The properties of Poly-Propylene Fiber Added with Silica Fume in Concrete: A Review

Sandeep Kumar[1] Kamlesh Kumar Choudhary[2]
[1]Research Scholar [2]Assistant Professor
[1,2]Department of Civil (Structural Engineering) Engineering
[1,2] Saraswati Institute of Engineering & Technology, Jabalpur, India

Abstract— Nowadays, a significant amount of concrete is used in the building industry. Concrete offers better resistance under pressure than steel does when it is stressed. A low effect, a scraped surface, limited malleability, and little break protection are all characteristics of regular cement. To improve the conductivity of plain concrete both before and after it breaks, short, irregular, and discrete strands can be added. To enhance the qualities of cement, half-and-half filaments are consolidated in addition to silica fume. In this study, different fiber-added materials can be combined with cement to improve synthetic and strength properties and plan for particular applications. By using different fiber extents of steel and polypropylene, the combination of strands—often referred to as "hybridization"—is presented. According to the IS code method of mix design, silica fumes ranging from 0 to 15 percent by volume of cement and poly-propylene fiber, steel (crimped) fibers, and hybrid fiber (poly-propylene and steel (crimped) fibers) were used as additives for each of the concrete mixes of M30 grade. All mixtures included a super plasticizer as well to enhance. Along with casting M30 grade concrete cubes and beams with 0 and 15% silica fumes, various amounts of steel fiber, polypropylene fiber, and hybrid fibers, by volume of cement, this study also identifies the fiber combinations that show the maximum compressive, flexural, and shear strength of concrete. Finally, we discovered that adding fiber and mineral admixtures to concrete causes it to have better properties than plain concrete.

Keywords: M30 Grade of Concrete, Cement, Polypropylene Fiber, Silica Fume, Sand, Coarse Aggregate, Workability

I. INTRODUCTION

The country's structural needs are growing, and since concrete is a key component of construction materials in a significant portion of this underpinning infrastructure, it is critical to improve its qualities through strength and solidity. Concrete is a medium-fragile substance. It becomes a more malleable substance when the strands expand to substantial size. Several flaws in plain concrete cement, including low elastic, limited pliability, little protection from breaking, and high fragility helpless sturdiness, are present. The breaks typically develop over time and under stress, hindering the waterproofing properties and exposing the interior of the substantial to harmful substances like moisture, bromine, corrosive sulphate, and so on. The openness causes the substantial to crumble, with the building. A battling methodology that combines the substantial with the growth of discrete strands is now in use to balance the breaks. Exploratory analyses have revealed that strands enhance the cement's mechanical qualities, such as flexural strength, compressive strength, rigidity, creep conduct, sway resistance, and sturdiness. Among them, steel strands and polymer filaments are particularly common in the cement industry. The viewpoint proportions, directions, mathematical shapes, circulations, and mechanical properties of the strands in substantial blends from a fragile to a more flexible material clearly influence how HFRC behaves.

II. REVIEW OF LITERATURE

A. *Aravind Sai Yandrapati*and M. Anil Kumar (2021)*

In this research, the mechanical properties of polypropylene and silica fume are examined with the 0.40% water-cement ratio of M40 grade concrete. The synthetic polypropylene fibers of length 12mm short fibers. in this study, the polypropylene fibers are used up to 0.3% (0%, 0.1%, 0.2%, 0.3%). And the silica fume is being utilized as a substitute for cement with a 4% mass of cement in all the mix proportions. The addition of silica fume to the cementitious matrix strengthened fiber scattering, resulting in a substantial decrease in the absorbency of the polypropylene fiber reinforced concrete(PPFRC). Super plasticizer is also added to these concrete mixes to increase workability. The concrete samples are prepared and cured for 7, 28 days. After completing the curing duration, samples were tested. After That finally, the mechanical properties, as comp. strength, split tensile, bending strength and mode of failure and ultimate load are determined and all proportions of the mix are compared to traditional concrete.

B. *Babar Ali a,*, Liaqat Ali Qureshi b, Rawaz Kurda (2020)*

Conventional plain concrete (PC) leads to large design thickness when used in applications where high flexural strength is required. Therefore, to minimize the consumption of natural resources and to avoid large design thickness, it is fundamental to upgrade the flexural strength of PC by using supplementary materials i.e. steel rebars, fibers. This study evaluated the environmental and economic performance of the pavements designed with different fibrous concrete composites (FCCs). FCCs were manufactured by incorporating 0.5 and 1.0% volume fractions of glass fiber (GF), hooked steel fiber (HSF), and polypropylene fiber (PPF) in the normal strength concrete (C30). Initially, the flexural properties of FCCs were evaluated and then these properties were utilized to design the thickness of jointed plain concrete pavement (JPCP). Using the cost and carbon emissions per cubic meter of each concrete mix, the environmental and economic performance of JPCP construction was estimated. The performance of different FCCs in the JPCP was compared with that of the conventional PC.

C. Ta-Yuan Han, Wei-Ting Lin, An Cheng, Ran Huang, Chin-Cheng Huang (2012)

This study evaluated the mechanical properties of cement-based composites produced with added polyolefin fibers and silica fume. Material variables included the water-cementations ratio, the dosage of silica fume, and the length and dosage of polyolefin fiber. Researchers conducted tests on compressive strength, splitting tensile strength, direct tensile strength, resistivity, rapid chloride penetration, and initial surface absorption, and performed microscopic observation. Test results indicate that the specimens containing silica fume have higher compressive strength than the control and specimen made with fibers. The specimens with polyolefin fiber and silica fume have considerably higher tensile strength and ductility than the control and specimens made with silica fume. The specimens containing silica fume and polyolefin fiber demonstrated better resistance to chloride penetration than composites with polyolefin fiber or silica fume. For a given volume fraction, short polyolefin fiber performs better than its long counterpart in improving the properties of concrete. Specimens containing silica fume demonstrated a significant increase in resistivity and decrease in the total charge passed and absorption. Scanning electron microscopy illustrates that the polyolefin fiber acts to arrest the propagation of internal cracks.

D. N. K. Amudhavalli , Jeena Mathew (2012)

Portland cement is the most important ingredient of concrete and is a versatile and relatively high cost material. Large scale production of cement is causing environmental problems on one hand and depletion of natural resources on other hand. This threat to ecology has led to researchers to use industrial by products as supplementary cementations material in making concrete. The main parameter investigated in this study is M35 grade concrete with partial replacement of cement by silica fume by 0, 5, 10,15and by 20%. This paper presents a detailed experimental study on Compressive strength, split tensile strength, flexural strength at age of 7 and 28 day. Durability study on acid attack was also studied and percentage of weight loss is compared with normal concrete. Test results indicate that use of Silica fume in concrete has improved the performance of concrete in strength as well as in durability aspect.

E. Chetan K N,Kotresh,Nishath Anjum,Sumanjali (March 2008)

The experiment work carried out by silica fume as a supplementary material for cement and evaluates cement for M20 grade of concrete. We are adding 0%, 5%, 10%, and 15% by weight of cement in concrete and also added glass fiber. The aim of investigation is study the possibilities to use glass fiber in addition to other constituents of concrete and strength properties. The influence of 0%, 0.5% 1%, and 1.5% fiber content by mass of cement and aspect ratio 857, fiber cut length 12mm is investigated to evaluate the effect of glass fibers improving the properties of concrete. At 1% addition of glass fiber, 10% silica fume with water cement ratio 0.50 the compressive strength test and split tensile strength gives best result in concrete. To validate the experimental results finite element analysis is carried out by using ANSYS 11 software.

III. OBJECTIVES OF STUDY

This study compares the compressive and flexural strengths as well as other strength parameters of polypropylene fiber-reinforced multi-blended concrete to conventional mix concrete. Consequently, our research aims to experimentally show the advantages of polypropylene fiber-reinforced multi-blended concrete over conventional mix concrete and to promote its use for improved strength and durability, as well as in light of the aforementioned economic and environmental factors.

In more detail, the study's objectives are as follows:

1) Studying silica fume and polypropylene fibre has an impact on strength when coupled with compelling samples.
2) To investigate the impact of cement when mixed with polypropylene fibre that emits different levels of silica fume.
3) To talk about the strength variation adjustment.
4) To prepare the concrete cubes & beams using by silica fume and Polypropylene Fiber mix concrete.
5) To compare various mixes, including normal mix and fiber-mixed concrete, and to determine the compressive strength of hardened concrete at 7 and 28 days of curing.
6) To compare various mixes, including normal mix and fiber-mixed concrete, and to determine the flexural strength of hardened concrete at 7 and 28 days of curing..

IV. MATERIALS USED

A. Concrete

These properties might be constrained by changing the proportionality of the fundamental minerals. Despite the fact that the remainder of the minerals make up a little piece of the concrete, these can affect sly affect the concrete's properties too. The potassium-and sodium oxides (the alkalis) are significant. They can cause the concrete to solidify quicker and make it extend. At the point when the various minerals in the concrete respond with water there will be heat age. Because of this keep the substantial clammy while solidifying to stay away from drying out and breaking.

Fig. 01: Concrete

B. Aggregate

The aggregate in the substantial comprises of sand and stone and makes up 60-70% of the substantial volume. As this is the biggest piece of the substantial the properties of the total may incredibly impact the properties of the substantial. It must not be breathable. It might not be rich, schistose, efflorescent, fibrous, or have any of those characteristics. should not contain chlorides, sulphates, or silicates (opal, rock) (sand from prior littoral zones). There shouldn't be much humus, mud, or earth in it. Regular material evaluation, grain shape evaluation, and shallow construction evaluation are used to evaluate the aggregate. The evaluation of the material implies the inclusion of different grain sizes in the total. It is appealing to have a good distribution of grain estimates because it means that each size's measurement will be roughly similar. This will result in few hollows and low air content in the substantial, which is advantageous because a high air content will reduce the substantial's strength. If there are few voids between the aggregate particles, then little concrete glue will be required to bind them together.

The shallow construction and grain shape give clues as to the states of the grains. Sand, rock, and other natural materials are frequently adjusted and smooth, whereas man-made materials like crushed stone have sharp edges and rough surfaces. Although there are occasionally requirements for these properties for concrete, these boundaries are typically significant for filling compounds for street development.

C. Fine Aggregate

When the granular material's particles are so small that they can fit through a 4.75mm sieve, it is referred to as fine aggregate. Aggregate is the granular material used to make concrete or mortar. In order to find the best material, you should be fully informed about the fine aggregate size, its density, and the grading zone. It is frequently used in the construction industry to increase the volume of concrete, making it a cost-saving material.

Usually, sand, crushed stone, and crushed bricks are used as fine aggregate in concrete or pavement construction.

1) Classification according to Source
2) Coral Sand
3) Glass Sand
4) Immature Sand
5) Gypsum Sand
6) Silica Sand
7) Pit Sand
8) River Sand
9) Sea Sand
10) Green Sand
11) Desert Sand
12) Lithic Sand
13) Mixed Carbonate-silicate Sand
14) Biogenic Sand
15) Garnet Sand
16) Olivine Sand
17) Volcanic Sand
18) Heavy Mineral Sand
19) Sands with Hematite Pigment
20) Continental Sand
21) Quartz Sand

Fig. 02: Sand as fine aggregates

D. Grading Of Fine Aggregates

All sand particles should pass through sieves numbered 4 to 16. Sand should not, however, contain very small particles. For dense mortars, sand must contain particles of uniformly varying sizes between these two extreme sizes (3/16 and 1/16 inch), or it must be well graded. 'Sieve Analysis' is used to classify these different sand particle sizes. A known amount of dry sand (typically 100–200 gm) is taken and sieved through a series of standard sieves in that order. To calculate the sample's "Fineness Modulus," the cumulative percentages of the various retained quantities are added and their totals are divided by 100. F is typically used to indicate it.

E. Coarse Aggregates

The aggregate that is retained after being sieved through a 4.75mm sieve is referred to as coarse aggregate. This category includes boulders, gravel, and cobblestone. The use of an aggregate of the maximum size may be subject to certain restrictions. Typically, 20mm size aggregate is used for concrete with high strengths and 40mm size aggregate for concrete with normal strengths. The size distribution of different coarse aggregates is shown below.

Fig. 03: the size distribution of different coarse aggregates

Coarse aggregate	Size
Fine gravel	4mm – 8mm
Medium gravel	8mm – 16mm
Coarse gravel	16mm – 64mm
Cobbles	64mm – 256mm
Boulders	>256mm

Table 01: The size distribution of different coarse aggregates

F. Cement

Cement is a general term for all types of adhesives, but in a more specific sense, it refers to the binders used in building and civil engineering construction. These cements are made of finely ground powders that, when combined with water, solidify to form a solid mass. Hydration, the chemical reaction of the cement compounds with water to produce microscopic crystals or a gel-like substance with a large surface area, is what causes setting and hardening.

Constructional cements, which will even set and harden under water, are frequently referred to as hydraulic cements because of their hydrating qualities. Of these, Portland Cement is the most significant.

Fig. 04: Cement

G. *Admixture*

The synthetic admixtures are added substances that are added to the new concrete to give it wanted properties either in new or solidified condition. These added substances were generally evolved in the 70's and 8 0's and today basically all substantial mixes contain some measure of added substances. The main classifications of compound admixtures are portrayed beneath.

Fig. 05: Admixtures

H. *Plasticizers*

The plasticizers are the most regular added substances and are added to expand the usefulness of the new concrete so that it's simpler to project, without adding more water and along these lines decrease the substantial's ability. This happens on the grounds that the plasticizers lessen the water's surface strain, hence decreasing the rubbing between the segments in the blend, and the thickness of the water film around the total grains is diminished and delivers water. The plasticizers have a place with two classifications; plasticizers and super plasticizers. The plasticizers depend on a material called lignosulfonate which starts from the wood preparing industry. At high measurements the plasticizer may have an impending result. This implies that the substantial dries increasingly slow aren't generally attractive. The super plasticizers typically have a preferable plasticizing impact over the normal plasticizer (12-40% water decreasing impact against just 8% for plasticizers).

Fig. 06: Plasticizers

I. *Retarders*

Retarders limit the hydration of the concrete by shaping a gradually dissolving layer around the concrete grains. They are utilized when it's alluring to defer the cementing season of the substantial. As models this might be alluring for long transportation, to lengthen the substantial's handling time in the projecting casing or when projecting in warm climate to keep away from quick hardening. As the plasticizers have impeding as a result, the retarders have plasticizing as a result.

The impact of the gas pedals is animating of the solidifying cycle. These added substances are moderately once in a while utilized in Norway. It could be fundamental with gas pedals when projecting in the colder time of year to acquire early expulsion of the projecting edge and ice opposition, and while creating pre focused on concrete. A difficult when utilizing gas pedals is that the sped-up solidifying interaction may deliver a great deal of warmth. This would then be able to make the substantial break, increment the substantial's potential for shrinkage or reduce the strength of the solidified cement.

Fig. 07: Retarders

J. *Air Entrainments*

The air entrainments tie numerous little and uniformly dispersed air rises into the concrete when the substantial is blended. The point with this might be to upgrade the ice opposition of the substantial, on the grounds that the air bubbles permit water in the substantial to extend without breaking the substantial. Another benefit given by high air content is that the air bubbles improve the substantial's cast capacity. The issue is that high air substance will diminish the strength of the substantial by 5% per each % of added air.

Fig. 08: Air Entrainments

K. *Fiber*

Fiber is a characteristic or manufactured substance that is fundamentally more than it is wide. Manufactured filaments can regularly be created efficiently and in huge sums contrasted with normal strands, yet for apparel regular filaments can give a few advantages, like solace, over their engineered partners.

1) *Fiber types*

Natural Fiber – Regular strands create or happen in the fiber shape, and incorporate those delivered by plants, creatures, and topographical cycles. They can be grouped by their starting point.

1) Vegetable strands
2) Wood fiber
3) Animal filaments
4) Mineral filaments
5) Biological filaments

Man-made Fiber – Man-made or synthetic filaments are stranding whose compound creation, design, and properties are fundamentally adjusted during the assembling cycle. Man-made filaments comprise of recovered strands and engineered strands.

1) Synthetic strands
2) Semi- Synthetic fiber
3) metallic filaments

L. *Polypropylene Fiber*

Two very delicate issues have come to light as a result of the current global health emergency: hygiene and safety. It's crucial to strictly adhere to all safety measures in regards to routine cleaning and thorough hygiene of the environments in which we live as well as the items with which we come into contact. The contemporary situation in which the consumer gives the concept of "well-being" and health an even greater value than aesthetic taste and comfort causes the modern features of polypropylene to reappear in this scenario.

The fact that polypropylene yarn can be easily sanitized with a 70% hydroalcoholic solution or with sodium hypochlorite up to 0.5% makes it especially suitable for the current state of public health. This is in addition to the significant advantages of being completely recyclable and guaranteeing the best degree of sustainability among all natural and synthetic fibres (production requires lower temperatures than other polymers and has a reduced impact in terms of water, energy, and CO2 emissions). This is the legal requirement for sanitization, and tests on fabrics in our lab using intense colours as well as light and dark shades revealed that the colour was completely resistant to mechanical and washing actions. In order to meet the new requirements for cleanliness and environmental protection, the time has come.

Polypropylene has the following properties:

1) Fairly low physical properties
2) Fairy low heat resistance
3) Excellent chemical resistance
4) Translucent to opaque
5) "living hinge" capability
6) Low price
7) Easy to process

Moisture regain	0.1%
Refractive index	1.49
Heat of fusion	21 cal/g
Specific heat	0.46 cal/(g x C)
Density of melt at 180°C	0.769 g/cc
Dissipation factor (0.1 MHz)	< 0.0002
Heat of combustion	19400 Btu/lb
Oxygen index	17.4
Decomposition temp. range	328 - 410 °C
Dielectric constant	(0.1 MHz) 2.25

Fig. 09: Polypropylene fibers

M. *Silica Fume*

Micro silica, also referred to as silica fume, is an amorphous (non-crystalline) polymorph of silica, which is silicon dioxide. It is an ultrafine powder with spherical particles and an average particle diameter of 150 nm that is gathered as a waste product from the production of silicon and ferrosilicon alloys. The primary use is as a pozzolanic component in high performance concrete.

Fig. 10: Silica Fume

The smelting procedure used in the silicon and ferrosilicon industries produces silica fume (SF). It is also referred to as micro silica, volatilized silica, silica dust, and condensed silica fume. Premium white or grey silica fume are the two available colors. Very small, vitreous particles with a surface area of 13,000 to 30,000 m^2/kg make up silica fume.

Its particles are about 100 times smaller than a cement particle on average. Silica fume is an extremely potent pozzolanic material due to its extreme fineness and high silica content. To enhance the properties of concrete, silica fume is used. As a result of its improved compressive strength, bond strength, and abrasion resistance as well as its reduced permeability, silica fume has been found to help shield reinforcing steel from corrosion.

V. METHODOLOGY

Methodology of conventional and Poly-Propylene fiber concrete

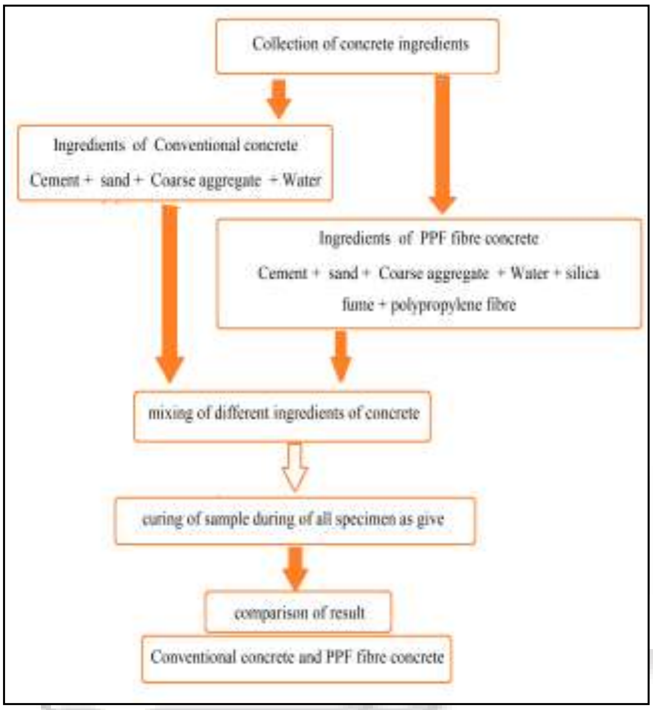

Fig. 11: Flow Chart of Methodology

The present study consists of an experimental study of polypropylene fibre in the development of the mechanical properties of concrete. The experimental method entails casting cubes (150mm x 150mm x 150mm), cylinders (15cm diameter and 30cm long), and structural member beams (1.5m x 150mm x 200mm) for M25 and M30 grade concrete according to the Indian standard method to determine the compressive strength and flexural strength of concrete for different proportions of polypropylene fibre as 3 kg/m3, 4 kg/m3, and 5 kg/m3 (i.e. 0. Mix design procedure as per IS: 10262-2009 for M30 grade of concrete

VI. CONCLUSIONS

1) Polymer-modified concrete materials are a very promising group of new building materials. They have remarkable potential thanks to a wide range of interesting functions, properties and applications. Such materials can meet many of the needs of current and future construction work.
2) Structures in aggressive environments that are not accessible for repair or subject to shock, cyclic or dynamic loads can benefit from PMC.
3) The properties of individual polymers and polymer modified concrete were investigated by several researchers.
4) The high cost of polymers can limit the use of these materials in the repair and restoration of concrete structures for practical use. However, their use with other auxiliary chemicals can reduce their cost. Thus, this cost reduction may facilitate the use of polymer in concrete. Therefore, cheaper polymers can be made for this purpose. Further development of polymer concrete may lead to the general use of the material in additional infrastructure applications
5) PMC materials can be used in residential and other civil buildings.

REFERENCES

[1] Aravind Sai Yandrapati*and M. Anil Kumar (2021) "Experimental study on mechanical properties of polypropylene fiber reinforced concrete with silica fume" IOP Conf. Series: Materials Science and Engineering 1136 (2021) 012020 IOP Publishing doi:10.1088/1757-899X/1136/1/012020 Babar Ali a,*, Liaqat Ali Qureshi b, Rawaz Kurda (2020) "Environmental and economic benefits of steel, glass, and polypropylene fiber reinforced cement composite application in jointed plain" concrete pavement https://doi.org/10.1016/j.coco.2020.100437 Available online 22 August 2020 2452-2139/© 2020 Elsevier Ltd. All rights reserved.

[2] Ta-Yuan Han, Wei-Ting Lin, An Cheng, Ran Huang, Chin-Cheng Huang (2012) "Influence of polyolefin fibers on the engineering properties of cement-based composites containing silica fume" journal ISSN: 0261-3069 DOI 10.1016/j.matdes.2011.10.038.

[3] N. K. Amudhavalli , Jeena Mathew (2012) "EFFECT OF SILICA FUME ON STRENGTH AND DURABILITY PARAMETERS OF CONCRETE" International Journal of Engineering Sciences & Emerging Technologies, August 2012. ISSN: 2231 – 6604 Volume 3, Issue 1, pp: 28-35 ©IJESET 28

[4] Chetan K N,Kotresh,Nishath Anjum,Sumanjali (March 2008) " Experimental Study on Silica Fume Concrete with Addition of Glass Fiber" International Journal of Emerging Technology and Advanced Engineering Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 7, Issue 5,

[5] Abdullah A Almusallam, Hamoud Beshr,Mohammed Maselhuddin , Omar S.B. Al Amoudi "Effect of silica fume on the mechanical properties of low quality coarse aggregate concrete " , cement and concrete composite 26 (2004) 891-900.

[6] Umesh Sharma, Ankita khatri, Abhishek kanoungo "use of micro silica as additive to concrete state of art" International journal of civil engineering research volume 5 no 1 (2014).

[7] Vikash shrivastava, Rakesh kumar , Agarwal V.C, Mehta P.K. "Effect of silica fume and metakaoline combination on concrete "International journal of civil and structural engineering volume 2 , no 3 ,2012.

[8] Krishna Prasanna, Venkata Kiranmayi K "Steel slag as substitute for fine aggregate in high strength concrete" International journal of engineering research & technology vol. 3 issue 10 october 2014.
[9] P.S. kothai, Dr. malathy "Utilization of steel slag in concrete as a partial replacement material for fine aggregate".
[10] PreetiP.Patel , Elizabeth George and deepasinha "Effect of silica fume on properties of concrete " BVM Engineering college , vallabhvidyanagar Anand Gujrat India.
[11] J.G. Cabrera, and Linsdale, C.J. "A new gas perameter for measuring the permeability of mortar and concrete." Magazine of concrete research 1988 (40), pp177-182.
[12] IS 10262-2009 Indian standard recommended guide lines for concrete mix design.
[13] IS 456-2000 Plain and reinforced concrete code of practice.
[14] Fulton F.S."The properties of Portland cement containing milled granulated blast furnace slag" Monograph , Portland cement institute , Johannesburg, 1974,pp 4-46.
[15] User guidelines for waste and byproduct material in Pavement construction publication Number: FHWA-RD-97-148.
[16] Verma ajay,chandakRajeev. "Effect of micro silica on the strength of concrete with OPC" International journal of scientific and engineering research volume 4 issue 1 january 2013.
[17] K Ganesh Babu and V.sreeramakumar "Efficiency of GGBS in concrete cement and concrete research vol ,30,2000,1036.
[18] Caijun Shi and Jueshi Qian "High performance cementing material from industrial slag" Resource conservation &Recyclin vol, 29,2000,195-207.
[19] A Oner & S Akyuz "An experimental study on optimum usage of GGBS for the compressive strength of concrete" Cement & Concrete Composite, Vol.29,2007,505-514.
[20] Sun S.S.Zhu G.L. Zhang Y "Application Technology of Iron and Steel Slag in China " China Waste steel vol 4 feb 2007 , pp 21-28
[21] Sobolev, K., "Mechano-chemical Modification of Cement with High Volumes of Blast Furnace Slag", Cement & Concrete Composites, Vol.27, 2005, pp848-853.
[22] Park, C.K., Noh, M.H. and Park, T.H., "Rheological Properties of Cementitious Materials Containing Mineral Admixtures", Cement and Concrete Research, Vol.35, 2005, pp842-849.

