EXPERIMENTAL INVESTIGATION ON EFFECT OF REPLACEMENT OF CEMENT WITH SILICA FUME AND STYROFOAM BALLS ON MORTAR CUBES

Submitted in partial fulfillment of the requirements of the degree of

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Transforming Education Transforming India

School of Civil Engineering
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DECLARATION

I Shahid Nabi Pala Student of Lovely Professional University bearing registration number 11206867 officially announce that the dissertation work titled as "Effect of Styrofoam balls and Silica fume by partial replacement of cement on mortar cubes" is my own work carried out to complete my M-tech thesis work for the completing my degree from Lovely Professional University Punjab India under the guidance of Asst. Professor R Navaneethan from JANUARY TO MAY 2017. I declare that the work is done by me and no material is copied from anywhere.

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I certified that the dissertation report entitled “Effect of Styrofoam balls and Silica fume as partial replacement of cement on mortar cubes” submitted by Shahid Nabi Pala student of Lovely Professional University Civil Department Phagwara Punjab bearing registration number 11206867 under my supervision. I declared that this report is not submitted by else anyone in any of the University or institution for granting any degree.

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AKNOWLEDGEMNT

This report carries all the necessary information as project problem. The entered specified course is covered in this project report. The project work is done by me in the university campus and this report is written by me.

I express my deep sense of gratitude towards my guide **R NAVANEETHAN** for his consistent guidance, encouragement, suggestions, valuable criticism and kind support. Without his help and patience it would not have been possible to observe this work which is on the "Effect of Styrofoam balls and silica fume as partial replacement by cement on mortar cubes".

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I would like thank my parents for their kind help, constant encouragement, love & affection & lots of adjustments without whom it would not have been possible to achieve this goal & for making me what I am today….

Signature of student
Shahid Nabi Pala

ABSTRACT

This study is conduct to find out the effect of Styrofoam balls and silica fume on various properties of mortar cubes such as compressive strength and density. The tests for compressive strength and density were conducted for 7 days and 28 days. The mortar mixture is prepared by replacing Portland cement with Styrofoam balls in the ratio of 0.5% and 1% by weight of cement and silica fume is varied at 10%, 15% and 20% by weight of cement. The combined effect of Styrofoam balls and silica fume is also studied on mortar cubes. Styrofoam balls are the material of low density which effects the strength properties of mortar cubes, to counterbalance this, silica fume is added, which is very fine material which increases the strength of the mortar cubes. Due to the Styrofoam balls, the density decreases upto 25-45% (at an average) as compared to normal mix mortar cubes. From the tests, the compressive strength comes out to be maximum at 15% replacement of cement with silica fume.

Index terms: Styrofoam balls, silica fume, compressive strength, density, mortar cubes, lightweight concrete.

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Chapter1

INTRODUCTION

1.1 GENERAL

Light weight mortar is a material which has various properties consists of cement based mortar mixed with 20% volume of air. Light weight mortar objects are using for many years for structural member and elements in bridges and buildings. Light weight mortar materials are now used in increasing number of applications, such as buildings and void fills. The history of light weight mortar is very large and come in notice in 1923 for use insulation material. For the past 20 years, improvement in engineering equipment's and good quality chemical agents increases the use of light weight mortar on large scale. The wide range applications of light weight mortar are; it is used in block production, panels, wall casting, floors, roofs, sound barrier walls, floating houses etc. Early studies states that density of normal mortar cubes were 2400 kg/m3, while as density of light weight mortar cubes were 1700, 1600 down to 300 kg/m3. Due to the decrease in density, the strength of mortar cubes were slightly decreased. The various advantages of using light weight mortar cubes are: light weight mortar cubes reduces the dead weight due to that seismic forces also reduces. Light weight mortar cubes are easy to transport, they have better insulation, self-compaction property, improved constructability etc. The higher cost of light weight mortar is reduced by reduction of structure elements, less reinforcing steel. The picture of light weight mortar cube is given in figure1:

FIGURE 1.1 Light weight mortar cube

CHAPTER 2
LITERATURE REVIEW

2.1 Peerzada Danish, Shahid ul Islam (2015):

The density of Styrofoam balls (shown in Fig. 2.1) is very low and water absorption capacity of Styrofoam balls is less. The addition of Styrofoam balls with mortar/concrete reduces the density of mortar to a greater extent. Due to the addition of Styrofoam balls, the strength of mortar cubes decreases slightly. When 1% of Styrofoam balls are added to mortar cubes the strength of cube decreases as comparable to the addition of 0.5% Styrofoam balls at 28 days. At 0.5% addition of Styrofoam balls to mortar, the strength comes out to be Maximum at 28days. Due to the addition of Styrofoam balls the density of mortar cubes decreases and comes out to be 40-50% less as compared to normal mortar cubes. The density of mortar cubes formed by 1% of Styrofoam balls comes out to be less as compared to the mortar cubes formed with 0.5% of Styrofoam balls, but the strength is less [1].

2.2 Hassan A. Mohamadien (2012):

Silica fume also knows as condensed silica or micro silica is a byproduct of ferrosilicon Alloy and silicon. Silica fume is material which increases the strength of the mortar.

When silica fume is replaced at 5%, 10%, 15%, 20%, 25%, the maximum strength is obtained at 15% replacement of cement with silica fume. The compressive strength of mortar containing 15% silica fume is 30%, 50% more at 7 days and 28 days. According to research compressive strength at 5%, 10%, 15%, 20%, 30% and 50% replacement of silica fume by replacement of cement is 121.6, 139.9, 148.3, 142.2, 133.8, and 82.1% respectively [2]. The picture of silica fume is shown and Styrofoam balls in Fig. 2.2.

Fig. 2.1 Styrofoam balls

Fig. 2.2 Silica fume

2.3 Rekha Ambi, Shamila Habeeb (2003):

The increase in the strength of mortar cube due to addition of silica fume is due to the filler effect of silica fume. Due to the replacement of silica fume which is very fine material fit into fine aggregate and cement particles and increases the strength.

Silica fume is added to concrete/mortar to enhance the strength of the concrete/mortar mix. Silica fume is having micro filler effect which decreases the porosity and hence increases the compressive strength of mortar .Due to the addition of silica fume in mortar, strength increases due to the formation of C-S-H (calcium silicate hydrate) gel, which is responsible for the increase of compressive strength [3]. The silica fume is replaced by cement in such a manner that it does not affect the workability of concrete/mortar. Strength in mortar also increases due to the result of improved bond between hydrated cement matrix and fine aggregate in the mortar mix. According to the study the tests is conducted at 0%, 5%, 10%, 15% and 20% replacement of cement with silica fume. The maximum compressive strength is obtained at 10% replacement of cement with silica fume. The compressive strength at 10% replacement comes out to be 51% more as compared to 0% addition of silica fume after 28 days and 45.5% after 56 days [4].

2.4 G. Appa Rao (2003):

Cracks in concrete/mortar is the main problem faced now-a-days. Cracks in mortar is caused due to various reasons. One of the main reason of cracks in mortar/concrete is due to the drying shrinkage (contacting hardened concrete due to loss of capillary water). Various experiments had done on drying shrinkage of concrete. In this paper effect of size of aggregate and silica fume on mortar is analyzed on long term drying shrinkage. Cement is partially replaced with silica fume by 0% to 30% and maximum size of aggregate used are 1.18 to 2.36mm. Results shows that mortar with higher content of silica fume has 7-10 times more drying shrinkage and due to the increase in size of fine aggregate, the drying shrinkage of mortar decreases.

2.5 Arun Kumar chakaborty, Sekhar Chandra Dutt (2001):

Various studies had been done on silica fume modified mortars according to Indian standard code (IS codes). Number of studies has been done to check the possibilities increases in compressive strength of mortar by addition of silica fume. One of the study shows that 15% replacement of cement with silica fume by weight shows the maximum strength for 28 days [5]

2.6 Rafat Siddique, Navneet chahal (2001):

Many studies had been done and many are still going on to utilize or recycle the many byproducts from the industries to minimize the effect of these on environment. Silica fume is the byproduct of the smelting process in the silicon and ferrosilicon industry. Silica fume is the very important byproduct used in production of cement paste (mortar) and concrete. By the addition of silica fume or replacement of cement with silica fume the compressive strength increases [6].

Haung and faldmen (1985) states that at 30% replacement of cement with silica fume shows the maximum compressive strength in mortar as compared mortar without silica fume. Increase in the compressive strength is due to the improvement in bond between sand and hydrated cement matrix in the mix.

According to Cong et al. (1992) compressive strength of mortar comes out to be maximum at 18% replacement of cement with silica fume.

According to Gutierrez et al. (2005), the compressive strength of the of glass fiber mortar is increased up to 68% due to the inclusion of silica fume in the matrix. Addition of any type of nature fiber decreases the compressive strength of mortar mix, to counter balance that silica fume is added or replaced.

2.6.1 Effect of addition/replacement of silica fume on workability:

Sellevold and Redjy (1983) states that addition of silica fume and super plasticizers decreases the water content at greater extent. This is due to the addition of super plasticizers which causes the dispersion of silica fume particles and cement and reduces the concentration of contact point between various grains that results less water requirement to gain a given consistency.

Alshamsi et al. (1993) stated that due to the addition of silica fume, workability of concrete decreases to a greater extent. This is mainly due to the physical characteristic property of silica fume. Due to the small grain size of silica fume, water demand increases that leads to the decreases in workability.

2.7 Stockholm, Sweden (2001):

The reaction of alkali aggregate has become a very serious problem in many countries in concrete structures. One of the major alkali aggregate reaction products is siliceous gel. There is increase in the volume of the cubes, due to the water absorption capacity of siliceous gel. Which leads to the destruction and expansion of concrete .Similar addition of silica fume causes cracks in mortar.

From this study, it is observed that mortar containing silica fume had small cracks on its surface when immersed in sodium chloride for 2 months. The cracks start increasing with time. After 1 month the width of cracks is almost 1mm.This is mainly caused due to that some silica fume did not reacted with cement and that part of silica fume may react with other component and creates silica gel, which leads to formation of cracks and destruction of mortar.

2.8 Menash D. Cohen, Ariel Goldman and Wai-Fah Chen (1999):

From the previous researches it is studied that due to the addition/replacement of silica fume increases the strength of the mortar and concrete. The increase in strength is due to the micro-filler effect and pozzolanic property of silica fume. But there are so many controversies around whether the strength is increased due to increase or modify of transition zone or due to the bulk paste by addition of silica fume. [7] From this paper it is conclude that silica fume is important for transition zone modification and due to the micro- filler effect of silica fume value of ‘E’ is affected.

2.9Houssam A. Toutanji (1995):

Number of experiments have been done on silica fume at various water cement ratio to check the compressive strength. In this paper five different water cement ratio used are: 0.22, 0.25, 0.28, 0.31 and 0.34 with 16% and 25% content of silica fume by weight of cement. To adjust the segregation, super Plasticizers are used.

Result shows that there in increase in compressive strength due to the increase in bond between aggregate and cement paste. Replacing cement with silica fume with addition of super plasticizers increases compressive strength but has no effect on strength of cement paste.

2.10 Kazuyuki and Mitsunori Kawamura (1994):

Various properties of mortar/concrete changes due to the addition/replacement of silica fume when these mix are put into the various acids. The mixes with silica fume shows good or improved results as compared to normal mixes, when they are attacked by sulfuric acid and sulfate solution attack. The resistance to sulfate attack and sulfuric acid attack is depending upon the type of acid.

CHAPTER 3

SCOPE OF THE STUDY

Light weight mortar is important in many construction industrial work. Now-a-days light weight mortar is used in making insulation walls, tiles, roofs, floors, floating houses, sound barrier walls etc. as shown in Fig. 3.1 and Fig. 3.2.Light weight mortar decreases the overall dead weight of structure, which decreases the overall cost of production of any project. Due to use of light weight mortar cubes in buildings heating and cooling effect changes according to environment condition. As we know shape of light weight mortar cubes is large and uniform, due to that thickness of plastering reduces and that reduces the overall cost of any project. Due to use of light weight mortar size of footing, beams, columns and other structural elements reduces. The other important property of light weight mortar is fire resistant, it does not get damaged if fire breaks out. Ratio of cement and sand used in this study is 1:3. This study or project is conducted at constant percentage of silica fume (15%), to maintain or counterbalance the compressive strength, that get reduced due to the use of Styrofoam balls at different percentage. The percentage of Styrofoam balls replaced with ordinary Portland cement in this project are 0%, 0.5% and 1%. We know that due to use of silica fume, workability of mortar/concrete decreases. To maintain workability superplastizier are used at limited quantity. OPC of 43 Grade of Jaypee brand is used in this project.This study is done according to IS: 2250 (1981), which is used for the manufacturing of mortar blocks.

Fig. 3.1 Light weight tiles used for floor

Fig. 3.2 Wall made of light weight cubes

CHAPTER 4

OBJECTIVE

1 To determine the density of mortar cubes by addition of Styrofoam balls at 0.5%.

2 To determine the effect on strength by combination of Styrofoam balls at 0.5% and 1% by keeping Silica fume constant at 15%.

3 To find out the combination effect of Styrofoam balls and silica fume on various properties, such as density, compressive strength of mortar cubes

CHAPTER 5

MATERIAL AND ITS PROPERTIES

5.1 CEMENT:

The cement used in this project is Portland cement. Portland cement is also knows as ordinary Portland cement (OPC). Ordinary Portland cement is the most common type of fume, fly ash etc. Ordinary Portland cement is widely used, because it is the basic ingredient of concrete, mortar, stucco etc. The ordinary Portland cement is generally used, where there is no exposure to Sulfate in underground water or soil. The 53 grade of ordinary Portland cement is generally used for civil engineering works, RCC, precast elements such as tiles, blocks, pipes and sheets etc. Ordinary Portland cement comes in different grades such as 43 grade, 53 grade etc. It is graded according to the strength of cement paste. The basic difference between various grades of OPC is done according to the compressive strength gained after 28 days. The difference between OPC 53 grade and OPC 43 grade is that 53 grade have 53mpa compressive strength, whereas 43 grade have 43mpa compressive strength after 28 days. The setting time of 53 grade OPC is faster than 43 grade of OPC. The compressive strength of 53 grade OPC is 27mpa, whereas 43 grade OPC have 23mpa after 7 days. Ordinary Portland cement of 43 Grade of Jaypee brand is used for the project. The picture is shown in Fig. 5.1 and Fig.5.2.

Fig. 5.1 Cement Powder

Fig. 5.2 Jaypee Cement Bag

5.2 STYROFOAM BALLS:

Styrofoam balls as shown in Fig. 5.3 (1-phenylethene-1, 2-diyl) also knows as polystyrene foam are light weight material that comes in different size and different color. Styrofoam balls is an aromatic polymer composite of monomer styrene, which is a liquid hydrocarbon manufactured from petroleum industry. Styrofoam balls are used in manufacturing in many household things, such as cups, plates, dustbin, etc. as shown in figure 9 and 10. Styrofoam balls are also used for packing different items for easy transportation of items from one place to another. Now a days styrofoam balls are used in every part of world. The sale of styrofoam are increasing day by day. Polystyrene is generally solid at room temperature, but it changes its state from solid to liquid when heated at 100 degree Celsius. Polystyrene is heated, so that it changes its state and it can be molded easily and it is cooled down to make styrene into solid state .Generally pure polystyrene is colorless and in solid state, but later we can change the color, size and state of polystyrene by different methods. Styrofoam balls are waterproof. It does not allow water to pass through it and it also does not absorb water. Generally when styrofoam balls are added to any concrete or mortar component it decreases the density of component. The compositions of styrofoam balls are given in table 5.1.

TABLE 5.1: PROPERTY OF STYROFOAM BALLS

Chemical composition (%)	CaO	68.50
	SiO_2	12.00
	SO_2	1.60
	Al_2O_3	7.00
	Fe_2O_3	4.81
	TiO_2	0.18
Physical Properties	PbO	1.60
	Cr_2O_3	1.60
	Specific gravity	3.15
	Surface area (M^2/g)	0.352(Blaine)
Particle size(micrometer)	10%	3.33
	50%	16.92
	90%	45.48

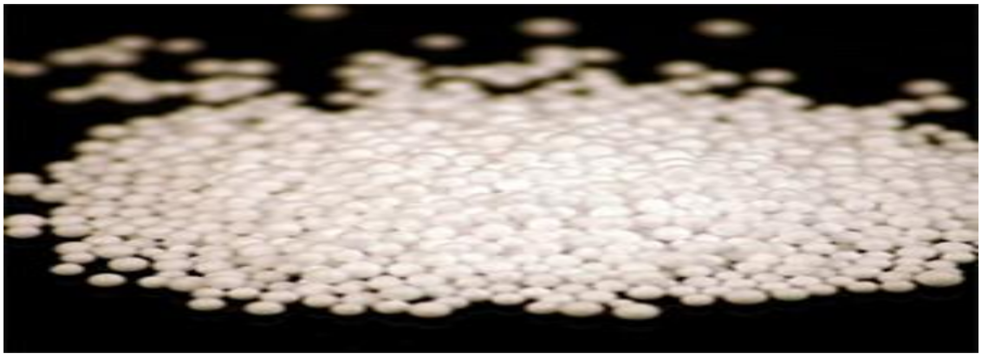

Figure 5.3 Styrofoam balls

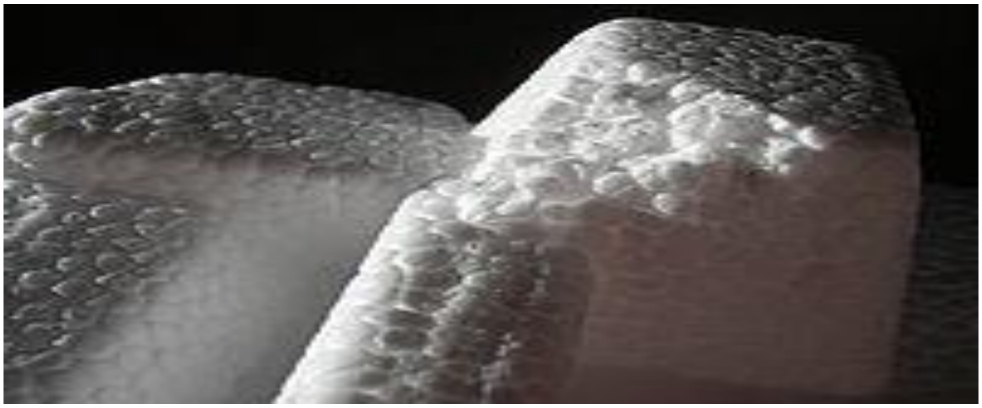

Figure 5.4 Styrofoam balls used for packing

Figure 5.5 Cup made of Styrofoam

5.3 SILICA FUME

Silica fume is a pozzolanic material which is a by-product of some certain metals which is being produced in electric furnaces. The amount of silica fume used in concrete/mortar is very small to increase the properties of concrete/mortar. The other names by which silica fume is knows in the market are; volatilized silica, micro silica and condensed silica fume. The size of silica fume is less that 0.1 microns. The addition or replacement of cement in concrete or mortar increases the water content in the mixture, so high range water reducing admixtures are used. In previous researches, it is shown that when silica fume is added in mortar/concrete the strength of the concrete increases. The strength of concrete/mortar increases only by replacing cement up to 15%, when more that 15% of cement is replaced with silica fume the strength start decreasing. The fineness of silica fumes is 100 times less than ordinary cement. The addition of silica fume in concrete also increases the ability to protect the concrete steel from corrosion. The various physical and chemical properties of silica fume is given in table given below:

TABLE 5.2 PHYSICAL PROPERTIES OF SILICA FUME

Color	Varies from light to dark gray
Specific gravity	2.1 to 2.3
Bulk loops density	230 to 300 kg/m3
Fineness	20,000m2/kg
Particle size	0.1 microns

TABLE 5.3 CHEMICAL PROPERTIE OF SILICA FUME

Constituents	**Percentage**
SiO_2	90-96
Al_2O_3	0.5-0.8
Fe_2O_3	0.2-0.8
MgO	0.5–1.5
CaO	0.1-0.5
Na_2O	0.2-0.7
K_2O	0.4-1

CHAPTER 6
RESEARCH METHODOLOGY

6.1 CEMENT

In this study various experiments are to be conducted on materials such as cement and fine aggregate to determent the various properties of material. The experiments or tests are conducted to determine whether they can be used or not to do the experiment or project. The following tests was done;

1. Initial and Final setting time of cement.
2. Consistency of cement.
3. Soundness of cement.
4. Fineness of cement.

The detail, procedure and instruments used in conducting these above experiments are given below one by one.

6.1.1 INITIAL AND FINAL SETTING TIME OF CEMENT:

Initial and final setting time of cement is done according to IS: 4031 part 5.

APPARATUS REQUIRED:

Vicat apparatus conforming to IS: 5513-1976, Balance (1000g) the permissible variation of balance should be +1.0g, Gauging trowel (According to IS: 10086-1982), Measuring cylinder.

INITIAL SETTING TIME:

Initial setting time is the time when needle of the vicat apparatus penetrates the cement paste between 5mm to 7mm from bottom of the mould just after water is added.

RESULT: The initial setting time of the cement comes out to 33minutes.

FINAL SETTING TIME:

Final setting time is defined as a time in which concrete/mortar changes its state from its initial plastic state to harden state.

Calculation:

Initial setting time=t_2-t_1

Final setting time=t_3-t_1

Here

t_1 = Time at which water is added.

t_2 = Time at which needle fails to penetrate 5mm to 7 mm from bottom of mould.

t_3=Time when the needle makes an impression but the attachment fails to do so.

RESULT: The final setting time out comes out to be 4 hours.

Figure 6.1 Vicat's apparatus test

6.1.2 CONSISTENCY OF CEMENT:

Consistency of cement can be defined in two ways; it is defined as percentage of water required for the cement paste, such that the vicat apparatus needle which is having a diameter of 10mm and 50mm long penetrates the cement paste 33 to 35 mm from mould top or 5 to 7 mm from bottom of mould.

APPARATUS REQUIRED: The Apparatus required for measuring consistency of cement are: Vicat Apparatus according to IS: 5513, Balance whose capacity should be 1000g and least count of balance is 1g, and measuring cylinder of capacity 100ml and least count is 1ml. The other apparatus required are tray and glass plate.

ENVIRONMENTAL CONDITION FOR PERFORMING CONSISTENCY TEST OF CEMENT:

The consistency test should be conducted in favorable environmental conduction. The test should be conducted at 27± 2º temperature and humidity should be 65±5 %.

CALCULATION:

The percentage of water (p) is calculated by weight of dry cement which is required for preparation of cement paste of standard consistency by given formula and is expressed it to first place of decimal.

$$P = \frac{W}{C} \times 100$$

Where:

w =Quantity of water added.

c =Quantity of cement used.

TABLE 6.1 CONSISTENCY READING TABLE

Weight of cement(g)	Water added (%)	Water added (g)	Penetration of plunger from bottom(mm)
300	25	75	40
300	27	81	36
300	30	90	12
300	32	96	7
300	35	105	4

RESULT: The Consistency of cement comes out to be 32%.

PRECAUTIONS:

1 The time in which water cement paste is thoroughly mixed (Gauging Time) should be strictly observed.

2 Testing should be done at well maintained room temperature (27±2º) as required.

3 Before starting the experiment make sure the apparatus used are clean.

4 No disturbance like vibrations should be nearby while doing experiment.

Consistency test is also helpful for determining the water content for tests like soundness (0.78P), compressive strength ($\frac{P}{4} + 3$) and initial and final setting time (0.85P).

Consistency of cement is conducted according to IS: 4031(part4).

Figure 6.2 Vicat Apparatus

6.1.3 TEST CONDUCTED TO CHECK THE FINENESS OF CEMENT:

Fineness of cement is defined as a particle size of cement. As we know there are so many properties of cement like hydration rate which is depend on fineness of cement. Rate of strength depends on hydration rate. Surface area-to-volume ratio depends on particle size of cement. Ratio is greater when particle size of cement is small and area is more for water cement interaction per unit volume.

Principle of finding fineness is to find/determine the proportion or weight of cement whose grain size is bigger/larger that mesh size (90µm).

Fineness of cement is done according to IS: 4031 (part1).

APPARATUS REQUIRED:

90µm is sieve, Balance capable of weighing 10kg to the nearest 10g, a brush with 25mm bristle for cleaning purpose, glass rod, pan, lid and stoppered jar.

CALCULATION:

To calculate the fineness we take mean of R_1 and R_2 and denote that by R in perentage, and expressed that nearest 0.1%.

CHECKING OF SIEVE:

1 Repeat the above mention steps with reference cement or certified reference material.

2 Find out two values q_1 and q_2 and take mean of these and denote that by Q.

3 Check the residue left in certified reference material on 90µm sieve.

4 After that we find out the correction factor by formula given below:

$$F = \frac{R}{Q}$$

Where

R = Residue of certified reference material which is known.

Q = Mean of q_1 and q_2.

Value of F may be 1.0 ± 0.2.

5 After that multiple correction factor (F) with R.

RESULT:

Weight of residue left on 90µm sieve =7gm

Therefore % of residue left by weight of cement taken for sieve analysis is calculated as below:

Weight of cement taken for analysis =200g

Therefore % = $\frac{7}{200} \times 100 = 3.5\%$

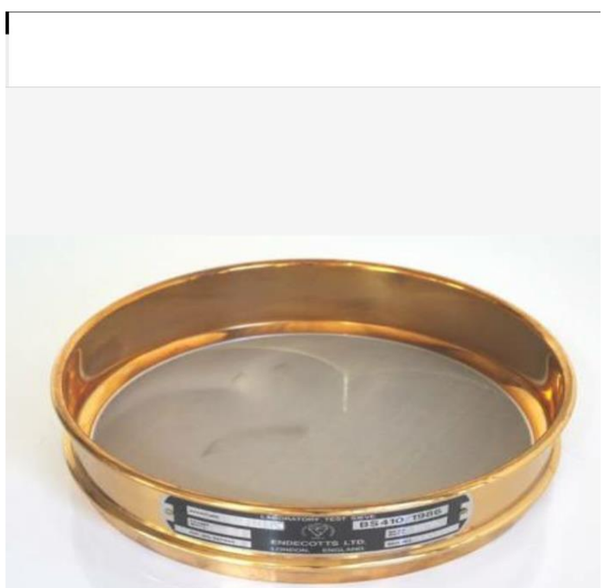

Figure 6.3 90 micron sieve

6.1.4 SOUNDNESS OF CEMENT (IS: 4031-PART 3-1988)

Due to temperature change, volume of mortar or concrete changes according to environment conditions. In hot conditions concrete/mortar expands whereas in cold condition it contracts. To minimize this effect soundness test of cement is done, because it is the soundness of cement due to which cement does not undergo in change in volume after set, and thus reduces that chance of expansion or contraction which leads the formation of cracks in mortar/concrete. The soundness means ability to resist volume expansion.

APPARATUS REQUIRED:

Le-Chatelier apparatus according to IS: 5514- 1969, Water bath whose range is 100ºC and least count of the bath is 1ºC, Caliper (30cm), Measuring cylinder of capacity 100ml and least count is 1ml and balance of capacity 100g and least count is 1g, Glass sheet, trowel, tray.

ENVIRONMENTAL CONDITIONS:

The soundness test of cement should be conducted at 27±2ºC and humidity should be 65±5ºC.

7 After that we take out the mould from the water bath and again measure the distance from indictor point and name that distance as d_2.

8 After that we calculate that value of d_1-d_2 which represent expansion of cement.

CALCULATION:

Value of d_1=2.3mm

Value of d_2=1.02mm

Value of d_1-d_2= 2.3-1.02= 1.28mm

RESULT: The soundness of cement comes out to be 1.28mm for OPC 43 grade.

PRECAUTIONS:

1 No extra force of pressure should be applied on mould while filling cement paste in mould.

2 Be very careful while taking or measuring any calculations.

3 Make sure mould is completely immersed in water while boiling.

4 All apparatus should be cleaned before use.

6.1.5 SPECIFIC GRAVITY OF CEMENT:

Specific gravity of cement is defined as ratio of weight of cement volume taken to the weight of equal volume of water. To find out the specific gravity of cement, kerosene is used but due to the nonreactive nature of kerosene with cement.

APPARATUS REQUIRED:

Le Chaterlier's flask, weighing balance, kerosene oil.

PROCEDURE:

CALCULATION:

Specific gravity of cement is calculated using the formula 1

$$G = \frac{(W2-W1)}{(W2-W1)-(W3-W4)} \times \hat{G}\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

Where G is the specific gravity of cement.

Ĝ is specific gravity of kerosene.

Weight of cement used=50g.

Weight of flask used (W1) =109g.

Weight of flask + cement +kerosene (W3) =395.4g.

Weight of flask + cement (W2) = 159g.

Weight of flask + kerosene (W4) = 358g.

RESULT: G specific gravity of cement is 3.14

6.2 FINE AGGREGATE:

Fine aggregate are particles of sand which is taken from land, river bed or from crushed stones, whose particle size is less than 4.75mm sieve. Fine aggregate is taken from primary, secondary or recycled sources. The test conducted on fine aggregate are:

1 Surface moisture content and absorption of fine aggregate.

2 Silt content test for fine aggregate.

3Specific gravity of cement and sand.

4 Sieve analysis of sand.

6.2.1 SURFACE MOISTURE CONTENT AND WATER ABSORPTION:

APPARATUS REQUIRED:

Apparatus which are required to find out surface moisture content and water absorption are; metal tray or frying pan, gas stove or an electric hair dryer, metal rod and scale for measurement.

ABSORPTION = $\frac{[(Wsd - Wbd)]}{Wbd} \times 100\%$.

CALCULATION:

$W = 500g \qquad W_{sd} = 494g \quad W_{bd} = 490g$

RESULT: Value of surface moisture content and water absorption comes out 1.21% and 0.81%.

4.2.2 SILT CONTENT OF SAND:

APPARATUS REQUIRED:

Measuring cylinder 250ml, and the material required common salt solution, scale for measuring.

This method is only used for natural sand for determining the silt content. The silt content percentage (%) should remain in limits as per standards.

CALCULATION:

$$\textbf{\% of silt by volume} = \frac{(\textit{Silt layer thickness})}{(\textit{sand+silt height})} \times 100$$

RESULT: From the above equation, volume of silt percentage comes out to be

6.2.3 SPECIFIC GRAVITY OF FINE AGGREGATE:

APPARTAUS REQUIRED:

Weighing balance of capacity greater than 3kg, Oven that maintains temperature in between 100ºC and 110ºc, Pycnometer whose capacity is 1 liter and have conical top with 6mm hole, Filter paper, Funnel, Air tight container and Tray.

CALCULATION:

$$\text{Specific gravity} = \frac{D}{C-(A-B)}, \text{ A =1830g, B = 1510g, C =500g, D =494g.}$$

RESULT: From the above equation the specific gravity of fine aggregate comes out to 2.74.

6.2.4 SIEVE ANALYSIS TEST:

Sieve analysis test is also known as gradation test which is conducted to assess the gradation of sand/fine aggregate, because various properties of mortar/concrete depends on size of partials of fine aggregate.

APPARATUS REQUIRED:

Set of sieve of different size; 4.75mm, 2.36mm, 1.18mm, 600μm, 300μm, 150μm. Balance whose accuracy should be 0.01 g, Oven, Mechanical sieve shaker.

RESULT: TABLE 6.2 SIEVE ANALYSIS RESULT TABLE

Is sieve	Weight retained (g)	% age of weight retained	Cumulative % age of retained weight	% age of passing
10mm	0	0	0	100
4.75mm	0	0	0	100
2.36mm	0	0	0	100
1.18mm	764	76.4	76.4	23.6
600μm	160	16	92.4	7.6
300μm	24	2.4	94.8	5.2
150μm	50	5	99.8	0.2
Pan	2	0.2	100	0
Total	1000	100		

From the above result it is concluded that sand lies in zone 2 according to IS: 383.

CHAPTER 7

RESULT AND DISSUCTION

In this study, the effect of replacement of cement with Styrofoam balls and silica fume on mortar cubes is studied. First cement is replaced with Styrofoam balls at 0.5% and 1% and then mortar cubes are tested for compressive strength and density and the results are compared with normal mortar cubes. The compressive strength and density is checked for 7, 14 and 28 days. For every test three specimen of mortar cubes are tested according to Indian Standard Code. After that, those mortar cubes are tested on compression testing machine, in which cement is replaced with silica fume at 10%, 15% and 20%. It is observed that maximum compressive strength comes out at 15% replacement of cement silica fume. Fig. 7.1 shows the doing of compression test on compression testing machine and Fig. 7.2 shows specimen after compression test. In compression testing machine. It is clear that the upper face of mortar cube is kept on side and load is acting on other side of the mortar cube. The rate of loading of compression testing machine on mortar cubes is set and is kept constant according to Indian Standard Code. In this experiment, the rate of loading is kept 2.8N/mm^2.

Figure 7.1: testing of specimen

Figure 7.2: Different mortar cubes

7.1 MIX PROPERTION:

An ordinary Portland cement of 43 grade with specific gravity of 3.15 are used in this experiment. The 1:3 mortar mix design is used for normal mortar cubes. In mortar second mix, cement is replaced with styrofoam balls at 0.5% and 1%. In third mix cement is replaced with silica fume at 10%, 15% and 20%. In fourth mix cement is replaced with combination of silica fume at 15% and 0.5% of styrofoam balls. The water cement ratio for all the mix design is kept at 0.3. It is observed that greater the water cement ratio, lesser is the compressive strength of mortar cubes. The various mix mortar which are used in this project is given below

TABLE 7.1 Different mix design

M1	Normal cubes	1:3
M2	Styrofoam balls	0.5%
		1%
M3	Silica fume	10%
		15%
		20%
M4	Silica fume + Styrofoam ball	15% silica fume + 0.5% styrofoam balls

7.2 SPECIMEN SIZE AND EXPERIMENT PROCEDURE:

The mortar mix design corresponds to IS: 2250-1981. 1:3 grade mortar has been adopted for all the specimens. The percentage of silica fume to be added corresponds to ACI committee 234(7). The cube size of (70.6×70.6×70.6) mm has been used to determine the compressive strength of mortar after 7, 14 and 28 days. The water cement ratio is kept at 0.32. The cubes used in this project are shown in Fig. 7.3 and Fig.7.4

Figure 7.3 Mortar cubes

Figure 7.4 Mortar cubes

Before mould is filled with mortar, mould is well cleaned, dried and oiled. The mould is filled with mortar in three layers and is compacted with compaction rod by giving 25 blows in each layer. After 24 hours, the mortar cubes are demoulded and then mortar cubes are put into the curing tank till the testing of cubes is done.

7.3 CURING OF SPECIMEN:

After 24 hours of casting of mortar cubes, the mould is demoulded and are put into the curing tank for 7days, 14days and 28days. The mortar cubes are taken out of curing tank before 6-8 hours and then testing is done. The mortar cubes are completely immersed in water in curing tank as shown in Fig. 7.5

Figure 7.5 Mortar cubes in curing tank

7.4 Result of compressive strength and density of mortar cubes containing Styrofoam balls:

The compressive strength and density of mortal cubes with partial replacement of cement with styrofoam balls in comparison with those of normal mortar cubes are given in table 7.2. It is clear from table 6.1 that there is decrease in density of mortar cubes when cement has been partially replaced by styrofoam balls. On 0.5% and 1% replacement of cement with styrofoam balls, the density decreases by 28.65% and 45.14% after 28 days respectively. It is majorly because of low density of styrofoam balls as these occupy more volume. However, there is decrease in compressive strength of mortar cubes when cement has been replaced by styrofoam nature because of their weak compressive nature and inert ability. The compressive strength decreases by 54.75% and 60.90% at 0.5% and 1% replacement. Due to inert nature of styrofoam balls, the bond formed is weak and leads to decrease in compressive strength. For 7, 14 and 28 days, three cubes of each mix, normal mix, 0.5% and 1% replacement of cement with styrofoam balls are tested for density and compressive strength according to IS-Code. For checking the density and compressive strength of mortar cubes, cubes are taken out from curing tank before 4-6 hours. For calculation of density of mortar cubes for 7, 14 and 28 days, average weight and volume of 3 cubes is taken for each day. For checking the compressive strength of mortar cubes, rate of loading on mortar cube is kept 2.8N/mm^2 and average load of 3 cubes is calculated and then compressive strength is calculated.

Table 7.2: Result of compressive strength and density of mortar cubes containing styrofoam balls:

Sample		Density(g/cm^3)			Compressive Strength(MPa)		
Days		7 days	14 days	28 days	7 days	14 days	28 days
M1	Normal	2030	2056	2060	13.9	15.1	17.9
M2	0.5%(STY)	1457	1465	1470	7.25	7.57	8.1
M3	1%(STY)	1115	1127	1130	5.05	5.9	7.0

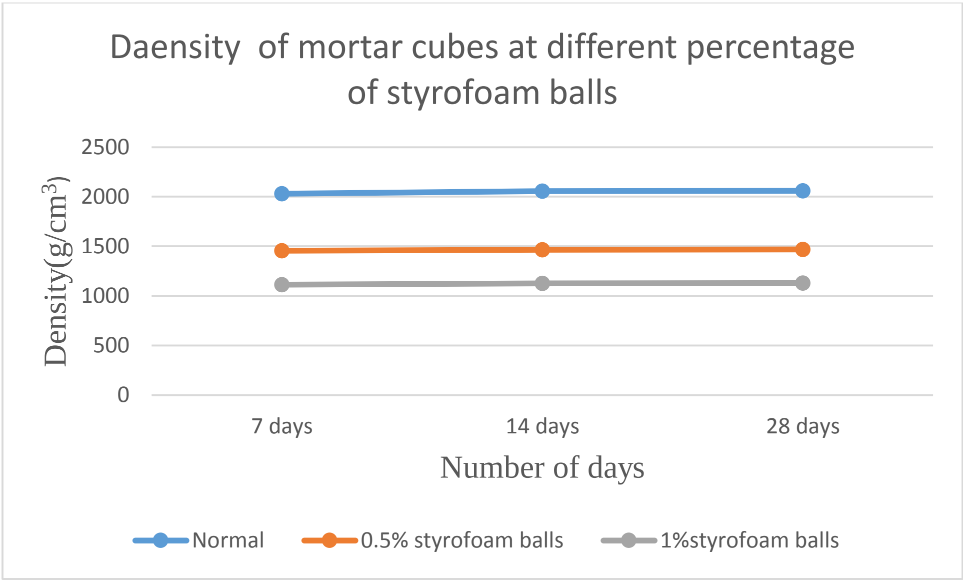

FIGURE 7.6: DENSITY VS NUMBER OF DAYS

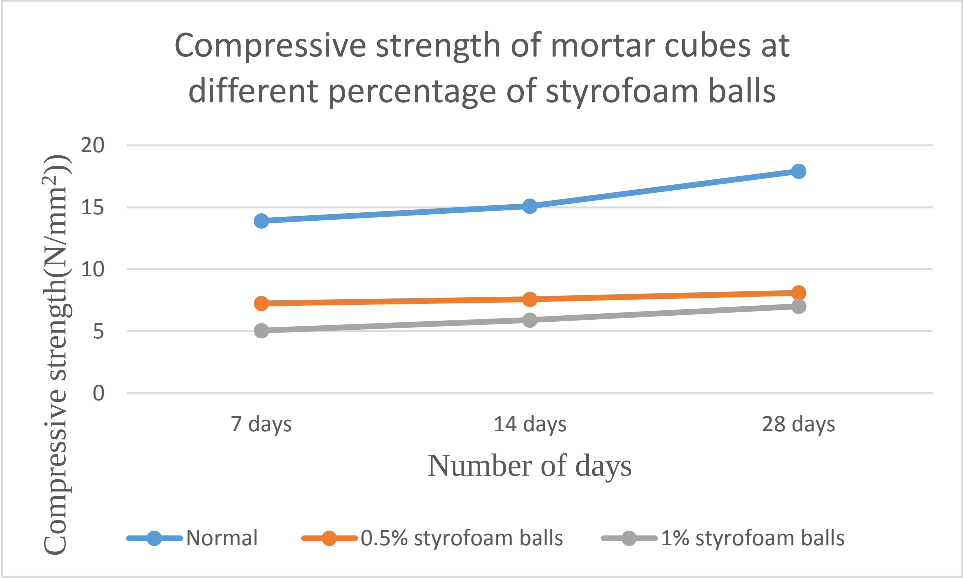

FIGURE 7.7: COMPRESSIVE STRENGTH VS NUMBER OF DAYS

7.5: Result of compressive strength and density of mortar cubes replacing cement with silica fume:

The compressive strength and density of mortal cubes with partial replacement of cement with Silica fume in comparison with those of normal mortar cubes are summarized in table 7.3. On replacing cement with silica fume, the density almost remains same as compared to normal cubes. There is increase in compressive strength when silica fume is replaced with cement. On 10%, 15% and 20% replacement of cement by silica fume, compressive strength increases by 11.82%, 22.27% and 15.96% after 28 days respectively. The increase in compressive strength is majorly contributed by micro-filler effect of silica fume. The optimum level of replacement of cement with silica fume is found to be 15%. Beyond 15% replacement level, decrease in compressive strength has been observed.

Table 7.3 Result of compressive strength and density of mortar cubes replacing cement with silica fume.

Samples		Density(g/cm^3)			Compressive strength(MPa)		
Days		7 days	14 days	28 days	7 days	14 days	28 days
M1	Normal	2030	2056	2060	13.9	15.1	17.9
M2	10%(SF)	2075	2080	2082	16.5	18.2	20.3
M3	15%(SF)	2100	2108	2117	18.4	20.7	23.03
M4	20%(SF)	2110	2117	2123	16.1	17.8	21.3

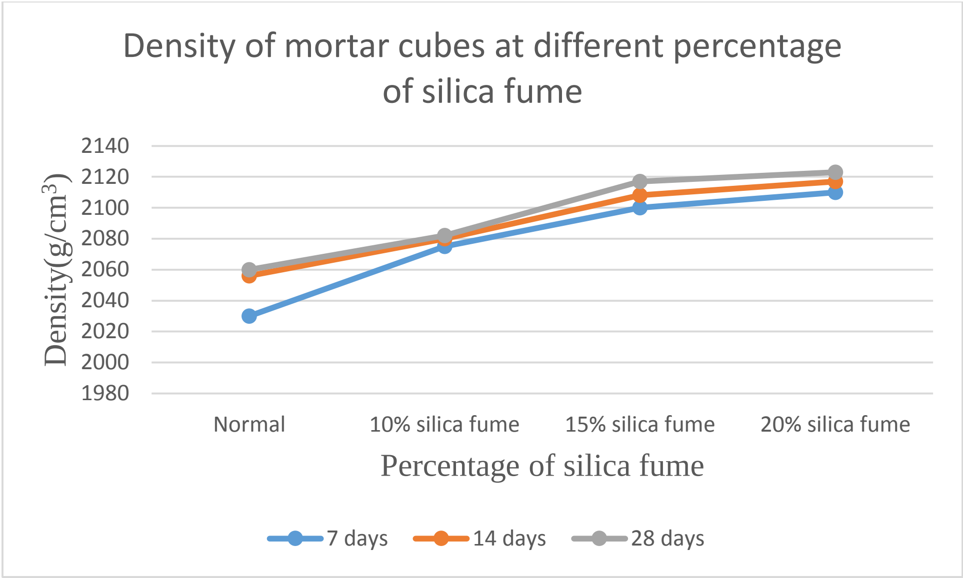

FIGURE 7.8: DENSITY OF MORTAR CUBES CONTAING SILICA FUME

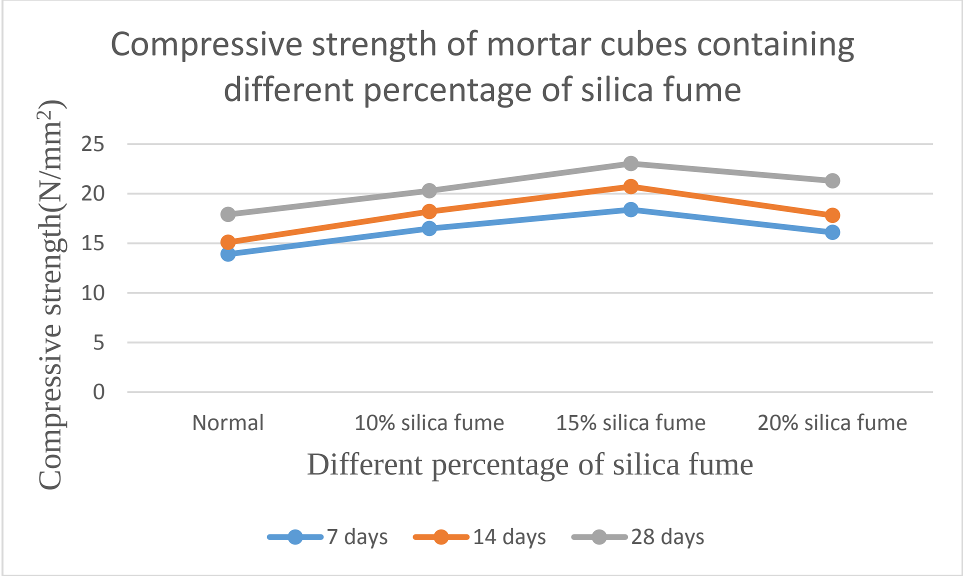

FIGURE 7.9: COMPRESIVE STRENGTH OF MORTAR CUBES CONTAING SILICA FUME

7.6 Result of compressive strength and density of mortar cubes replacing cement With Silica fume and Styrofoam balls:

The compressive strength and density of mortar cubes containing 15% silica fume and 0.5% of Styrofoam balls replaced with cement in comparison with normal mortar cubes shown in table 7.4. On combined replacement of cement with 15% silica fume and 0.5% Styrofoam balls, both density and compressive strength decreases by 22.18% and 31.28% respectively in comparison with normal cubes. Thus silica fume contributed to increase in compressive strength because of presence of more CSH gel which leads to better bonding of individual constituents of mortar.it is observed that compressive strength of mortar cubes is slightly increased when silica fume is added in combination with Styrofoam balls as compared to the those mortar cubes which only contains Styrofoam balls.

Table 7.4 Result of compressive strength and density of mortar cubes

Samples		Density(g/cm^3)			Compressive strength(MPA)		
Days		7 days	14 days	28 days	7 days	14 days	28 days
M1	Normal	2030	2056	2060	13.9	15.1	17.9
M2	0.5%(STY)+15%(SF)	1594	1603	1608	8.22	9.27	12.3

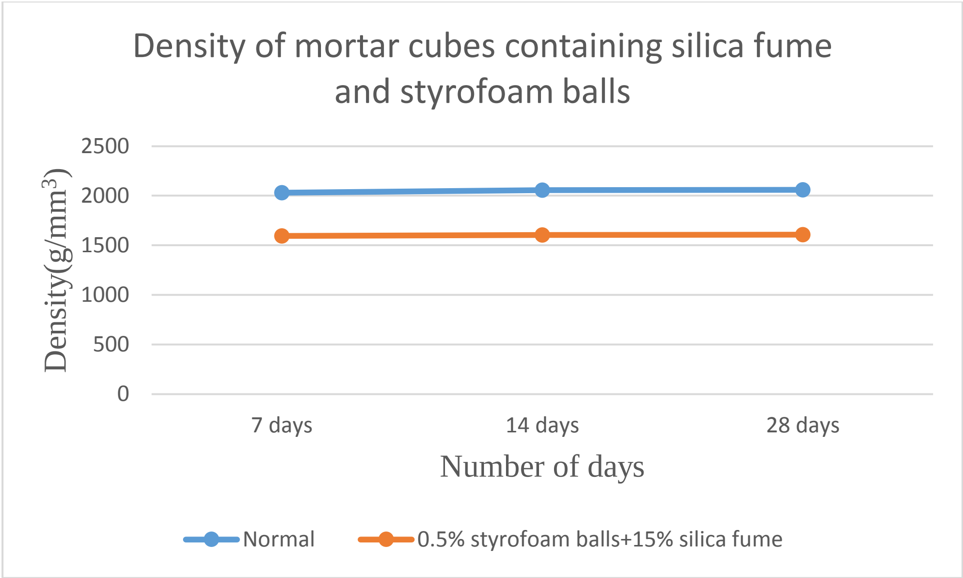

FIGURE 7.10: DENSITY OF MORTAR CUBES CONTAINING SILICA FUME AND STYROFOAM BALLS

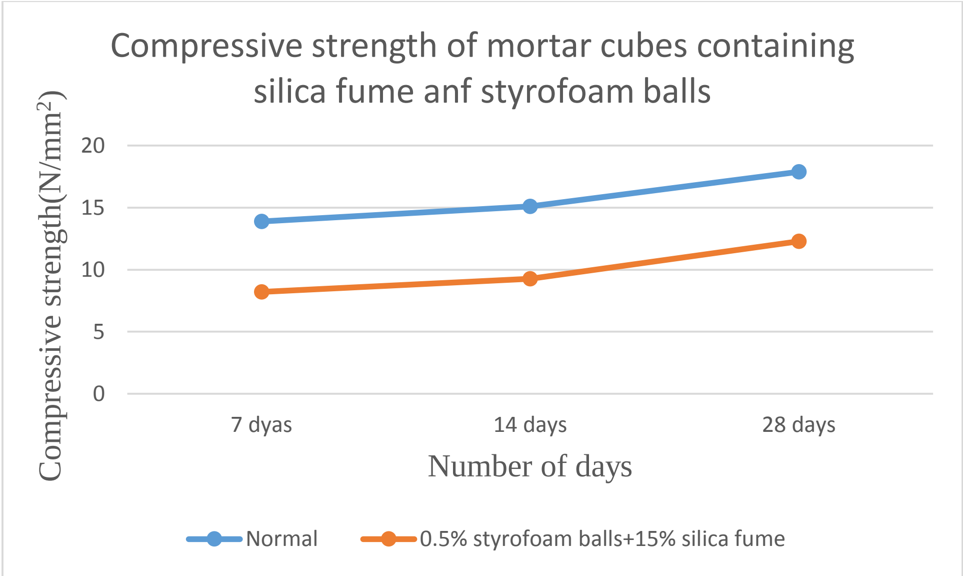

FIGURE 7.11: COMPRESSIVE STRENGTH OF MORTAR CUBES CONTAINING STYROFOAM BALLS AND SILICA FUME

CHAPTER 8

CONCLUSION AND FUTURE SCOPE

Mortar blocks are prepared by combination of fine aggregate, cement with water. Generally in normal mortar blocks, the density lies in between 2300kg/m^3 and 2400kg/m^3. In this study we use styrofoam balls which is light weighted material. The following are the result of various experiments:

1. Due to the use of styrofoam balls, density of mortar cubes decreases to a greater extent.

2. At 0.5% replacement of cement with styrofoam balls, the density of mortar cubes decreases by 28.65% after 28days as compared to normal mortar cubes.

3. At 1% replacement of cement with styrofoam balls, density of mortar cubes decreases upto 45.14% after 28days as compared to normal mortar cubes.

4. After 28days the density of mortar cubes containing 1% styrofoam balls is less as compared to mortar cubes containing 0.5% of styrofoam balls.

5. The compressive strength of mortar cubes containing styrofoam balls is less as compared to normal mortar cubes after 28days.

6. At 0.5% replacement of cement with styrofoam balls, the compressive strength is more as comparable to mortar cubes containing 1% replacement of cement with styrofoam balls.

7. It is observed that at 15% replacement of cement with silica fume, the compressive strength of mortar cubes comes out to be maximum.

8. On combination of Styrofoam balls and silica fume in mortar, it is observed that silica fume somehow counterbalance the compressive strength of mortar cubes which decreases due to the Styrofoam balls.

9. Light weight mortar is obtained by replacement of cement with styrofoam balls, therefore there is huge decrease in dead weight. Therefore it can reduce the overall dead load of a structure.

FUTURE SCOPE:

Light weight mortar is important in many construction industrial work. The various future scope of this project are:

1. Now-a-days light weight mortar is used in making insulation walls, tiles, roofs, floors, floating houses, sound barrier walls etc.

2. Light weight mortar decreases the overall dead weight of structure, which decreases the overall cost of production of any project.

3. Due to use of light weight mortar cubes in buildings heating and cooling effect changes according to environment condition.

4. As we know shape of light weight mortar cubes is large and uniform, due to that thickness of plastering reduces and that reduces the overall cost of any project.

5. Due to use of light weight mortar size of footing, beams, columns and other structural elements reduces.

6. The other important property of light weight mortar is fire resistant, it does not get damaged if fire breaks out.

REFERENCES

1 Danish, Peerzada, and Shahid ul Islam. "Effect of Styrofoam Balls and Aluminum Oxide on Strength Properties of Cement Motor Cubes." *International Journal of Scientific & Engineering Research* 6.1 (2015): 1099.

2 Mohamadien, Hassan A. "The Effect of marble powder and silica fume as partial replacement for cement on mortar." *International journal of civil and structural engineering* 3.2 (2012): 418.

3 Rekha Ambi, Shamila Habeeb Strength Studies on Silica fume Based Cement Mortar *International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 Trends and Recent Advances in Civil Engineering (TRACE- 24th-25th January 2014)*

4 Bhanjaa, S. B. Sengupta Influence of silica fume on the tensile strength of concrete, *Cement and Concrete Research 35*, 2005, 743–747

5 Yogendran V, Langan BW, Haque MN, Ward MA. Silica fume in high-strength concrete. ACI Materials Journal 1987: 84(2):124±9.

6 Siddique, Rafat, and Navneet Chahal. "Use of silicon and ferrosilicon industry by-products (silica fume) in cement paste and mortar." *Resources, Conservation and Recycling* 55.8 (2011): 739-744.

7 Darwin, David and Slate, F.O, J. of Materials, JMLSA, V.5, N.1, March 1999.

8 Chakraborty, Arun Kumar, and Sekhar Chandra Dutta. "Study on silica fume modified mortar with various Indian cements cured at different temperatures." *Building and Environment* 36.3 (2001): 375-382.

9 Andersson, Jan-Olof, et al. "Thermo-Calc & DICTRA, computational tools for materials science." *Calphad* 26.2 (2002): 273-312.

10 Torii, Kazuyuki, and Mitsunori Kawamura. "Effects of fly ash and silica fume on the resistance of mortar to sulfuric acid and sulfate attack." *Cement and Concrete Research* 24.2 (1994): 361-370.

11 Rao, G. Appa. "Investigations on the performance of silica fume-incorporated cement pastes and mortars." *Cement and Concrete Research* 33.11 (2003): 1765-1770.

12 Cheng-Yi, Huang, and Rolf F. Feldman. "Influence of silica fume on the microstructural development in cement mortars." *Cement and Concrete Research* 15.2 (1985): 285-294.

13 Alshamsi, A. M., A. R. Sabouni, and A. H. Bushlaibi. "Influence of set-retarding superplasticisers and microsilica on setting times of pastes at various temperatures." *Cement and Concrete research* 23.3 (1993): 592-598.