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Performance Evaluation for Strength of M30 Design Mix Concrete with Partial Replacement of Conventional Ingredients in Cement and Fine Aggregates

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ABSTRACT

Concrete has been a major construction material for centuries. Yet concrete construction so far is mainly based on the use of virgin natural resources. Cement and aggregate, which are the most important constituents used in concrete production, are the vital materials needed for the construction industry. This inevitably led to a continuous and increasing demand of natural materials used for their production. Parallel to the need for the utilization of the natural resources emerges a growing concern for protecting the environment and a need to preserve natural resources, such as aggregate, by using alternative materials that are either recycled or discarded as a waste.

The present investigation revealed the effect of using silica fume and brick kiln dust as a partial replacement of cement and fine aggregate, respectively on the mechanical properties of the concrete. Due to the depletion of natural sand resource worldwide with the increment of industrial waste, simultaneously, partial replacements of fine aggregate with brick kiln dust have been attempted. Therefore, the primary objective of this research work was to conduct the study on M30 concrete whose compressive, tensile and flexural strength was observed. For this study, the different proportions of silica fume (5%, 10%, 15%, 20% and 25%) and the different proportion of copper slag (10%, 20%, 30%, 40% and 50%) were replaced with cement and fine aggregate, respectively.

Key Words: ***Brick kiln dust, silica fume, by-product, mechanical properties, Compressive strength, Split tensile strength, Flexural strength.***

INTRODUCTION

Concrete is a composite construction material, composed of cement (commonly Portland cement) and other cementitious (a high-strength cementitious mortar which set within 1.5 hours) materials such as fly ash and slag cement, aggregate generally a coarse aggregate made of gravels or crushed rocks such as limestone, or granite, plus a fine aggregate such as sand, water, and chemical admixtures [1].

Cement:

Cement is a generic name that can apply to all binders. The chemical composition of the cements can be quite diverse but by far the greatest amount of concrete used today is made with Portland cements. For this reason, the discussion of cement in this thesis is mainly about the Portland cement [2]. Portland cement, the basic ingredient of concrete, is a closely controlled chemical combination of calcium, silicon, aluminum, iron and small amounts of other ingredients to which gypsum is added in the final grinding process to regulate the setting time of the concrete. Lime and silica make up about 85%

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of the mass. Common among the materials used in its manufacture are limestone, shells, and chalk or marl combined with shale, clay, slate or blast furnace slag, silica sand, and iron ore. Each step in the manufacturing of Portland cement is checked by frequent chemical and physical tests in plant laboratories. The finished product is also analyzed and tested to ensure that it complies with all specifications. The term "Portland" in Portland cement originated in 1824 when an English mason obtained a patent for his product [3]. This was because his cement blend produced concrete that resembled the color of the natural limestone quarried on the Isle of Portland in the English Channel.

Fig 1.1: Cement

Silica Fume:

Silica fume is a highly reactive material that is used in relatively small amounts to enhance the properties of concrete. It is a by product of producing certain metals in electric furnaces [4].

The American concrete institute (ACI) defines silica fume as “very fine non- crystalline silica produced in electric arc furnaces as a by product of the production of elemental silicon or alloys containing silicon” (ACI 116R). It is usually a gray colored powder, somewhat similar to portland cement or some fly ashes. Silica fume is usually categorized as a supplementary cementitious material. This term refers to materials that are used in concrete in addition to portland cement. These materials can exhibit the following properties.

Fig 1.2: Silica fume

Silica fume is a by-product resulting from the reduction of high purity quartz with coa1 in electric are furnace in the manufacture of ferro-silicon and silicon metal.

The fume, which has a high content of amorphous silicon dioxide and consists of very fine spherical particles, is collected by filtering the gases escaping from the furnaces.

Silica Fume - Is this the correct name?

During the last severa1 years, silica fume has been variously called silica dust, condensed silica fume, and silica powder [5]. In French, they use the term “poussière de silice.” Before the technical literature becomes cluttered with these different names, it is important that a consensus be researched on the correct name. The most appropriate term appears to be condensed silica fume.

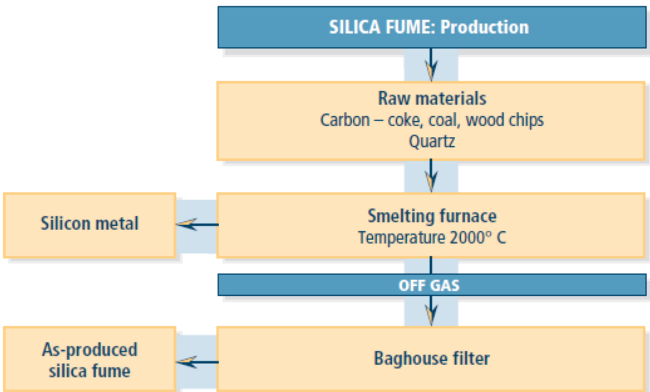

Fig 1.3: Schematic of silica fume production

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Effect of Silica Fume on the Hardened Properties of Cement/Mortar/Concrete:

When silica fume is added to concrete, it results in significant change in the compressive strength of the mix. This is mainly due to the aggregate-paste bond improvement an enhanced microstructure. Huang and Feldman found that mortar without silica fume has lower strength than cement paste with the same water–cement ratio, while mortar with 30% of cement replaced with silica fume has a higher strength than cement- silica fume paste with the same water cementitious ratio [6]. They concluded that the addition of silica fume to mortar resulted in an improved bond between the hydrated cement matrix and sand in the mix, hence increasing strength. This improved bond is due to the conversion of the calcium hydroxide, which tends to form on the surface of aggregate particles, into calcium silicate hydrate due to the presence of reactive silica.

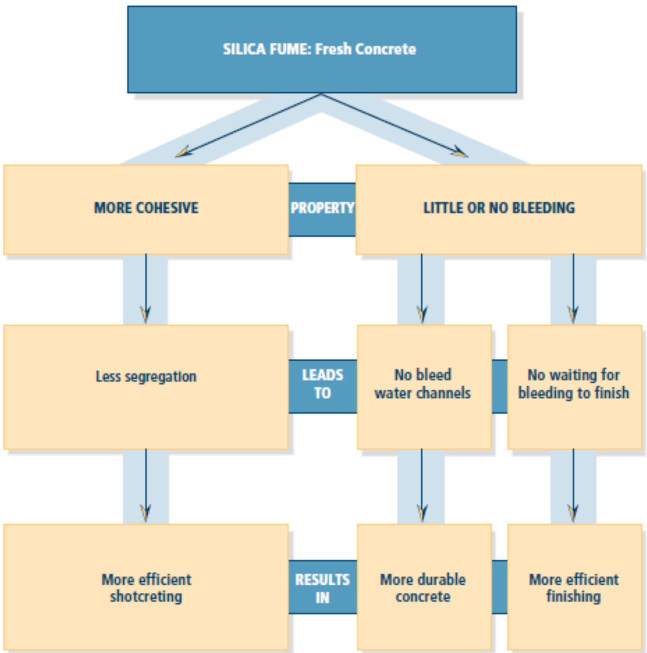

Fig 1.5: Effects of silica fume on fresh concrete and how those effects improve constructability and the final concrete

Methods of using silica fume in concrete:

As a partial replacement for cement In this approach, which is most commonly used, part of the cement is replaced by a much smaller quantity of silica fume. In spite of this, there may be an increase in the water demand. If it is desired to maintain the same water-to-(cement plus silica fume) ratio, super plasticizers may be used to maintain the required slump. There is a resulting increase in the compressive strength as compared with that of the control mix [7].

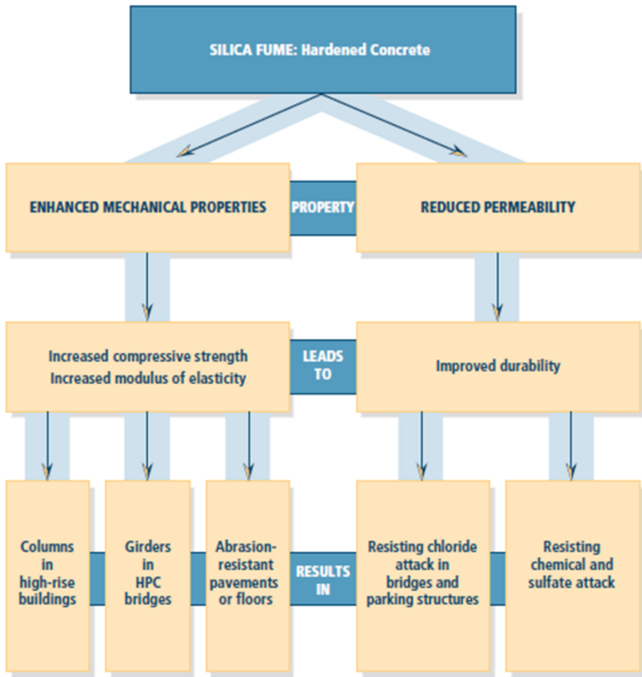

Fig 1.6: Effects of silica fume on hardened concrete and how those effects are used in concrete applications

Applications of silica fume:

High Performance Concrete (HPC) containing silica fume; for bridges, parking decks, marine structures and bridge deck overlays which are subjected to constant deterioration caused by rebar corrosion current, abrasion and chemical attack problems. Silica fume will protect concrete against deicing salts, seawater, and road traffic and freeze/thaw cycles. Rebar corrosion activity and concrete deterioration are virtually eliminated, which minimizes maintenance expense.

High-strength concrete enhanced with silica fume; provides architects and engineers with greater design flexibility. Traditionally used in high-rise buildings for the benefit of smaller columns (increasing the usable space) high strength concrete containing silica fume.

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Silica-fume Shotcrete; delivers greater economy with low costs, greater time savings and more efficient use of sprayed concrete. Silica fume produces superior shotcrete for use in rock stabilization; mine tunnel linings, and rehabilitation of deteriorating bridge and marine columns and piles. Greater bonding strength assures ou standing performance of both wet and dry process shotcreting with less rebound loss and thicker applications with each pass of the shotcrete nozzle [8].

Repair Products; silica fume is used in a variety of cementitious repair products. Mortars or grouts modified with silica fume can be tailored to perform in many different applications overhead and vertical mortars benefit from silica fume's ability to increase surface adhesion. Silica fume significantly improves cohesiveness making it ideal for use in underwater grouts, decreases permeability in grouts used for post-tensioning applications and increases the resistance to aggressive chemicals.

Refractory and Ceramics; the use of silica fume in refractory castables provides better particle packing. It allows for less water to be used while maintaining the same flow characteristics. It also promotes low temperature sintering and the formation of mullite in the matrix of the castable. This produces a castable that has a low permeability to avoid gas, slag and metal penetration. Castables incorporating silica fume are stronger than non-silica fume containing castables especially at high temperatures with higher density they attain lower porosity and are more volume stable.

Aggregates (F.A, C.A):

Aggregates generally occupy 70 to 80 % of the volume of concrete and can therefore be expected to have an important influence on its properties. They are granular materials derived for the most part from natural rock and sands. Moreover, synthetic materials such as slag and expanded clay or shale are used to some extent, mostly in lightweight concrete. In addition to their use as economical filler, aggregates generally provide concrete with better dimensional stability and wear resistance. Based on their size, aggregates are divided into coarse and fine fractions. The coarse aggregate fraction is that retained on the 4.75 mm sieve. The aggregate which is passing through 4.75 mm sieve is known as fine aggregate [9]. River sand confirming to IS: 2386-1975 is used. Locally available sand confirming zone II.

Fig1.7: Coarse Aggregate and Fine Aggregate

Brick Kiln Dust:

Brick Dust is a waste product obtained from different brick kilns and tile factories. Now day‘s construction work is on large scale so demand of brick also increases so due to this brick kiln industries all over the world also increased. Tons of waste products like Brick Dust or broken pieces or flakes of bricks (brick bat) come out from these kilns and factories. So far, such materials have been used just for filling low lying areas or are dumped as waste material.

One of the oldest construction materials is brick, which was first used in Southern Turkey. There are two major ingredients from which building bricks are made, one is clay and other is artificial sand (Fly ash, pond ash). Brick dust is the waste product which comes from the field where bricks are made and from the demolition waste of the building. As Brick is composed of clay which contains sufficient amount of soluble silica and alumina finely grounded brick dust when combined with lime shows pozzolanic reaction. As earliest said that Brick is the oldest and majorly used construction material so large amount of Brick dust is generated during manufacturing of Bricks and demolition of the constructional structure so it is a major problem to dispose such a large amount of Brick Dust [10].

If Brick dust is used as a replacement for a percentage of fine aggregate then is will not only reduce the problem of disposing this waste, it will also reduce the environmental impact which is caused by the CO2 emission from the manufacturing of the cement.

Fig 1.8: Brick kiln ash

The objective of this research is to study the feasibility of utilizing the Brick- kiln-Ash produced by Brick industries in India as a replacement for Fine aggregate in concrete. Brick-Kiln-Ash is a by-product which is produced after firing of brick using coal as a fuel. It is having Cementitious property but its physical properties are similar to sand that is used in this study. Indian brick industry is utilizing 15-20 million tons of coal per year. Indian brick industry is the 3rd largest utilize of coal in India after thermal power plants and steel industries. After China, India is the second largest producer of bricks. This Brick Kiln Ash is dumped as a waste material and which causes environmental pollution. Brick Kiln-Ash can be used as an alternative to natural sand. Hence the use of Brick Kiln Ash in concrete as fine aggregate will reduce not only the demand of natural sand but also the environmental pollution and burden. Moreover the incorporation of Brick-Kiln-Ash will considerably reduce the production cost of concrete. In brief the effective utilization of Brick-Kiln-Ash will turn waste material into a valuable resource for the concrete production [11].

Super plasticizer:

High range water reducing admixture called as super plasticizers are used for improving the flow or workability for decreased water-cement ratio without sacrifice for compressive strength. These admixtures when they disperse in cement agglomerates significantly decrease a viscosity of the paste by forming a thin film around the cement particles. In the present work water-reducing admixture Glenium B233 conforming to ASTM C494 Types F, EN934-2 T3.1/3.2, IS 9103: 1999 is used. GLENIUM B233 is an admixture of a new generation based on modified polycarboxylic ether. The product has been primarily developed for applications in high performance concrete where the highest durability and performance is required.

Fig 1.9: Glenium B233- polycarboxylic ether

Water:

Water is a key ingredient in the manufacture of concrete. Attention should be given to the quality of water used in concrete. The time-honored rule of thumb for water quality is “If you can drink it, you can make concrete with it.” A large amount of concrete is made using municipal water supplies. However, good quality concrete can be made with water that would not pass normal standards for drinking water. Mixing water can

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cause problems by introducing impurities that have a detrimental effect on concrete quality. Although satisfactory strength development is of primary concern, impurities contained in the mix water may also affect setting times, drying shrinkage, or durability or they may cause efflorescence. Water should be avoided if it contains large amounts of dissolved solids, or appreciable amounts of organic materials [12].

METHODOLOGY

Concrete is composed of cement and aggregates combined with water. It is the most widely used construction material has several desirable properties like high compressive strength, stiffness and durability under usual environmental factors. At the same time concrete is brittle and weak in tension. Plain concrete has two deficiencies, low tensile strength and a low strain of fracture. These shortcomings are generally overcome by reinforcing concrete. A strong stone-like mass is formed from a chemical reaction of cement and water. The concrete paste is plastic and can be moulded into any form or trowelled to produce a smooth surface. Hardening of concrete starts immediately after mixing, but precautions are taken to avoid rapid loss of moisture. An excess 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 [13].

Materials:

The raw materials required for the concrete in the present work are;

- Cement
- Fine Aggregate
- Coarse Aggregate
- Water
- Silica fumes

Cement:

The most common cement used in the construction industry is ordinary Portland cement confirming to IS-12269-1987. This is made by heating limestone with small quantities of other materials to 1450^{0}C in a kiln and the process is called calcination.

The cement to be used for concrete making should be fresh and should have uniform colour. It should not contain any lumps and should be free from foreign matter.

Fine Aggregates:

Aggregates passing through a 4.75mm and retained on 150µ sieve are termed as fine aggregates. The fine aggregate conforming to Zone-II according to IS: 383 were used in the mix design. The fine aggregate used was obtained from a nearby river source.

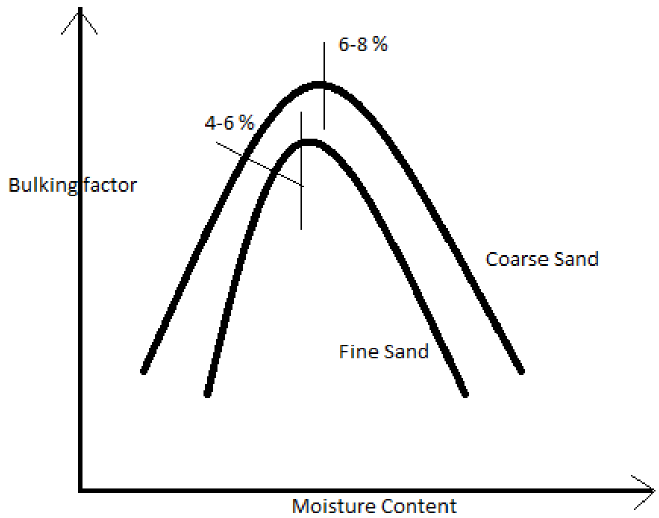

Fig 3.1: Bulking of Sand

Coarse Aggregates:

Aggregates having a size greater than 4.75mm are termed as coarse aggregates. The coarse aggregate used in this experimental investigation is 20mm and below 20mm size, crushed and angular in shape. The aggregates are free from dust before use in concrete.

Water:

Water should be clear, potable fresh water with a pH value (7 to 8) which is free from organic substances, durability and concentration of acids. The term drinkable water is often used to explain the need for clean and not contaminated.

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Silica fume:

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Silica fume is a by-product resulting from the reduction of high purity quartz with coa1 in electric are furnace in the manufacture of ferro-silicon and silicon metal. The fume, which has a high content of amorphous silicon dioxide and consists of very fine spherical particles, is collected by filtering the gases escaping from the furnaces.

Viscosity Modifying Admixture (VMA)

GLENIUM STREAM 2 is a premier ready-to-use, liquid, organic, viscosity-modifying admixture (VMA) specially developed for producing concrete with enhanced viscosity and controlled rheological properties.

Concrete containing GLENIUM STREAM 2 admixture exhibits superior stability and controlled bleeding characteristics, thus increasing resistance to segregation and facilitating placement.

Mechanism of action:

GLENIUM STREAM 2 consists of a mixture of water soluble copolymers which is adsorbed onto the surface of the cement granules, thereby changing the viscosity of the water and influencing the rheological properties of the mix.

GLENIUM STREAM 2 is chloride-free and compatible with all cements. It is incompatible for use with naphthalene sulphonate based super plasticiser admixtures.

Initial setting time:

The stiffening of cement paste is called setting. The time elapsed between the moment water is added to the cement and the time when the paste starts losing its plasticity. The needle fails to pierce the block 5±0.5mm measured from the bottom of the mould shall be the initial setting time. The experiment is conducted using Vicat's apparatus as per the procedure given in IS 4031:1988. The initial setting time is noted when the Vicat needle penetrates through a depth of 33 to 35 mm from the top.

Final setting time:

The time elapsed between the moment when water is added to the cement and the paste has completely lost its plasticity and attained sufficient firmness. The time at which the needle fails to make any impression on the surface is the final setting time. This is also determined by using Vicat's apparatus and as per the procedure given in 4031:1988 [14].

Fig-3.4: Vicat apparatus and needles

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Silica fume:

Silica fume is collected from Adhipathi minerals 7 Chemicals pvt.ltd, Miyapur in Hyderabad and laboratory study was carried out for salient characteristics of such Grading, Specific Gravity and compaction.

Fig 3.8: Silica fume

Sieve Analysis of B.K.D:

To decide the percentage of retained sample in each sieve and sieve size taken as per IS 460-1962.Sieve size was in between 4.75 mm to 75microns. Observation of sieve analysis is shown in table below.

S.No	Sieve size	Weight retaining W1 (grams)	% retained in each sieve (W1/W)*100	Cumulative weight retained (grams)	% passing (100-col. 4)
	1	2	3	4	5
1	4.75 mm	33.8	11.27	11.27	88.73
2	2 mm	32.1	10.7	21.97	78.03
3	1 mm	37.0	12.33	34.30	65.7
4	425 µm	36.3	12.10	46.40	53.7
5	212 µm	37.2	12.40	58.80	41.2
6	125 µm	46.0	15.33	74.13	25.87
7	75 µm	32.5	10.83	84.96	15.04
	Total				367.64

Table 3.1: Observation of sieve analysis

Fineness modules = (Total % of passing/100)

= 367.64/100

= 3.7

Test on workability of concrete:

Flow Table:

This is an apparatus to study fluidity of the concrete using the slump cone. The ability of the concrete to spread on the table immediately after lifting the cone, within a specified time. The maximum diameter whichever it occur in its slump flow.

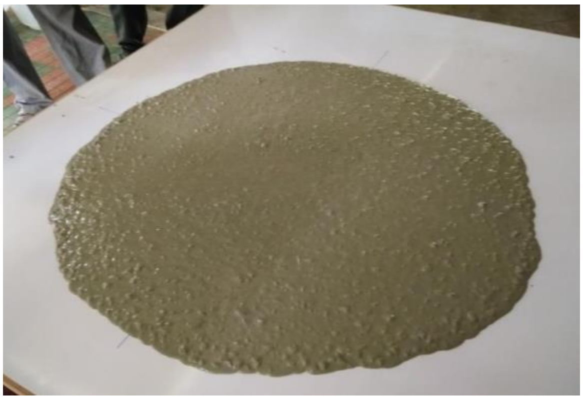

Fig- 3.9: Flow table test

V-Funnel

This is an apparatus to study flow ability/deform ability. The concrete which is to be tested is charged into a v-funnel and bottom gate is released. The whole concrete flows through aperture 65x75mm.The time duration of the total concrete traveling through the above said aperture indicates its flow-ability.

L-Box

This is an apparatus to study segregation resistance. The concrete which is to be tested is charged in the L-box column up to a height of 600mm and releases the bottom gate to allow to travel the concrete through 12mm rods @50mm intervals to a flat bed, the soundness to the flow without segregation shows its cohesiveness, while spreading horizontally it is desirable that the concrete settles evenly.

U-Box

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Fig-3.10: L-Box and V-Funnel test

Fig-3.11: U-Box test

This is also an instrument to study segregation resistance like L-Box. The concrete is filled up in one side of the U tube to a height of 680mm and releasing bottom gate to concrete flows on to the other side of the U tube. By studying the levels, the segregation resistance of the given tested sample can be assessed.

Superplasticisers

Polycarboxylic ether based super plasticisers are generally used in SCC to increase the work-ability of concrete at lesser water to cement ratios. Superplasticisers do not participate in the cement chemistry.

Mineral Admixtures

The role of Brick kiln ash (clay + Fly ash) as mineral admixture in concrete to increases its strength, durability besides sustainable cost-effective. Further it is also partly plays the role of Superplasticisers due to their rapid mobility of spheroid shape of brick kiln ash particles increase the work-ability. However unlike this fly ash mineral admixtures participate in cement chemistry getting additional strength by converting the surplus hydrated lime of OPC.

Collection of Materials:

Jaypee cement- OPC: 53 Grade, Silica fume Fine aggregate- Zone II

Coarse aggregate passing through 6.7mm sieve and retained on 12.5mm sieve

Brick kiln ash

Potable water

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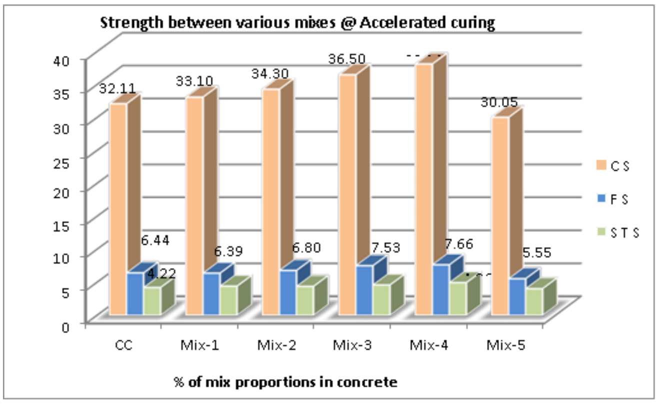
Fig 3.12: Cement and Silica fume ash

EXPERIMENTAL RESULTS

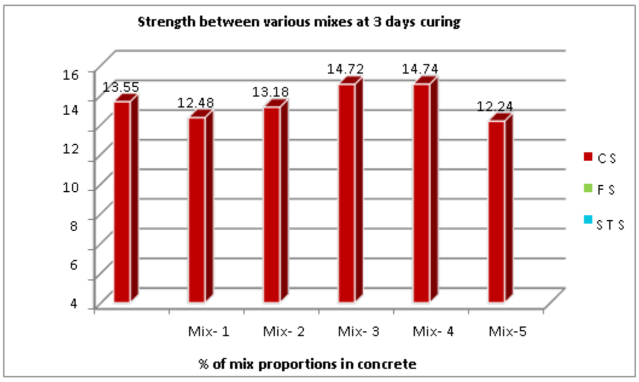
GRAPHS:

Strength of concrete for the various specimens at the age of accelerated curing:



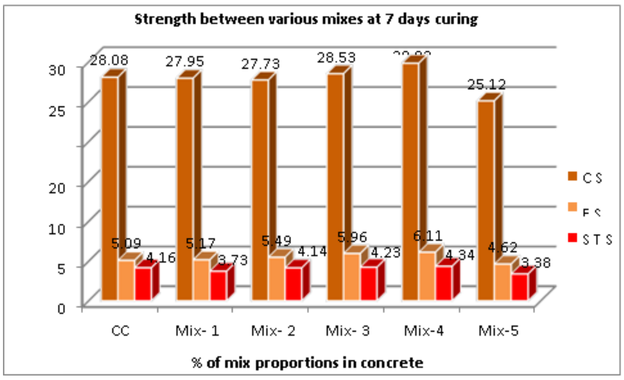
G 2: Strength of concrete for the various specimens at the age of accelerated curing

Strength of concrete for the various specimens at the age of 3 days curing:



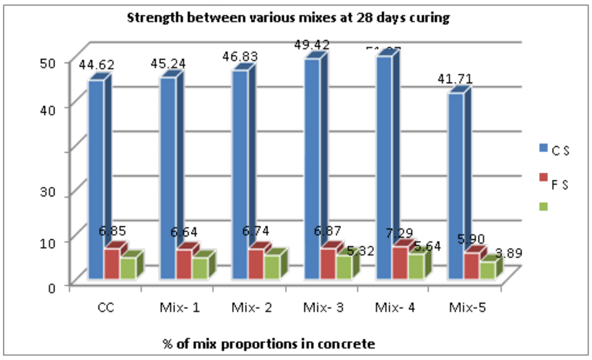
G 3: Strength of concrete for the various specimens at the age of 3 Days curing

Strength of concrete for the various specimens at the age of 7 days curing:



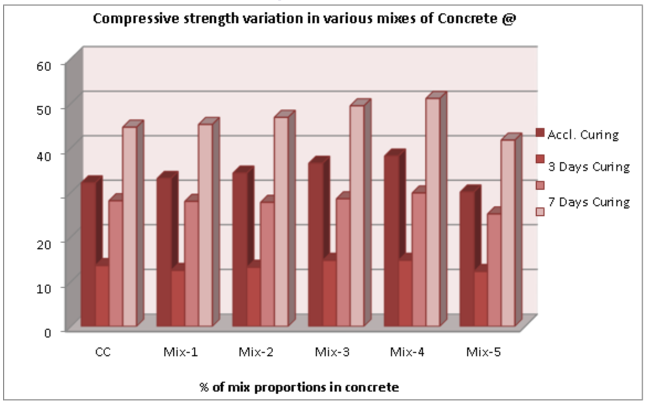
G 4: Strength of concrete for the various specimens at the age of 7 day curing

Strength of concrete for the various specimens at the age of 28 days curing:



G 5: Strength of concrete for the various specimens at the age of 28 day curing

Compressive strength variation in various mixes of Concrete @ different ages:



G 6: Compressive strength variation in various mixes of Concrete @ different ages

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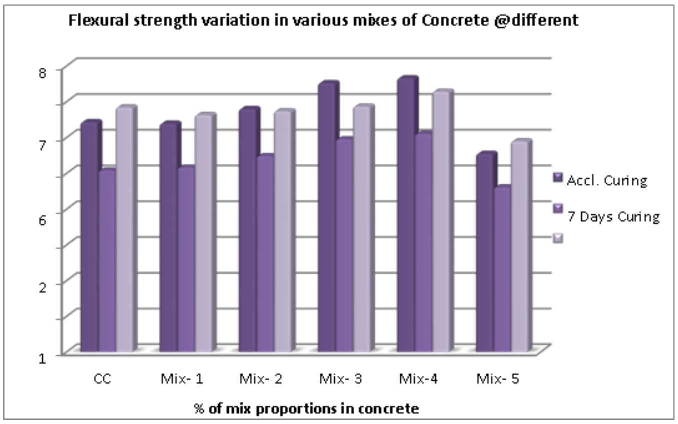
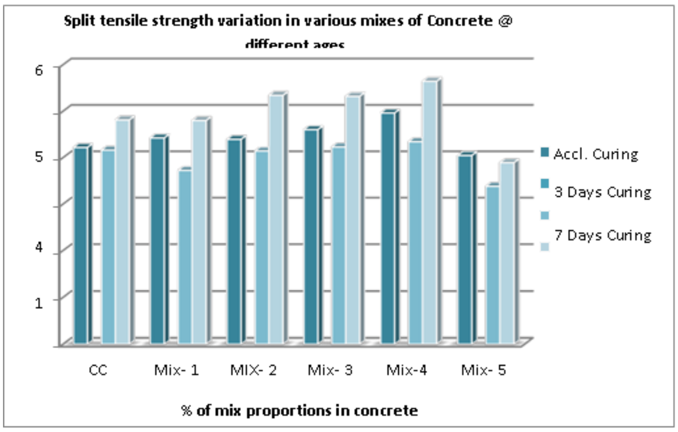
Flexural Strength variation in various mixes of Concrete @ different ages:



G 7: Flexural strength variation in various mixes of Concrete @ different ages

5.5.6 Split tensile strength variation in various mixes of Concrete @ different ages:



G 8: Split tensile strength variation in various mixes of Concrete @ different ages

CONCLUSIONS

Results:

The strength development characteristics of silica fume concrete from recent investigated. Regardless of the percentage of silica fume used and whether the slump is maintained constant by the addition of extra water or by the use of Superplasticisers, the l-day compressive strength of silica fume concrete is generally lower than or equal to the strength of control concrete. However, at 28 days and beyond, the compressive strength of silica fume concrete is generally higher and in some instances markedly so. It appears that silica fume performs more efficiently in super plasticized concretes having high water-cement ratios. More supporting data are needed. The strength- development pattern of flexural and splitting tensile strength of concrete incorporating silica fume is somewhat similar to that for the compressive strength. Silica fume concrete performs very much like fly ash/slag concretes regarding strength development. The important exception is that silica fume appears to be a more efficient pozzolanic material and the results of the pozzolanic reactions are evident at early ages rather than at later ages, as is the case with fly ash/slag concretes.

The basic material test results showed the similarities between fine aggregate and Brick- Kiln-Ash and it can be used as Fine aggregate.

Advantages of using silica fume in concrete:

Silica Fume has been used all over the world for many years in the area where high strength and durable concrete were required. Silica Fume improves the characteristics of both fresh and hard concrete.

- High early compressive strength.
- High tensile, flexural strength and modulus of elasticity.
- Enhanced durability.
- Increased toughness.
- Increased abrasion resistance on decks, floors, overlays and marine structures.
- Superior resistance to chemical attack from chlorides, acids, nitrates and sulphates and life-cycle cost efficiencies.
- Higher bond strength.
- High electrical resistivity and Very low permeability to chloride and water intrusion.

REFERENCES

[1]. Abdulrahman Rasol "Effect of Silica Fume on Concrete Properties and Advantages for Kurdistan Region, Iraq" Ijset, Volume 6, Issue 1 ISSN 2229-5518, January-2015.

[2]. Abrar a. Khan "Physico-chemical properties of brick kiln dust amended soils and their effect on solanum tuberosum" vol 18 issn 1024-8668, eco print 2011.

[3]. Amith S D "An Experimental Study on Flexural behaviour of Reinforced Concrete Beam by Partial Replacement of Fine aggregate with Coal based Brick-Kiln-Ash", IRJET Volume: 02 Issue: 02 e-ISSN: 2395 -0056, June-2015.

[4]. Des king "The effect of silica fume on the properties of concrete as defined in concrete society report 74, cementitious materials" article online id: 100037011 august 2012, Singapore.

[5]. "Guide for the Use of Silica Fume in Concrete" Reported by ACI Committee 234R- 96 reapproved 2000.

[6]. Harjinder Singh "effect of silica fume on the strength of cement mortar" IJRET e- ISSN: 2319-1163 P-ISSN: 2321-7308.

[7]. IS 456-2000 Code of practice for plain and reinforced concrete (3rd revision)

[8]. IS 10262-2009 Code of Practice for concrete Mix Proportioning-Guidelines (1st Revision).

[9]. IS 2386(PT7) – 1963 Methods of test for aggregates for concrete.

[10]. IS 516-1959 Method of test for strength of concrete.

[11]. IS 383-1997 Specification for Coarse and Fine Aggregates from Natural sources for Concrete.

[12]. Metwally A.A. Abd Elaty "Performance of Portland cement mixes containing silica fume and mixed with lime-water" HBRC Journal, 23 December 2013.

[13]. M. Anisur Rahman "Use of Silica Fume in Stabilizing Cement-Dune Sand for Highway Materials" American Journal of Civil Engineering 2017; 5(1): 41-49 doi: 10.11648/j.ajce.20170501.16 ISSN: 2330-8729 (Print); ISSN: 2330-8737 (Online).

[14]. M.S. Shetty. "Concrete technology (theory and practice), S. Chand & Company LTD. 2002