of mortars among 0 - 40% of SCBA added in the clinker. 28.15 Mpa was recorded and it was an appreciable strength development, when sugar was added as the admixture. This was 16.6% higher than control value. By addition of 0.03% of sugar based admixture into the concrete, it showed better results in strength aspects especially in modulus of rupture. Herbal juice was prepared with herb and palm jiggery, soaked in the water for about 15 days and ambient temperature of 27° to 29°C was maintained. 5% of this juice and lime water was used in the composition and it was concluded that, increments in stransverse strength was 1.6, 3% of tensile strength and 2.5% of compressive strength. Retarders were used to improve the workability of concrete and increased the temperature with different combination of admixtures. This paper emphasizes the effect of Sugar on strength properties of concrete. The experimentation has been carried out for evaluating the strength properties of concrete using Sugar as admixtures into the concrete composition. Based on the literature, the main function for usage of Sugar is to extend the initial setting time of concrete. Usually these type of admixtures used in the special cases like large piers and long piles. Three different percentages of admixtures are chosen in the experimentation as 0, 0.05 and 0.1% by weight of cement. Finally it was concluded that workability and compressive strength of concrete enhanced when admixtures like Sugar added into the concrete composition.

[4]Refer to paper by *Shi Caijun, Li Yinyu * ON INVESTIGATION ON SOME FACTORS AFFECTING THE CHARACTERISTICS OF ALKALI-PHOSPHORUS SLAG CEMENT, Accepted: 30 October, 2013: Alkali-slag cements are of higher strength, and their other properties are also better than those of Portland cement. In this paper, the authors studied how the properties of alkali-phosphorus slag cement were influenced by the modulus of water glass ($Na_2O:nSiO_2$), soluble phosphates, water to solid ratio and the fineness of the slag when water glass and granulated phosphorus slag (GPS) were used to make alkali-GPS cement. The water is included in this calculation because the carbonation test was treated as a closed system. It is assumed that the only water present at the conclusion of the carbonation treatment had been present in the chamber at the beginning of the test as mix water. The aggregates are excluded because they do not absorb CO2. If the increase in mass during the carbonation was solely due to the incorporation of carbon dioxide into solid carbonation products then a measure of the mass gain of the closed system can provide an effective estimate of CO2 uptake. Carbonated or hydrated powder samples of 50 g were placed into ceramic crucibles and were oven dried at 105°C to remove any Uncombined water. The samples were then heated in a muffle furnace to 540 and 980°C. It is understood that the mass loss from 105 to 540°C is attributable to the loss of chemically bound water which can be used to estimate the hydration products such as calcium silicate hydrate and calcium hydroxide. The experimental results indicated that the modulus of water glass had great influence, but soluble phosphates had little influence on the properties of the cement. If the water to solid ratio was increased, it was not helpful both to the early hydration and to the strength of the cement. There would be a critical fineness after some days. If the fineness was larger than the critical value, the fineness hardly affected the strength of the cement.

[5]Refer to paper by *A.A. Ramezanianpour and V.M. Malhotra ON EFFECT OF CURING ON THE COMPRESSIVE STRENGTH, RESISTANCE TO CHLORIDE-ION PENETRATION AND POROSITY OF CONCRETES INCORPORATING SLAG, FLY ASH OR SILICA FUME. Accepted: 25 June, 2002. This paper reports an investigation in which the performance of slag, fly ash, and silica fume concretes were studied under four different curing regimes. The water-cementitious materials ratio of all the concrete mixtures was kept constant at 0.50, except for the high-volume fly ash concrete mixture, for which the ratio was 0.35. The concrete specimens were subjected to moist curing, curing at room temperature after de-moulding, curing at room temperature after two days of moist curing, and curing at 38 °C and 65% relative humidity. The compressive strength was determined at various ages, and the resistance to chloride-ion penetration was measured according to ASTM C 1202 at different ages up to 180 days. Mercury intrusion porosimetry tests were performed on the 28-day old mortar specimens for comparison purposes. The results indicate that the reduction in the moist-curing period results in lower strengths, higher porosity and more permeable concretes. The strength of the concretes containing fly ash or slag appears to be more sensitive to poor curing that the control concrete, with the sensitivity increasing with the increasing amounts of fly ash or slag in the mixtures. The incorporation of slag or silica fume, or high volumes of fly ash in the concrete mixtures, increased the resistance to chloride ions and produced concretes with very low permeability.

[6]**Refer to paper by *F Puertas, S Martínez-Ramírez, S Alonso, T Vázquez ON ALKALI-ACTIVATED FLY ASH/SLAG CEMENTS: STRENGTH BEHAVIOUR AND HYDRATION PRODUCTS. Accepted: 10 June, 2011**. The activation of fly ash/slag pastes with NaOH solutions have been studied. The parameters of the process studied are: activator concentration (NaOH 2 and 10 M), curing temperature (25°C and 65°C), and fly ash/slag ratios (100/0, 70/30, 50/50, 30/70, and 0/100). The equations of the models describing the mechanical behavior of these pastes have been established as a function of the factors and levels considered. The ratio of fly ash/slag and the activator concentration always result to be significative factors. The influence of curing temperature in the development of the strength of the pastes is lower than the contribution due to other factors. At 28 days of reaction, the mixture 50% fly ash/50% slag activated with 10 M NaOH and cured at 25°C, develop compressive mechanical strengths of about 50 MPa. The nature of the reaction products in these pastes has been studied by insoluble residue in HCl acid, XRD, FTIR and MAS NMR. It has been verified that slag reacts almost completely. It has also been determined that the fly ash is partially dissolved and participates in the reactive process, even in pastes activated at ambient temperature. The main reaction product in these pastes is a hydrated calcium silicate, like CSH gel, with high amounts of tetra coordinated Al in its structure, as well as Na ions in the interlayer spaces. No hydrated alkaline alumino-silicates with three-dimensional structure characteristics of the alkaline activation of fly ashes were formed.

[7]**Refer to paper by *Suman Rana ON EFFECT OF SUGAR ON SETTING-TIME AND COMPRESSIVE STRENGTH OF ORDINARY PORTLAND CEMENT PASTE. Accepted: 27-29 September, 2014.** The use of sugar to delay setting of cement at construction site seems reasonable as it is cheap and readily available. But, addition of sugar has inevitable implications not only on setting time but also on compressive strength of cement paste. So, its effect needs to be well-understood for better control over its use. Test samples prepared by using 53 grade OPC cement and sugar in increasing proportion did not show a fixed result. Addition of sugar 0.07% by weight of cement resulted in 3 hours and 35 minutes delay in total setting time and around 4% increase in strength of cement. But, sugar content above 0.13% by weight of cement reduced setting time and sample was marked with cracks at the surface while hardening. Sugar when used in correct proportion acts as retarder but when it is used in excessive amount it reverse its property i.e. acts as accelerator. So it

should be used in proper supervision. An amount of 0.07% by weight of cement is found to delay both the setting time and also shows around 4% increase in compressive strength. Sugar above 0.13% by weight of cement accelerated the setting time with nominal gain in initial strength. Excessive volume expansion was noted in the sample as cracks were formed in the sample itself. So a careful use of sugar can be economical in comparison to commercially available set retarders. Sugar falls under the category of 'coating ' admixture ;in the presence of water a cement particle sends out a swarm of calcium ions into the surrounding water and any substance capable of immobilizing or delaying this surge will also slow down the interchanges between the water and the particle, thus retarding the hydration process. Concreting in hot weather i.e. above 100°F accelerates the early hydration of cement and produce concrete having high strength at early ages, but the later strength is reduced considerably. Further, the rapid evaporation of water causes plastic shrinkage (cracks developed before the concrete has hardened) in concrete and subsequent cooling would cause tensile stresses and cracking.

[8]Refer to paper by *Sean Monkman and *Yixin Shao on CARBONATION CURING OF SLAG-CEMENT CONCRETE FOR BINDING CO2 AND IMPROVING PERFORMANCE. Accepted: April, 2010. Carbonation curing is different from weathering carbonation in that the former is applied at a very early age while the latter occurs in matured concrete. This research aims to investigate carbonation curing as a way of simultaneously binding carbon dioxide into slag-cement concrete products and improving their performance. The blended cements are attractive from a net carbon uptake standpoint because of the reduced cement content and from a long-term performance standpoint because of their latent cementations reactivity. It is expected that carbonation curing would provide the slag-cement concrete with higher early strength and the subsequent hydration would contribute to the later development of strength and durability. Early age carbonation curing of slag-cement concrete was investigated to assess the feasibility of binding CO2 in slag-cement building products while improving their short-term and long-term performances. Four binder types were compared: an ordinary Portland cement; 85/15 slag cement; a 75/25 slag blend; and a 50/50 slag blend. A 2-h carbonation-curing treatment allowed concretes to bind 8–10% CO2 by mass of binder and attain as much as 82% of the 24-h hydration strength. The subsequent strength development of carbonated concrete was slower in the first 24 h possibly due to the carbonate buildup, but it was comparable to the conventionally hydrated concrete after 28 days. The carbonated concrete was shown to have fracture toughness comparable to that of the hydrated concrete. The freeze/thaw durability of the concrete in deicing salt solution was vastly improved by the carbonation treatment. The pH of the carbonated concrete was reduced but was still above the threshold level required for the passivation of iron. The use of slag in carbonation curing is beneficial to strength gain, shrinkage reduction, and deicing salt resistance.

[9]**Refer to paper by* A. S. AI-Gahtani, *1 Rasheeduzzafar, 2 and *S. S. A1-Saadoun on REBAR CORROSION AND SULFATE RESISTANCE OF BLAST-FURNACE SLAG CEMENT. Accepted: October 4, 1994.** This study was designed to evaluate the relative corrosion and sulfate resistance of concrete made with Portland cements containing 2%-14% C3A without and with 50%, 60%, 70%, and 80% cement replacement by blast-furnace slag (BFS). The results show that BFS blended-cement concretes had a significantly superior corrosion-resistance performance. The best corrosion protection was obtained with 50% BFS cement, which, depending on the C3A content of the parent cement, showed a 3.82-3.16 times better performance in terms of corrosion-initiation time compared to the parent plain-cement concrete. BFS blending was especially beneficial in improving the corrosion-resistance performance of Type V low C3A cements. Performance on exposure to sodium-sulfate (NS) solution, replacement level only at 70% and above, showed sulfate resistance to be better than that of the Type V sulfate-resistant cement. BFS blending, even with high C3A cement (9%, 11%, and 14%) at 70% and above-replacement level, imparted a high degree of sulfate resistance. The cement with high C3S/C2S ratio has a perceptible adverse-interactive effect and causes sulfate deterioration even with low-C3A sulfate- resistant cements. In MS-NS environment, due to the magnesium-gypsum type of attack, the 60% BFS cement deteriorated even more severely than the plain Type V and Type I cement. Cement-blending materials such as blast-furnace slag, silica fume, and fly ash offer significant opportunities for the immunization of the cement-paste component from certain deleterious-chemical actions such as sulfate attack and alkali-silica reaction. Apart from bringing certain changes in the chemical environment of concrete, the addition of these supplementary-pozzolanic materials brings about a very significant change in the physical structure of the hardened-cement paste. This study is related to an evaluation of the durability performance of granulated blast-furnace (GBF) slag cement concrete in aggressive environments, and is part of a comprehensive durability-research program at the King Fahd University of Petroleum and Minerals, initiated in 1981. Addition of slag as a separate ingredient in concrete has several advantages over the process of inter-grinding granulated slag with Portland-cement clinker (Sutterheim 1968). Hence, in this study, GBF slag has been used as a separate cementitious material, added and mixed thoroughly with ordinary Portland cement.

[10] **Refer to paper by *Juan M. Manso *Milagros Losañez *Juan A. Polanco and *Javier J. Gonzalez on LADLE FURNACE SLAG IN CONSTRUCTION. Accepted: 1 October, 2005.** Ladle furnace reducing slag is a common byproduct in steelmaking of carbon and low alloy steels. After air cooling and weathering over several days, this material is completely ground into fine white particles. Physical, chemical, and crystalline characterizations were performed in order to verify possibilities for its direct application as a construction material. Two ways are proposed for the immediate use of ladle furnace slag: masonry mortars and paving mixes for rural roads with low levels of traffic. Ladle furnace reducing slag _LFS_ is a byproduct of steelmaking industries obtained from the ladle furnace refining of carbon and low alloy steels. This process makes it possible to eliminate the sulphur and takes place in the presence of a basic slag in which the most significant oxides are SiO2, Al2O3, CaO, and MgO. The final addition of alloy elements completes the steelmaking process and the molten steel is passed to the tundish. The slag is poured from the ladle in a liquid state and is cooled to room temperature. This process is the same for steels produced from basic oxygen furnaces _BOFs_ and from electric arc furnaces _EAFs_, requiring an average of 30 kg LFS slag per ton of steel produced. Therefore LFS is an important byproduct all over the world, and is usually stocked in waste yards alone or mixed with EAF or BOF slag. These days however the environmental demands in

Advanced countries make it necessary to find new solutions for all industrial wastes, and LFS is one such material. Two main groups can be identified among the possibilities for reuse of LFS: those involving an industrial transformation with a noteworthy economic cost and those aimed at finding an inexpensive use as a construction material.

[11] **Refer to paper by *Mieke De Schepper; *Pieter Verlé; *Isabel Van Driessche; and *Nele De Belie on USE OF SECONDARY SLAGS IN COMPLETELY RECYCLABLE CONCRETE. Accepted: May 21, 2014.** In today's society, concrete is a popular building material: it is strong, gives flexibility in design, and comes with a relatively low cost. However, like all materials, it also comes with an environmental cost. About 42% of the 15 billion tons (Langer et al. 2004) of aggregates produced each year are used in concrete, of which only 8% are recycled aggregates (Arab 2006). This use of enormous amounts of natural raw materials is the first environmental problem of the concrete industry. Indeed, at the end of a concrete's life cycle, there is the waste production: 12–21% of the total waste generated in the European Union is concrete demolition waste. These numbers are the motivation for many researchers to work toward a more sustainable construction by resource efficiency and recycling. To optimize product-recycling opportunities, the Cradle-to- Cradle (C2C) concept

was developed. In C2C production, all material inputs and outputs are either seen as biological nutrients or as technical resources. Biological nutrients can be composted or consumed whereas technical resources can be recycled or reused without loss of quality. Applying this idea to the production of concrete, a completely recyclable concrete (CRC) was designed. In order to make CRC a valuable technical resource for cement production, without need for ingredient adjustments, the concrete mixture should be chemically equivalent to a traditional cement raw meal. The primary ingredient for CRC is limestone aggregate as a source for CaO, the main ingredient for Portland cement production. A completely recyclable concrete (CRC) is designed to have a chemical composition equivalent to the one of general raw materials for cement production. By doing so, this CRC can be used at the end of its service life in the cement clinkering process without need for ingredient adjustments, and with improvement of the resource efficiency of cement and concrete production. Copper slag is interesting as an iron source for the production of such a CRC and can be added to concrete, either as alternative binder or as aggregate. By isothermal calorimetry and compressive strength tests it was found that the addition of copper slag as cement replacement is of minor interest. But a study toward the compressive strength and durability of concrete with copper slag as aggregate replacement had promising results. The performance of these concretes was comparable with or even better than the reference concrete, regarding strength and most durability aspects such as porosity and permeability, and resistance against carbonation and chloride ingress. Only the resistance to freeze thaw attack with deicing agents was inferior.

[12]Refer to paper by *Xiao-Yong Wang and *Han-Seung Lee on EVALUATION OF PROPERTIES OF CONCRETE INCORPORATING FLY ASH OR SLAG USING A HYDRATION MODEL. Accepted: July 1,2011. Both granulated slag and fly ash are general industrial by-products that have been used as mineral admixtures to improve the durability of and produce high strength and high performance concrete. In addition, economic and ecological benefits, such as energy-savings and resource-conservation, can be achieved by using blended cement a micro structural hydration model of portland cement that considered the reduction in the hydration rate that occurs because of the reduction of free water and the reduction of the interfacial area of contact between the free water and the hydration products. By using the proposed model, Park predicted the following properties of hardening cement paste: the degree of hydration, the rate of heat evolution, the relative humidity, and the total porosity. Compared to Portland cement, the hydration of cement incorporating supplementary cementing materials is much more complex because of the coexistence of cement hydration and the reactions of the mineral admixtures. a hydration model was presented to estimate the heat release of mass concrete in the presence of silica fume. In the model, the degree of reaction of silica fume was evaluated through the degree of cement hydration. This model is valid when the amount of silica fume is limited to less than 10% of the weight of the cement. Granulated slag from metal industries and fly ash from the combustion of coal are industrial by-products that have been used widely as mineral admixtures in normal and high-strength concrete. Because of the reaction between calcium hydroxide and fly ash or slag, the hydration of concrete containing fly ash or slag is much more complex than that of Portland cement. In this paper, the production of calcium hydroxide in cement hydration and its consumption in the reaction of mineral admixtures is considered to develop a numerical model that simulates the hydration of concrete containing fly ash or slag. The properties of concrete incorporating fly ash or slag, such as the adiabatic temperature increase, chemically bound water, reaction degree of mineral admixture, and the compressive strength, are determined by the contribution of both cement hydration and the reaction of the mineral admixtures. The proposed model is verified with experimental data from concrete with different water to cement ratios and mineral admixture substitution ratios.

[13]Refer to paper by *Noel P. Mailvaganam and *Claude Bedard, P.E. on THE USE OF SUGAR AS A CHEMICAL ADMIXTURES IN CONCRETE. Accepted: November 2015. Today's concrete incorporates a mixture of chemical and mineral admixtures. They interact with cement constituents and influence cement hydration. An admixture's performance is dependent on its type and dosage, composition, specific surface area of the cement, type and proportions of the aggregate, sequence of addition of water and admixture, compatibility of admixtures, water/ cement ratio, and temperature and conditions of curing. The use of a mixture of admixtures in a mix raises further compatibility issues, which need rectifying before field use. Incompatibilities between admixtures will be discussed in a future forum contribution, along with the resolution of related problems. Chemical admixtures affect the properties of concrete in diverse ways, and more than one effect can occur at a time e.g. chemical interference with hydration reactions or physical interaction with the hydration product. As more chemicals are added to the mix, compatibility with the cement and other admixtures becomes the central parameter governing the selection. Side effects or reactions among chemicals attributable to the sequence of addition, cement type, temperature change, and batching equipment can all affect performance. It is important to understand admixture-cement and admixture-admixture interactions so optimal use of materials can be achieved, admixture-cement incompatibility can be prevented, better troubleshooting of field problems is possible, and more accurate prediction of concrete properties is possible.

2.2 Research Gap

Referring to the papers on the “Slag Cement and Sugar as an admixture” we came across various methods of improvement of the strength of the concrete mix. The papers gave a brief review of how the compressive strength and the tensile strength of the concrete mix improved. Usage of sugar and slag cement to improve the strength property of the concrete mix proved to be economical one. The heat of hydration increased with the use of the slag cement whereas, the rebar corrosion and sulphate resistance improved by the use of blast furnace slag. The papers represented that use of sugar can be done in hot climatic conditions because sugar delays the setting time of the concrete mix.

The literature review helped to explain the properties and gain in the strength of the concrete mix.

The details of experiment program in terms of material properties, test set-up for measuring different parameters are discussed

3.1 Concrete

Concrete is a material composed of cement and water combined with sand, gravel, crushed stone, or other inert material such as expanded slag or vermiculite. A strong stone-like mass is formed from chemical reaction of the cement and water. The concrete paste can be easily molded into any form or toweled to produce a smooth surface. Hardening starts immediately after mixing, but precautions are taken, usually by covering, to avoid rapid loss of moisture since the presence of water is necessary to continue the chemical reaction and increase the strength. Too much of water, however, produces a concrete that is more porous and weaker. The quality of the paste formed by the cement and water largely determines the character of the concrete.

3.2 Material and its properties

Cement, fine aggregates, coarse aggregates, recycled coarse aggregate, silica fume and water are used for present investigation. The properties of these materials are discussed in the following sections.

3.2.1 Cement

Cement is a fine, grey powder. It is mixed with water and materials such as sand, gravel, and crushed stone to make concrete. The cement and water form a paste that binds the materials together as the concrete hardens. The ordinary cement contains two basic ingredients namely argillaceous and calcareous. In argillaceous materials, clay predominates and in calcareous materials calcium carbonate predominates. Portland cement is manufactured by grinding together calcareous (limestone, chalk, marl, etc.) and argillaceous (shale or clay) materials in approximate proportion of 2:1 and other silica, alumina or iron oxide bearing materials. Portland cement referred as (Ordinary Portland Cement) is the most important type of cement.

The OPC is classified into three grades, namely 33 Grade, 43 Grade, 53 Grade depending upon the strength of 28 days. The grade indicates the compressive strength of cement at

28 days tested according to IS: 4031- part IV (Methods of physical tests for hydraulic cement).

Figure 3.1 OPC 53 grade

3.2.2 Fine Aggregates

The material which passes through 4.75 mm sieve is termed as fine aggregate. Usually natural sand is used as a fine aggregate at places where natural sand is not available crushed stone is used as a fine aggregate.

Table 3.1 Sieve analysis of fine aggregate

Sr. no	Sieve no	Wt. retained(gm)	Cumulative wt. retained	Cumulative % Retained	cumulative% passing
1	**4.75**	**1**	**1**	**0.1**	**99.9**
2	**2.36**	**22**	**23**	**2.3**	**97.7**
3	**1.18**	**77**	**100**	**10**	**90**
4	**600µ**	**153**	**253**	**25.3**	**74.3**
5	**300µ**	**264**	**517**	**51.7**	**48.3**
6	**150µ**	**425**	**942**	**94.2**	**5.8**
7	**Pan**	**58**	**1000**	**100**	**0**
8	**TOTAL**			**Σ283.6**	

Fineness Modulus of fine aggregate **= ΣF/100** = 283.6/100 = **2.836**

3.2.3 Coarse Aggregate

Generally, aggregates occupy 70% to 80% of the volume of concrete and have an important influence on its properties. They are granular materials, derived for the most part from natural rock (crushed stone, or natural gravels) and sands. In order to obtain a good concrete quality, aggregates should be hard and strong, free of undesirable impurities, and chemically stable. Soft and porous rock can limit strength and wear resistance, and sometimes it may also break down during mixing and adversely affect workability by increasing the amount of fines. The broken stone is generally used as a coarse aggregate. The nature of work decides the maximum size of the coarse aggregate. Locally available coarse aggregate having the maximum size of 20 mm was used in the present work

Table 3.2 Sieve analysis of coarse aggregate

Sr. no	Is sieve (mm)	Weight retained (gm)	Cumulative weight retained	Cumulative % Retained	Cumulative % passing Through
1	**40**	**0**	**0**	**0**	**100**
2	**20**	**145**	**145**	**7.25**	**92.75**
3	**10**	**1829**	**1974**	**98.7**	**0.3**
4	**4.75**	**124**	**1998**	**99.9**	**0.1**
5	**2.36**	**0**	**1998**	**99.9**	**0.1**
6	**1.18**	**0**	**1998**	**99.9**	**0.1**
7	**600µ**	**0**	**1998**	**99.9**	**0.1**
8	**300µ**	**0**	**1998**	**99.9**	**0.1**
9	**150µ**	**0**	**1998**	**99.9**	**0.1**
10	**Pan**	**2**	**2000**	**100**	**0**
	TOTAL			**Σ805.35**	

Fineness Modulus of Coarse aggregate **= 805.35 / 100 = 8.0535**

3.2.4 Water

Water is an important ingredient of concrete as it actively participates in the chemical reaction with cement. Since it helps to form the strength giving cement gel, the quantity and quality of water is required to be looked into very carefully. Potable water is generally considered satisfactory. In the present investigation, tap water is used for both mixing and curing purposes.

3.2.5 Slag Cement

An intimately inter-ground mixture of Portland cement clinker and granulated slag With addition of gypsum and permitted additives or an Intimate and uniform blend of Portland cement and finely ground granulated slag. Portland slag cement shall be manufactured either by Intimately inter-grinding a mixture of Portland cement clinker and granulated Slag with addition of gypsum (natural or chemical) or calcium sulphate, or by an intimate and uniform blending of Portland cement and finely ground granulated slag. that the resultant mixture would produce cement capable of complying with this specification. No material shall be added other than gypsum (natural or chemical) or water or both. However, when gypsum IS added It shall be In such amounts that the sulphur trioxide (SO,) In the cement produced docks not exceed the limits specified Besides. Not more than one percent of air-entraining agents or surfactants which have proved not to be harmful. The slag constituent shall be not less than 25 percent nor more than 6S percent of the Portland slag cement.

Chemical requirements:

Portland cement clinker used In the manufacture of Portland slag cement shall comply in all respects with the chemical requirements specified for the 53 grade ordinary Portland cement ill IS 269 : 1989, and the purchaser shall have the right, If he so desires, to obtain samples of the clinker used In the manufacture of Portland slag cement. The Portland slag cement shall comply with the following chemical requirements when tested In accordance With the methods given 10 IS 4032:

The major constituents of the slag cements are;

- Max Magnesium Oxide (MgO) = 8·0 %
- Sulphur trioxide (SO,) = 3·0 %
- Sulphide sulphur (S) = 1·5 %
- Loss on ignition = 5 %
- Insoluble residue = 4 %

3.2.6 Curing Conditions

Curing is the process in which the concrete is protected from loss of moisture and kept within a reasonable temperature range. The result of this process is increased strength and decreased permeability. Curing is also a key player in mitigating cracks in the concrete, which severely impacts durability. Cracks allow open access for harmful materials to bypass the low permeability concrete near the surface. Good curing can help mitigate the appearance of unplanned cracking. When smart, suitable, and practical curing is used, the amount of cement required to achieve a given strength and durability can be reduced by either omission or replacement with supplementary cementitious materials. Since the cement is the most expensive and energy intensive portion of a concrete mixture, this leads to a reduction in the cost as well as the absolute carbon footprint of the concrete mixture. Additionally, practical curing methods can enhance sustainability by reducing the need for resource intensive conditioning treatments, should the curing method be incompatible with the intended service environment. All concrete samples were placed in curing basin after 24 hours from casting. The samples were remained in curing basin until tested at the specified age. The samples were kept in the water tank for 3, 7 and 28 days. And hence the compressive and tensile forces were calculated after the specific days. The Figure (4.22) illustrates the appearance of curing basin which used in this study.

Figure 3.2 Curing of the concrete blocks

CHAPTER 4 METHODOLOGY

4.1 General

This chapter covers all the various tools; equations, software's and methods which are used for analysis and study that are to be included. The design of the concrete being used for the derivation of the end strength of various days according to the project being undertaken is too enumerated down in the chapter.

4.2 Computations of the Strength

The general purpose of the project was to calculate and compare the strength of the cube blocks being casted and checked for 3, 7 & 28 days. Thus the following computation of the strength was to calculated;

4.2.1 Compressive Strength:

Compressive 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), whereas tensile strength resists tension (being pulled apart). In the study of strength of materials, tensile strength, compressive strength, and shear strength can be analyzed independently. Stacking strength of a fiberboard container measured as the maximum load that can be applied to it under specified conditions before it is crushed, and expressed in newtons or pounds per square inch.

Printing directly onto the container face or surface reduces its compression strength by crushing the material and saturating the fibers with ink Also, called compression resistance, compressive strength, or crush resistance. When a specimen of material is loaded in such a way that it extends it is said to be in tension. On the other hand, if the material compresses and shortens it is said to be in compression. On an atomic level, the molecules or atoms are forced apart when in tension whereas in compression they are forced together. Since atoms in solids always try to find an equilibrium position, and distance between other atoms, forces arise throughout the entire material which oppose both tension and compression.

The phenomena prevailing on an atomic level are therefore similar. The "strain" is the relative change in length under applied stress; positive strain characterizes an object under tension load which tends to lengthen it, and a compressive stress that shortens an object gives negative strain. Tension tends to pull small sideways deflections back into alignment, while compression tends to amplify such deflection into buckling. Compressive strength is measured on materials, components, and structures. By definition, the ultimate compressive strength of a material is that value of uniaxial compressive stress reached when the material fails completely. The compressive strength is usually obtained experimentally by means of a compressive test. The apparatus used for this experiment is the same as that used in a tensile test. Compressive 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), whereas tensile strength resists tension (being pulled apart). In the study of strength of materials, tensile strength, compressive strength, and shear strength can be analyzed independently. Compressive strength can be measured by plotting applied force against deformation in a testing machine, such as a universal testing machine. Some materials fracture at their compressive strength limit; others deform irreversibly, so a given amount of deformation may be considered as the limit for compressive load. Compressive strength is a key value for design of structures.

Figure 4.1 Measuring the compressive strength

Compressive strength is often measured on a universal testing machine; these range from very small table-top systems to ones with over 53 MN capacity. Measurements of compressive strength are affected by the specific test method and conditions of measurement. Compressive strengths are usually reported in relationship to a specific technical standard. When a specimen of material is loaded in such a way that it extends it is said to be in tension. On the other hand, if the material compresses and shortens it is said to be in compression.

On an atomic level, the molecules or atoms are forced apart when in tension whereas in compression they are forced together. Since atoms in solids always try to find an equilibrium position, and distance between other atoms, forces arise throughout the entire material which oppose both tension and compression. The phenomena prevailing on an atomic level are therefore similar.

The "strain" is the relative change in length under applied stress; positive strain characterizes an object under tension load which tends to lengthen it, and a compressive stress that shortens an object gives negative strain. Tension tends to pull small sideways deflections back into alignment, while compression tends to amplify such deflection into buckling. Compressive strength is measured on materials, components, and structures. By definition, the ultimate compressive strength of a material is that value of uniaxial compressive stress reached when the material fails completely. The compressive strength is usually obtained experimentally by means of a compressive test.

The apparatus used for this experiment is the same as that used in a tensile test. However, rather than applying a uniaxial tensile load, a uniaxial compressive load is applied. As can be imagined, the specimen (usually cylindrical) is shortened as well as spread laterally. The compressive strength of the material would correspond to the stress at the red point shown on the curve. In a compression test, there is a linear region where the material follows Hooke's Law.

Hence for this region $\sigma = E\epsilon$ where this time E refers to the Young's Modulus for compression. In this region, the material deforms elastically and returns to its original length when the stress is removed. This linear region terminates at what is known as the yield point. Above this point the material behaves plastically and will not return to its original length once the load is removed.

A stress–strain curve is plotted by the instrument and would look similar to the following:

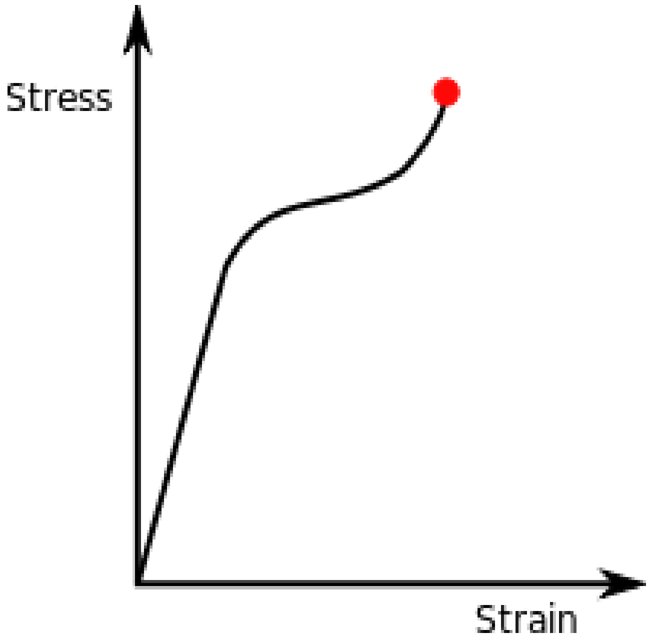


Figure 4.2 True Stress-Strain curve for a typical specimen

There is a difference between the engineering stress and the true stress. By its basic definition the uniaxial stress is given by:

$$\sigma = \frac{F}{A}$$

Where, F = Load applied [N], A = Area [m^2]

As stated, the area of the specimen varies on compression. In reality therefore the area is some function of the applied load i.e. A = f(F). Indeed, stress is defined as the force divided by the area at the start of the experiment. This is known as the engineering stress and is defined by,

$$\sigma_e = \frac{F}{A_0}$$

A_0=Original specimen area [m^2]

Correspondingly, the engineering strain would be defined by:

$$\epsilon_e = \frac{l - l_0}{l_0}$$

Where;

l = current specimen length [m] and l_0 = original specimen length [m]

The compressive strength would therefore correspond to the point on the engineering stress strain curve $(\epsilon_e^*, \sigma_e^*)$ defined by

$$\sigma_e^* = \frac{F^*}{A_0}$$

$$\epsilon_e^* = \frac{l^* - l_0}{l_0}$$

Where,

F^* = load applied just before crushing

l^* = specimen length just before crushing.

Figure 4.3 Testing of cubes

Procedure:

- Specimens stored in water shall be tested immediately on removal from the water and while are still in the wet condition, surface water and grit shall be wiped off the specimen.
- If the specimen received dry shall be kept in water for 24 hours before they are taken for testing.

- Before placing the specimen in the testing machine the bearing surface of the testing machine shall be wiped clean and any loose sand or other material should be removed from the surface of the specimen, which are to be in contact with the compression platens.
- In case of cubes, the specimen shall be placed in the machine in such a manner that the load shall be applied to opposite sides of the cubes as cast, i.e. not to the top and bottom. The axis of the specimen shall be carefully aligned with the centre of thrust of the spherically seated platens.
- No packing shall be used between the faces of the specimen and the steel platen of the testing machine.
- The load shall be applied without shock and increased continuously, until the resistance of the specimen to the increasing load breaks down and any unusual features in the type of failure shall be noted.
- Calculation of compressive strength: Divide the maximum load applied to the specimen during the test by the cross sectional area of the specimen.

4.2.2 Split Tensile Strength:

The tensile strength is one of the basic and important properties of the concrete. The concrete is not usually expected to resist the direct tension because of its low tensile strength and brittle nature. However, the determination of tensile strength of concrete is necessary to determine the load at which the concrete members may crack. The cracking is a form of tension failure. Apart from the flexure test the other methods to determine the tensile strength of concrete can be broadly classified as (a) direct methods, and (b) indirect methods. The direct method suffers from a number of difficulties related to holding the specimen properly in the testing machine without introducing stress concentration, and to the application of uniaxial tensile load which is free from eccentricity to the specimen. As the concrete is weak in tension even a small eccentricity of load will induce combined bending and axial force condition and the concrete fails at the apparent tensile stress other than the tensile strength. As there are many difficulties associated with the direct tension test, a number of indirect methods have been developed to determine the tensile strength. In these tests in general a compressive force is applied to a concrete specimen in such a way that the specimen fails due to tensile stresses developed in the specimen. The tensile stress at which the failure occurs is termed the tensile strength of concrete. The splitting tests are well known indirect tests used for determining the tensile strength of concrete sometimes referred to as split tensile strength of concrete. The test consists of applying a compressive line load along the opposite generators of a concrete cylinder placed with its axis horizontal between the compressive platens. Due to the compression loading a fairly uniform tensile stress is developed over nearly 2/3 of the loaded diameter as obtained from an elastic analysis. The magnitude of this tensile stress (acting in a direction perpendicular to the line of action of applied loading) is given by the formula (S: 5816-1970):

$$O_{sp} = \frac{2P}{\prod dl}$$

Ultimate tensile strength (UTS), often shortened to tensile strength (TS) or ultimate strength, is the capacity of a material or structure to withstand loads tending to elongate, as opposed to compressive strength, which withstands loads tending to reduce size. In other words, tensile strength resists tension (being pulled apart), whereas compressive strength resists compression (being pushed together). Ultimate tensile strength is measured by the maximum stress that a material can withstand while being stretched or pulled before breaking. In the study of strength of materials, tensile strength, compressive strength, and shear strength can be analyzed independently. Some materials break very sharply, without plastic deformation, in what is called a brittle failure. Others, which are more ductile, including most metals, experience some plastic deformation and possibly necking before fracture. The UTS is usually found by performing a tensile test and recording the engineering stress versus strain. The highest point of the stress–strain curve (see point 1 on the engineering stress/strain diagrams below) is the UTS. It is an intensive property; therefore its value does not depend on the size of the test specimen. However, it is dependent on other factors, such as the preparation of the specimen, the presence or otherwise of surface defects, and the temperature of the test environment and material. Tensile strengths are rarely used in the design of ductile members, but they are important in brittle members. They are tabulated for common materials such as alloys, composite materials, ceramics, plastics, and wood. Tensile strength can be defined for liquids as well as solids under certain conditions. For example, when a tree [3] draws water from its roots to its upper leaves by transpiration, the column of water is pulled upwards from the top by the cohesion of the water in the xylem, and this force is transmitted down the column by its tensile strength. Air pressure, osmotic pressure, and capillary tension also plays a small part in a tree's ability to draw up water, but this alone would only be sufficient to push the column of water to a height of less than ten meters, and trees can grow much higher than that (over 100m) is determined by indirect test methods.

Tensile strength is an important property of concrete because concrete structures are highly vulnerable to tensile cracking due to various kinds of effects and applied loading itself. However, tensile strength of concrete is very low in compared to its compressive strength. Due to difficulty in applying uniaxial tension to a concrete specimen, the tensile strength of concrete is determined.

Figure 4.4 Wooden planks being used while calculating the Tensile strength

It is the standard test to determine the tensile strength of concrete in an indirect way. A standard test cylinder of concrete specimen is placed horizontally between the loading surfaces of compression testing machine. To allow the uniform distribution of this applied load and to reduce the magnitude of the high compression stresses near the points of application of this load, strips of wood are placed between the specimen and loading platens of the testing machine. Concrete cylinders split into two halves along this vertical plane due to indirect tensile stress generated by poisons effect. Due to the compressive loading, an element lying along the vertical diameter of the cylinder is subjected to uniform tensile stress acting horizontally . the loading condition produces a high compressive forces immediately below the loading points. It is estimated that the compressive stresses acts at about 1/6 depth and the remaining 5/6 depth is subjected to tension due to poisons effect. Assuming concrete specimen behaves as an elastic body, Uniform lateral tensile stress of ft acting along the vertical plane causes the failure of the specimen, which can be calculated from the formulas,

$$ft = \frac{2p}{\pi DL}$$

Where;

P = Compressive load at failure

L= Length of cylinder

D= Diameter of cylinder

4.2.3 Flexural Strength:

Flexural strength, also known as modulus of rupture, bend strength, or fracture strength, is a material property, defined as the stress in a material just before it yields in a flexure test. The transverse bending test is most frequently employed, in which a specimen having either a circular or rectangular cross-section is bent until fracture or yielding using a three point flexural test technique. The flexural strength represents the highest stress experienced within the material at its moment of rupture. It is measured in terms of stress, here given the symbol σ. When an object formed of a single material, like a wooden beam or a steel rod, is bent (Fig. 1), it experiences a range of stresses across its depth.

At the edge of the object on the inside of the bend (concave face) the stress will be at its maximum compressive stress value. At the outside of the bend (convex face) the stress will be at its maximum tensile value. These inner and outer edges of the beam or rod are known as the 'extreme fibers'. Most materials fail under tensile stress before they fail under compressive stress, so the maximum tensile stress value that can be sustained before the beam or rod fails is its flexural strength.

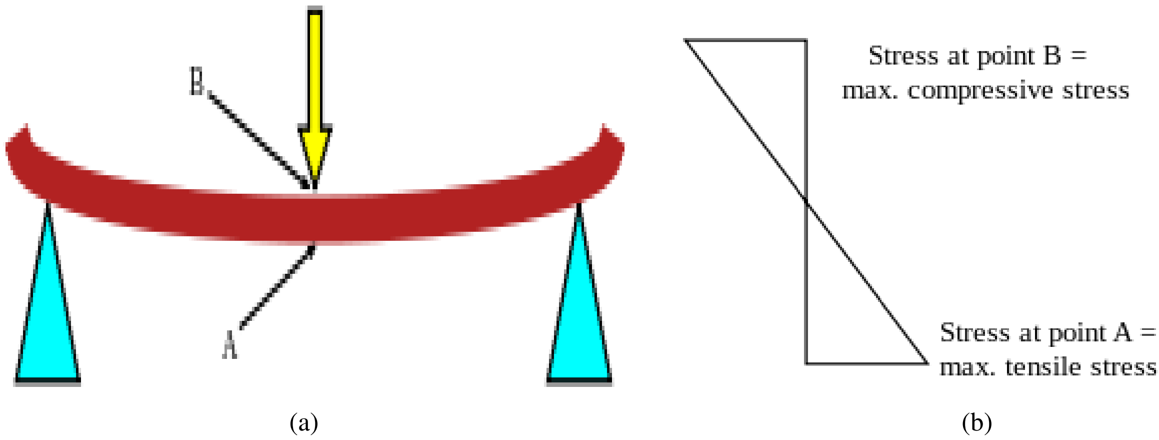


Figure 4.5 (a) Beam under bending. Extreme fibers at B (Compression) and A (Tension) (b) Stress distribution curve

The typical arrangement for the test is shown in fig above. Equal load are applied at a distance of one third from both of the beam supports. It induces equal reaction same as the loading at both of the supports. Loading on beam is increased in such a manner that rate of increase in stress in the bottom fiber lies within the range of .02MPa & .10MPa. The lower rate being for low strength concrete and the higher rate for high strength concrete. From the above loading configuration it is clear that at the middle one- third portion, in between two loadings, beam is subjected to pure bending. No shear force is induced within this portion. It is this portion of beam where maximum pure bending moment of the Pd/2 is induced accompanied by zero shear force. As loading increases, if fracture occurs within the middle one third of the beam, the maximum tensile stress reached called "modulus of rupture" f_{bt} is computed from the standard flexure formula,

$$Fbt = \frac{PL}{bd}$$

Where;

P = Load at failure

l = beam span between supports

d = Depth of the beam

b = Width of the beam

F_{bt} = Modulus of rupture

4.3 Moulds

A Mould is a frame for casting precast concrete units. The moulds are the structure being used to hold fresh concrete, and to set well under various environmental conditions. Thus, moulds held the fresh concrete and hence make it enough tough to with stand the self weight of the concrete. Various moulds were being used in the project mainly to have a specimen ready for the testing of the strength. The three moulds variedly used in the project were;

4.3.1 Cubical Moulds:

The standard size of cube is 150 mm. Cubes of 100 mm size are not suitable for concrete having a nominal maximum aggregate size exceeding 20 mm. Cubes of 150 mm size are not suitable for concrete having a nominal maximum aggregate size exceeding 40 mm. The moulds for the specimens must be made of cast iron or cast steel. The inside faces must be machined plane. The cube mould is normally made in two halves to facilitate removal of the concrete cube without damage. Each mould has a base, which is a separate metal plate, preferably fastened to the mould by clamps or springs. When assembled, all the internal angles of the mould must be right angles. In the Whole project 150×150×150 mm cube were used in the construction of the mould.

Figure 4.6 Cubical Moulds

4.3.2 Cylindrical Moulds:

These shall be made in such a manner as to facilitate separation of the mould longitudinally into two parts. Testing concrete cylinders for compressive strength tests. Specifications: The mould is split vertically into two parts. The mean internal diameter is within 0.2mm and height is within 1mm. The ends are machined to 0.05. The base plate and top plate are machined flat to 0.03mm. 100×200 mm sized cylinders were used in the construction of the cylindrical blocks.

Figure 4.7 Cylindrical Moulds

4.3.3 Beam Moulds:

Steel beam moulds are manufactured in accordance to dimensions and tolerances stated in the related standards. Two part and clamp attached base plate steel moulds are designed to be durable, resistant and easy to clean. The beam mould is basically a durable structure to with stand heavy wet concrete weight.

Figure 4.8 Beam Moulds

5.1 Design of M-40 Grade

Parameters for mix design M40

Grade Designation	=	M-40
Type of cement	=	O.P.C-43 grade
Fine Aggregate	=	Zone-II
Sp. Gravity Cement	=	3.15
Fine Aggregate	=	2.74
Coarse Aggregate (20mm)	=	2.74
Coarse Aggregate (10mm)	=	2.66
Maximum water cement ratio	=	0.40

Mix Calculation: –

1. Target Mean Strength = 40 + (5 X 1.65) = 48.25 MPa
2. Water cement ratio = 0.40
3. Cement content = $\frac{197}{0.40}$ = 492.50 Kg/m^2 hence, take 450 kg
4. Calculation of water = 450 X 0.4 = 180 kg which is less than 186 kg (As per Table No. 4, IS: 10262)

Hence,

Water = 186 + (6/10)*18 = 197 Lit

5. Calculation for C.A. & F.A= $V = [W + (C/S_c) + (1/p) \times (f_a/S_{fa})] \times (1/1000)$

$Ca= [1-P/P \times F_a \times S_{ca}/S_{fa}]$

Where;

V = Absolute volume of fresh concrete,

W = mass of water (kg) per m^3 of concrete,

C = mass of cement (kg) per m^3 of concrete,

S_c = specific gravity of cement,

p = Ratio of fine aggregate to total aggregate by absolute volume,

f_a, C_a = Total mass of fine aggregate and coarse aggregate (kg) per m^3 of concrete respectively, and

S_{fa}, S_{ca} = specific gravities of saturated surface dry fine aggregate and Coarse aggregate respectively.

As per Table No. 3, IS-10262, For 20mm maximum size entrapped air is 2%.

Assume F.A. by % of volume of total aggregate = 36.5 %

- Calculations of Fine Aggregate:

  V = $[W + (C/S_c) + (1/p) \times (f_a/S_{fa})] \times (1/1000)$

  0.98 = [197 + (492.16 / 3.15) + (1 / 0.365) (Fa / 2.74)] (1 /1000)

  Fa = 766.76 kg

- Calculations of coarse aggregate

  $Ca = [1\text{-}P/P \times F_a \times S_{ca}/S_{fa}]$

. Ca = 1-0.365/0.365 × 623.63 × 26/26

  Ca = 1046 kg.

Hence, calculated ratio for 1 m^3 block = **1: 1.7: 2.3**

5.2 Net Quantity Required:

The net amount of cement, sand and aggregates required for casting beam, one cylinder and one cube is computed:

5.2.1 Cubical Mould:

Volume of one Cube = 150*150*150

= 3375 cm^3 or 0.003375 m^3

Therefore,

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

$24*10^3$ = Mass/0.00375m^3

Mass = $24\times10^2 \times 0.003375$

Mass = 8.1 Kg

(a) Cement Required:

$$= \frac{1}{4.8} \times 8.1 \times 1$$

= **1.69 Kg**

(b) Fine Aggregates Required:

$$= \frac{1}{4.8} \times 8.1 \times 1.4 = 2.4 \text{ Kg}$$

= **2.4 Kg**

(c) Coarse Aggregates Required:

$$= \frac{1}{4.8} \times 8.1 \times 2.4 = 4.08 \text{ Kg}$$

= **4.08 Kg**

5.2.2 Cylindrical Mould:

Volume of one cylinder = πr^2h

= $3.14 \times 2500 \times 200$

= 1570 cm^3 or 0.00157 m^3

Therefore,

Mass = Density × Volume

= $24 \times 10^2 \times 0.001570$

Mass = 3.8 Kg

(a) Cement Required:

= $\frac{1}{4.8} \times 3.8$

= **0.785 kg**

(b) Fine aggregates required:

= $\frac{1}{4.8} \times 3.8 \times 1.4$

= **1.099 Kg**

(c) **Coarse aggregates required:**

= $\frac{1}{4.8} \times 3.8 \times 2.4$

= 1.**680 Kg**

5.2.3 Beam Mould:

Volume of one beam = $100 \times 100 \times 500$

= 5000 cm^3 or 0.005 m^3

Therefore,

Mass = Density × Volume

= $24 \times 10^2 \times 0.005$

Mass = 12.0 Kg

(a) Cement Required:

= $\frac{1}{4.8} \times 12$

= 2.5 Kg

(b) Fine Aggregates Required:

= $\frac{1}{4.8} \times 12 \times 1.4$

$$= \quad \mathbf{3.5\ Kg}$$

(c) Coarse Aggregates Required:

$$= \quad \frac{1}{4.8} \times 12 \times 2.4$$

$$= \quad \mathbf{6\ Kg}$$

5.3 Workability:

Concrete slump test is to determine the workability or consistency of concrete mix prepared at the laboratory or the construction site during the progress of the work. Concrete slump test is carried out from batch to batch to check the uniform quality of concrete during construction. The slump test is the most simple workability test for concrete, involves low cost and provides immediate results. Due to this fact, it has been widely used for workability tests since 1922. The slump is carried out as per procedures mentioned in ASTM C143 in the United States, IS: 1199 – 1959 in India and EN 12350-2 in Europe.

5.3.1 Procedure

- Clean the internal surface of the mould and apply oil.
- Place the mould on a smooth horizontal non- porous base plate.
- Fill the mould with the prepared concrete mix in 4 approximately equal layers.
- Tamp each layer with 25 strokes of the rounded end of the tamping rod in a uniform manner over the cross section of the mould. For the subsequent layers, the tamping should penetrate into the underlying layer.
- Remove the excess concrete and level the surface with a trowel.
- Clean away the mortar or water leaked out between the mould and the base plate.
- Raise the mould from the concrete immediately and slowly in vertical direction.
- Measure the slump as the difference between the height of the mould and that of height point of the specimen being tested

(a) **(b)** **(c)** **(d)**

Figure 5.1 Procedure of slump cone test

5.3.2 Height measurement

The test is carried out using a mould known as a slump cone or Abrams cone. The cone is placed on a hard non-absorbent surface. This cone is filled with fresh concrete in three stages. Each time, each layer is tamped 25 times with a rod of standard dimensions. At the end of the third stage, concrete is struck off flush to the top of the mould. The mould is carefully lifted vertically upwards with twisting motion, so as not to disturb the concrete cone.

Concrete subsides. This subsidence is termed as slump, and is measured to the nearest 5 mm if the slump is <100 mm and measured to the nearest 10 mm if the slump is >100 mm

Figure 5.2 Height measurement of the slump

5.4 Compression Test

Stacking strength of a fiberboard container measured as the maximum load that can be applied to it under specified conditions before it is crushed, and expressed in Newton's or pounds per square inch. Printing directly onto the container face or surface reduces its compression strength by crushing the material and saturating the fibers with ink Also, called compression resistance, compressive strength, or crush resistance. Compressive 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.

- A concrete Cubes of sizes 150mm X 150mm X 150mm is subjected to the action of compressive forces along two opposite edges. By applying the force in this manner, the cube is subjected to compression.

- 3, 7 & 28 Days curing of the cubes were done and after that a the compression load as calculated out through the help of compressive testing machine.

The Compressive strength $= \frac{P}{A}$

Where,

P = Load acting on the surface

A = Area of the cube (i.e. Length X Breadth)

5.4.1 Procedure

Preparation of Concrete Mix:

- Mix the cement and fine aggregate on a water tight none-absorbent platform until the mixture is thoroughly blended and is of uniform color
- Add the coarse aggregate and mix with cement and fine aggregate until the coarse aggregate is uniformly distributed throughout the batch
- Add water and mix it until the concrete appears to be homogeneous and of the desired consistency

Sampling:

- Clean the mounds and apply oil
- Fill the concrete in the molds in layers approximately 5cm thick
- Compact each layer with not less than 35strokes per layer using a tamping rod (steel bar 16mm diameter and 60cm long, bullet pointed at lower end)
- Level the top surface and smoothen it with a trowel

Curing:

- The test specimens are stored in moist air for 24hours
- After this period the specimens are marked and removed from the molds and kept submerged in clear fresh water until taken out prior to test.

Precautions:

- The water for curing should be tested every 7days and the temperature of water must be at 27+-2oC.

Testing:

- Remove the specimen from water after specified curing time and wipe out excess water from the surface.
- Take the dimension of the specimen to the nearest 0.2m
- Clean the bearing surface of the testing machine
- Place the specimen in the machine in such a manner that the load shall be applied to the opposite sides of the cube cast.
- Align the specimen centrally on the base plate of the machine.
- Rotate the movable portion gently by hand so that it touches the top surface of the specimen.
- Apply the load gradually without shock and continuously at the rate of 140kg/cm2/minute till the specimen fails
- Record the maximum load and note any unusual features in the type of failure.

5.5 Split Tensile Strength

Specimens were crushed at 7days and at 28 days of sizes 100mm diameter X 200mm height is subjected to the action of compressive forces along two opposite edges. Applying the force in this manner, the cylinder is subjected to compression near the loaded region and the length of cylinder is subjected to uniform tensile stress.

- The split tensile strength = 2P/∏dl

Where, P = the compressive load on cylinder

l = Length of cylinder

d = Diameter of cylinder

Preparation of Concrete Mix:

- Mix the cement and fine aggregate on a water tight none-absorbent platform until the mixture is thoroughly blended and is of uniform color
- Add the coarse aggregate and mix with cement and fine aggregate until the coarse aggregate is uniformly distributed throughout the batch
- Add water and mix it until the concrete appears to be homogeneous and of the desired consistency

Sampling:

- Clean the mounds and apply oil
- Fill the concrete in the molds in layers approximately 5cm thick
- Compact each layer with not less than 35strokes per layer using a tamping rod (steel bar 16mm diameter and 60cm long, bullet pointed at lower end)
- The standard tamping bar is used and the stroke of the bar should be distributed in a uniform manner.
- The stroke should penetrate in to the underlying layer and the bottom layer should be rotted throughout its depth.
- After top layer has been compacted, the surface of the concrete should be finished level with the top of the mould, using a trowel and covered with a glass or metal plate to prevent evaporation.

Curing:

- The test specimens are stored in moist air for 24hours
- After this period the specimens are marked and removed from the molds and kept submerged in clear fresh water until taken out prior to test.

Precautions:

- The water for curing should be tested every 7days and the temperature of water must be at 27+-2oC.

Testing

- Take the wet specimen from water after 7 days of curing
- Wipe out water from the surface of specimen
- Draw diametrical lines on the two ends of the specimen to ensure that they are on the same axial place.
- Note the weight and dimension of the specimen.
- Set the compression testing machine for the required range.
- Keep are plywood strip on the lower plate and place the specimen.
- Align the specimen so that the lines marked on the ends are vertical and centered over the bottom plate.
- Place the other plywood strip above the specimen.
- Bring down the upper plate to touch the plywood strip.

- Apply the load continuously without shock at a rate of approximately 14-21kg/cm2/minute (Which corresponds to a total load of 9900kg/minute to 14850kg/minute)
- Note down the breaking load(P)

CHAPTER 6 RESULTS

6.1 Initial and Final Setting time

The initial and final setting time of the sugar and slag cement was noted down and checked for further results;

6.1.1 Initial and Final setting time of Slag cement:

Table 6.1 Initial and final setting time of Slag cement

% age of Slag cement by weight	Initial setting time	Final setting time
0 %	32 min	600 min
30 %	34 min	600 min
50 %	31 min	600 min

6.1.2 Initial and Final setting time of Sugar:

Table 6.2 Initial and final setting time of Sugar

% age of sugar by weight	Initial setting time	Final setting time
0 %	32 min	600 min

0.06 %	48 min	600 min
0.08 %	55 min	600 min

6.2 Workability

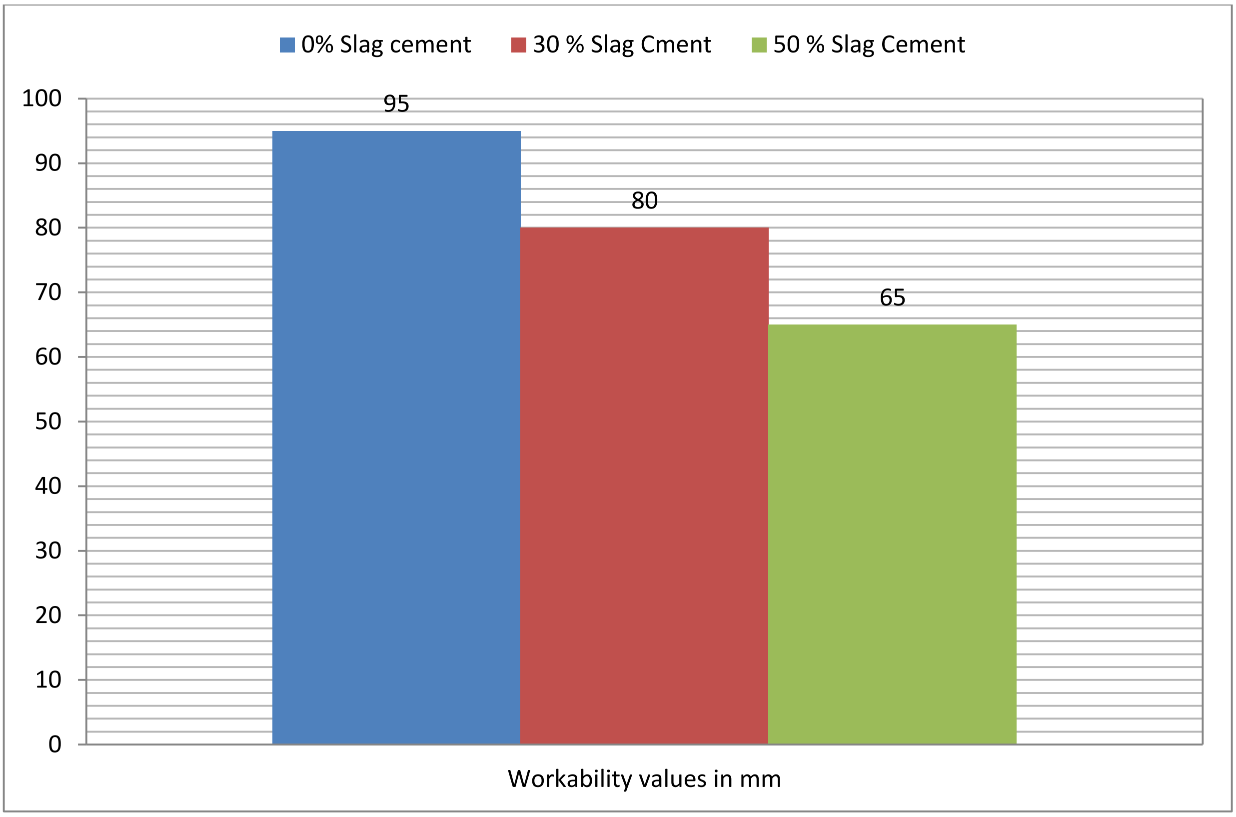
Concrete slump test is carried out from batch to batch to check the uniform quality of concrete during construction. Here, are the values of the slump cone workability test conducted in the laboratory;

6.2.1 Slump value for Slag cement:

Table 6.3 Slump cone workability values for Slag Cement

% age of Slag cement by weight →	**0 %**	**30 %**	**50 %**
Slump Value →	95 mm	80mm	65 mm

Graph 6.1 Slump cone workability values using slag cement

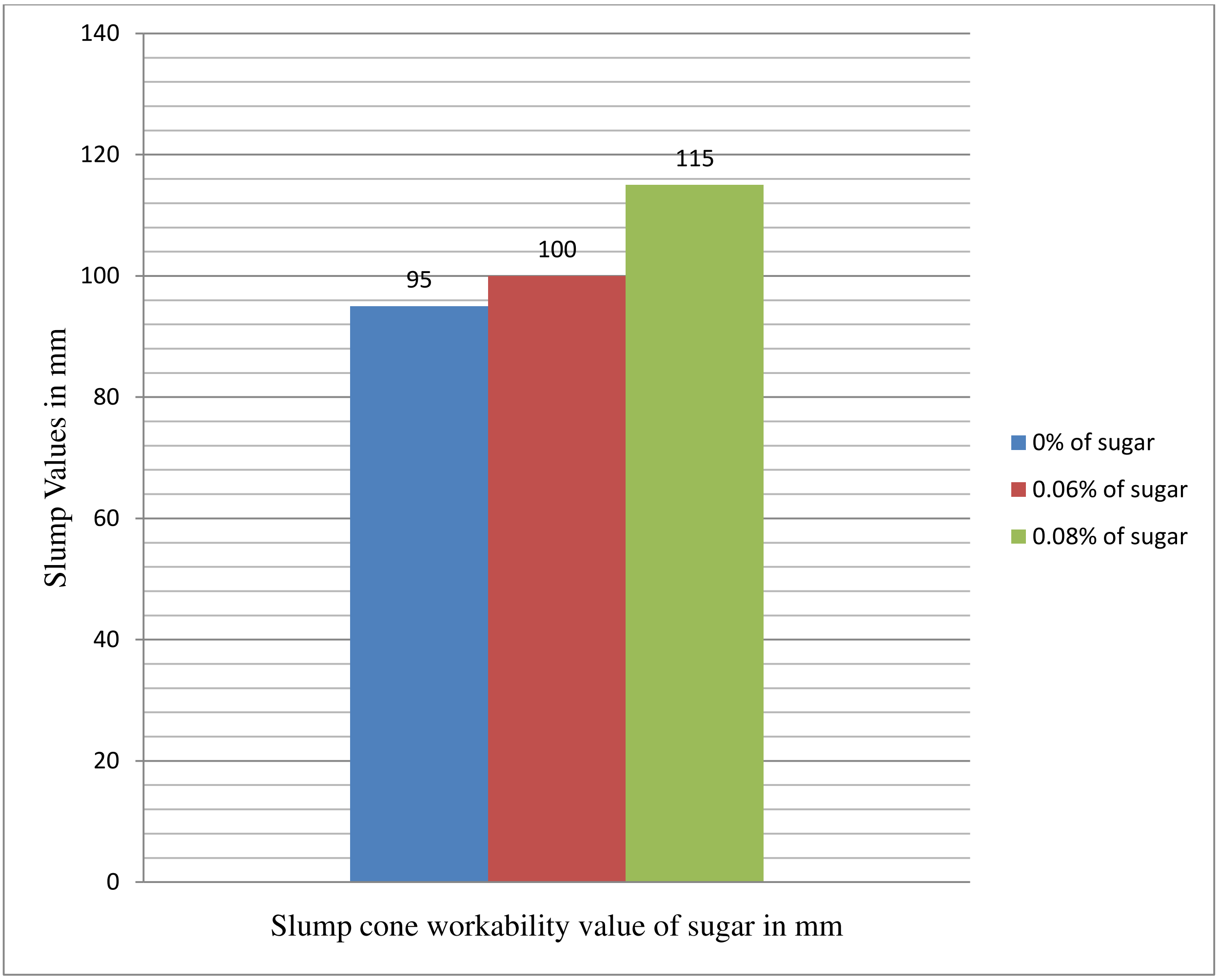


6.2.2 Slump value for Sugar:

Table 6.4 Slump cone workability value for Sugar

% age of Sugar by weight →	**0 %**	**0.06 %**	**0.08 %**
Slump Value →	95 mm	100 mm	115 mm

Graph 6.2 Slump cone workability values using Sugar



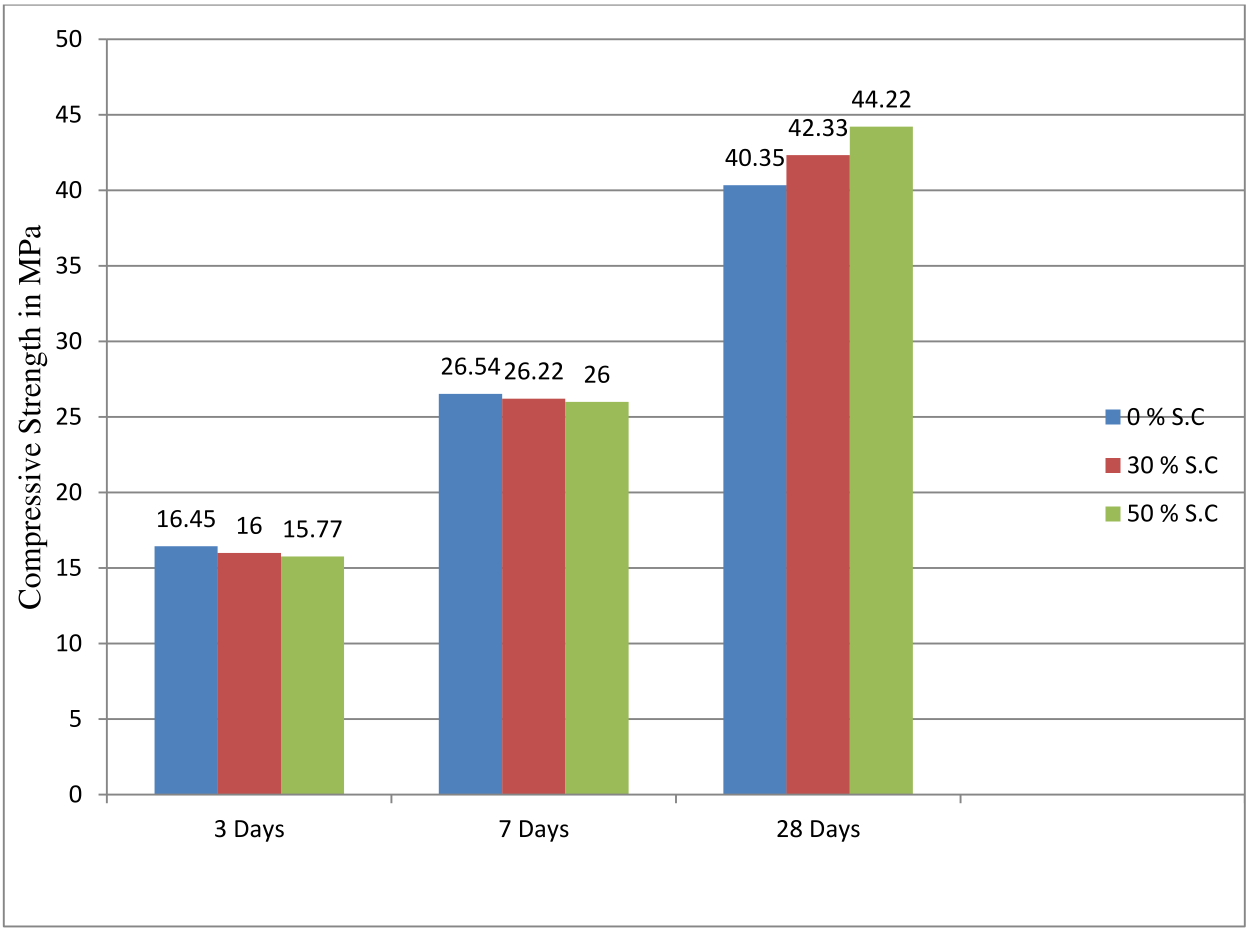
6.3 Compressive Strength

6.3.1 Using Slag Cement as an admixture

Table 6.5 Compressive strength results of slag cement

COMPRESSIVE STRENGTH OF CUBE BLOCKS (MPa)			
Percentage of Slag Cement	**3 Days**	**7 Days**	**28 Days**
0	16.45 (370 KN)	26.45	40.35
30	16 (360 KN)	26.22	42.23
50	15.77 (355 KN)	26	44.22

Graph 6.3 Results of Compressive strength using Slag Cement

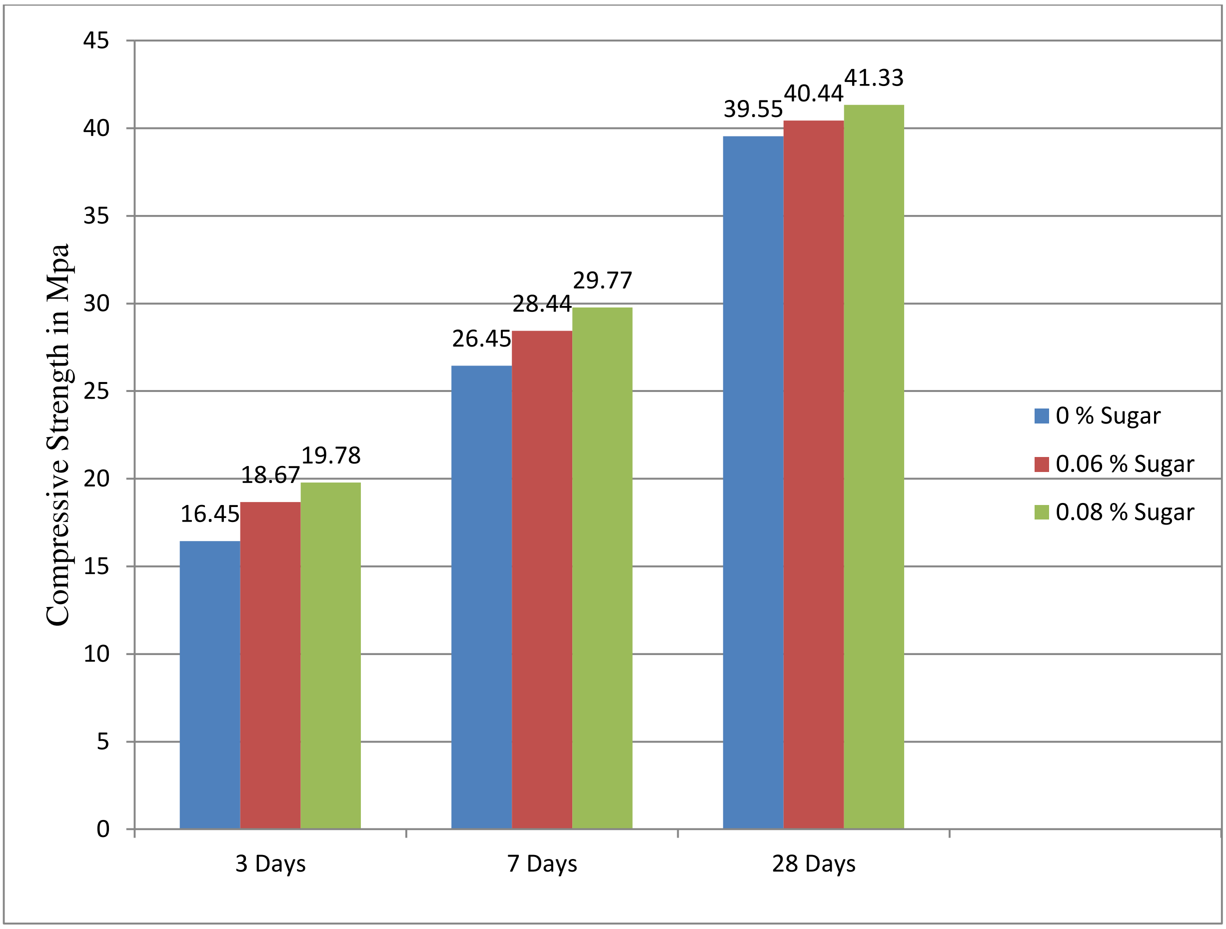


6.3.2 Using Sugar as an admixture:

Table 6.6 Compressive strength results of Sugar

COMPRESSIVE STRENGTH OF CUBE BLOCKS (MPa)			
Percentage of Sugar by weight	**3 Days**	**7 Days**	**28 Days**
0	16.45	26.45	40.35
0.06	18.67	28.44	40.44
0.08	19.78	29.77	41.33

Graph 6.4 Results of Compressive strength using Sugar



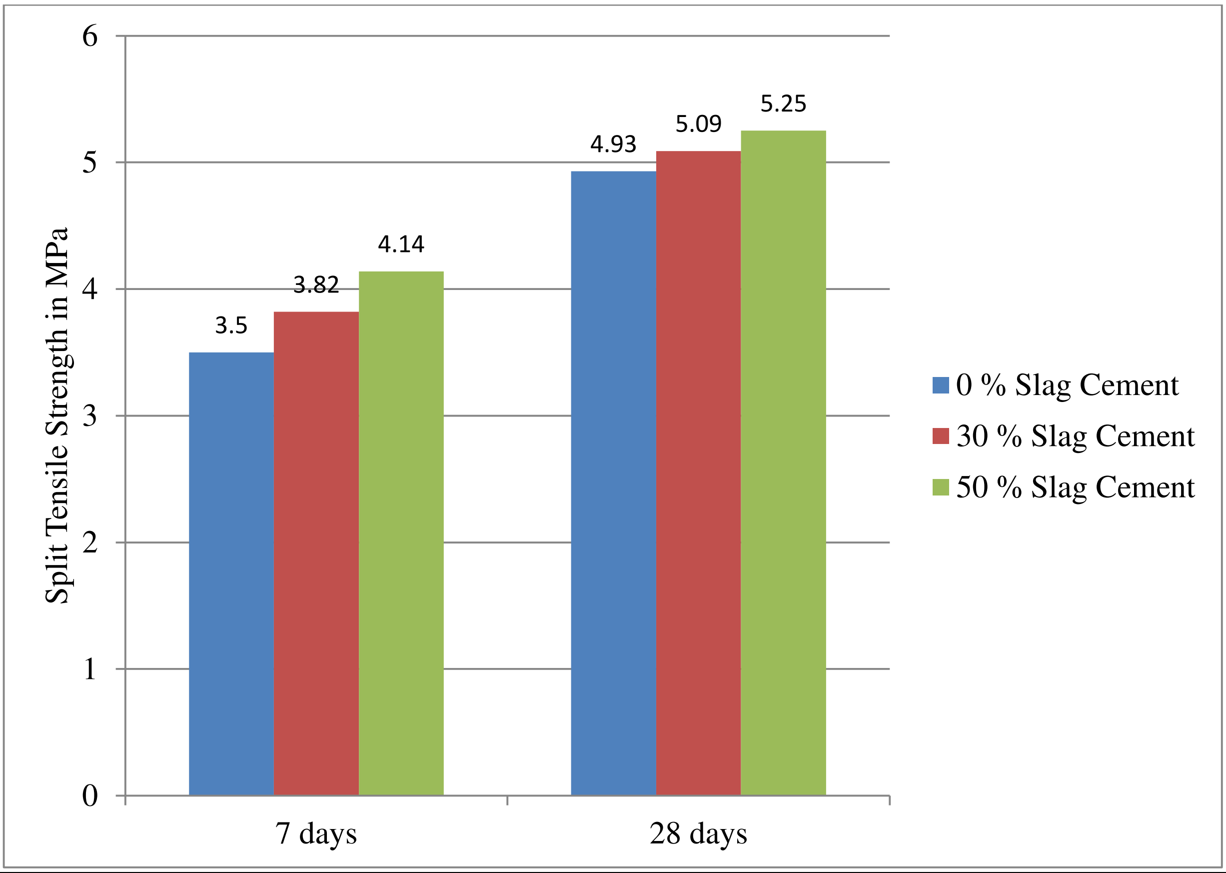
6.4 Split Tensile Strength:

6.4.1 Using Slag Cement as an admixture:

Table 6.7 Results of Split Tensile strength using Slag Cement

SPLIT TENSILE STRENGTH OF CYCLINDRICALBLOCKS (MPa)		
Percentage of Slag Cement	**7 Days**	**28 Days**
0	**3.50**	**4.93**
30	**3.82**	**5.09**
50	**4.14**	**5.25**

Graph 6.5 Results of Split Tensile strength using Slag Cement



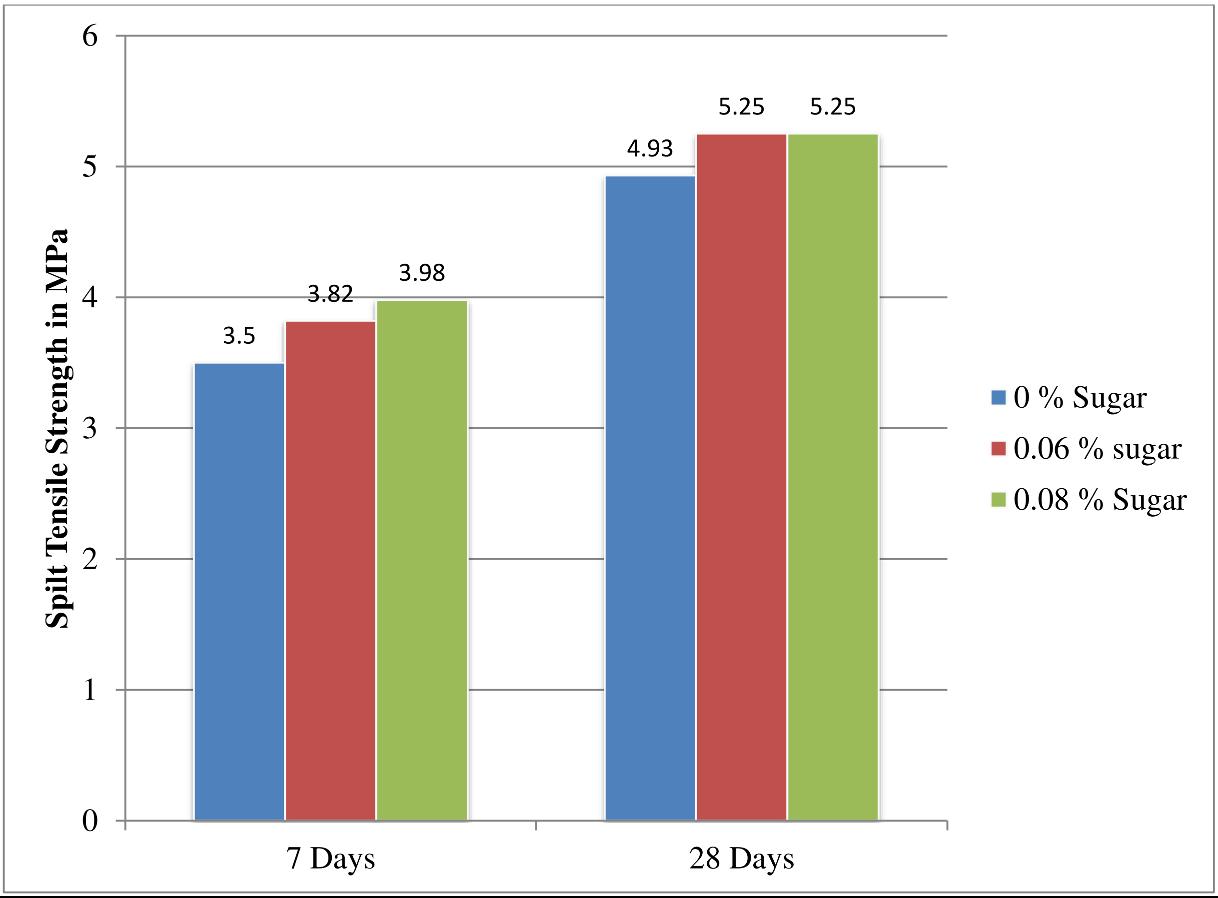
6.4.2 Using Sugar as an admixture:

Table 6.8 Results of Split Tensile strength using sugar

SPLIT TENSILE STRENGTH OF CYCLINDRICALBLOCKS (MPa)		
Percentage of Sugar by weight	**7 Days**	**28 Days**
0	**3.50**	**4.93**
0.06	**3.82**	**5.25**

0.08	**3.98**	**5.25**

Graph 6.6 Results of Split Tensile strength using Sugar



CHAPTER-7 CONCLUSION

7.1 Conclusions

The experimental results on the use of sugar and slag cement proved that the good quality and high strength concrete mix can be prepared. There was an increase in the compressive and the tensile strength of the cement. The test result showed that the increase in the strength as compared to the normal concrete mix after 28 days was 15 %.

- There was a considerable increase in the compressive strength of the concrete using sugar and slag cement. The economy of the mix design using admixtures was same as the economy of the normal M40 mix.
- The slump value of slag cement decreased as their addition caused early setting of cement due to presence of higher content of C_3A in slag cement which increases the rate of reaction which is responsible for early setting of cement.

- Whereas, in case of sugar the slump cone workability values increased as the sugar acts as a retarder which delays the rate of reaction causing delay in the early setting of the concrete.
- Sugar acts as a retarder and slow down the initial setting time of the cement as compared to ordinary concrete, because it resist the C-S-H gel formation among the concrete mix. Resistance against chloride, air, and water permeability was increased to
- Slag cement caused 14% increase in compressive strength after 28 days and 9 % increase in tensile strength.
- Since slag cement is finer than the cement and posses a specific gravity of 2.57 hence, it posses better compaction than OPC. The void gets properly compacted due to small size of slag cement.
- Slag cement is the one of the most popular pozzolanas, whose addition to concrete mixtures results in lower porosity, permeability and bleeding . The main results of pozzolanic reactions are: lower heat liberation and strength development; lime- consuming activity; smaller pore size distribution.
- Similarly, Sugar caused an increase of 12% in compressive strength and tensile strength was also increased by 8%. The sugar acts as a binder and forms a gel type formation which binds the particle and eliminates the voids in between the C-S-H gel.
- Sugar cannot be used more than 1% of the weight of cement as it lead to non-binding behavior, which lead to the dispersion of the concrete when was de-moulded.

7.2 Future Scope:

In this project sugar and slag were used to increase the strength. Some other methods can be adopted to increase the strength such as fly ash, silica fume and rice husk. Further testing and studies on sugar and slag cement is recommended to indicate the strength characteristic of the admixtures used. This research was intended to examine the influence of slag additions in concrete and RCC elements for M40 mixes. The same word can be extended to higher grades of concrete mixes with varying water/cement ratio

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