iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 10 Issue: VIII Month of publication: August 2022

DOI: https://doi.org/10.22214/ijraset.2022.46463

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue VIII August 2022- Available at www.ijraset.com

Strength Evaluation of High Strength Concrete by Using Fly Ash and Silica Fume as A Partial Replacement of Cement

Piyush Kumar
M.Tech Scholar, Department of Civil Engineering, Mewar University

Abstract: Presently large amounts of fly ash are generated in thermal industries with an important impact on environment as well as humans. In recent years, many researchers have established that the use of supplementary cementitious materials like fly ash (FA), GGBS, blast furnace slag, silica fume, metakaolin, and rice husk ash, hypo sludge etc. can, not only improve the various properties of concrete, but also can contribute to economy in construction costs. This research work describes the feasibility of using Fly ash and Silica Fume as partial replacement of cement. The cement has been replaced by fly ash accordingly in the range of 0%, 10%, 20%, 30%, 40%, 50%, and 60% by weight of cement and 10% of silica fume in common for M30 grade of Concrete. Concrete mixtures produced, tested and compared in terms of compressive strength and split tensile strength with the conventional concrete for 7, and 28 days. It is found that, 30% of fly ash and 10% of silica fume can be replaced and good strength obtained is comparable to the conventional concrete mix.

Keywords: Fly Ash, Silica Fume, Compressive Strength, Split Tensile Strength, Waste Utilization, Durability

I. INTRODUCTION

Concrete is the secondary most widely used material after water and over six milliard tons of concrete is produced each year. Concrete is specific to separate approach like new construction, repair, rehabilitation and retrofitting. Concrete building components in separate sizes and shapes include wall panels, doorsills, beams, pillars and more. Post-tensioned slabs are a select method for industrial, commercial and residential floor slab construction. It makes sense to order the uses of concrete on the basis of where and how it is manufacture, together with its techniques of application, since these have different requirements and properties.

Concrete's versatility, durability, supportable, and economy have made it the world's most widely used construction material. About four tons of concrete are manufacture per person per year worldwide and about 1.7 tons per person in the United States. The term concrete mentioned to a mixture of aggregates, usually sand, and either gravel or crushed stone, held together by a binder of cementitious paste.

II. LITERATURE REVIEW

Krishan Kumar, et al (2019) in this investigation experimental program was carried out to study the utilization of fly ash for enhancement in properties of materials and technology. Cement content is replaced by fly ash according to the range of 0%, 10%, 20%, 30%, 40% and 50% by weight of cement for M35 design mix with 0.43 water cement ratio and analyzed on different parameters. The experimental results show that the use of 30% fly ash and 70% of cement provides a good performance in terms of compressive strength when compared with the cement having no fly ash content.

Vallabuni, Sandeep, et al (2018) this paper attempts the investigation on the use of fly ash in cement concrete industries. In developed countries use of mineral admixtures such as fly ash and silica fume and rise husk ash etc., has already adopted in making concrete. An investigation was undertaken to study the effects of fly ash in concrete. Cement replacement levels by fly ash were 0, 20, 30, 40, 50 and 60 percent are proposed for analysis in this project work. As quality criteria, Compressive strengths of cubes at the ages of 3, 7, and 28, days were determined as per the normal Code practices. The results are presented in the relevant tables and graphs. The performance of the designed mixes using fly ash content is good enough and the results are presented for kind recommendation to the various cement concrete industries.

Soma Gorai (2017) studied that industrial waste creates significant environmental problems when released into the atmosphere. In the past, vast majority of the material generated each year was held in ash dams or similar dumps but in recent years a number of technologies have been developed for the beneficial utilization of fly ash in different fields.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue VIII August 2022- Available at www.ijraset.com

The utilization of fly ash in construction, mine back fill, road sub-base, agricultural field, paints, wood substitute composites and also as a low-cost adsorbent for the removal of organic compounds.

Yadav et al (2017) this experiment study is aimed to investigate the physical, chemical and mechanical properties of fly ash cement concrete for road construction. From research, it has been observed that the use of 30% of fly ash and 70% of cement possess a superior performance. Moreover, in construction, the use of fly ash would result in the reduction of the cost of materials and the reduction of greenhouse gas emission.

High strength of concrete can be prepared and the incorporation of admixture or substitute to improve the properties of concrete. Test result of specimens indicates the bonding strength of properties, workability, and different reaction when the water ratio a change its content.

Slump test having an appropriate workable mixing the slump of a concrete, gave sufficient compressive strength.

Dr.S.Sundararaman1, et al (2016) studied that feasibility of using the thermal industry waste in concrete production as partial replacement of cement.

Fly ash and silica fume can be used as filler and helps to reduce the total voids content in concrete. The cement has been replaced by fly ash accordingly in the range of 0%, 25%, 30%, 35%, 40%, 45%, 50%, 55% and 60% by weight of cement and 10% of silica fume in common for M30 mix. Concrete mixtures produced, tested and compared in terms of compressive and split tensile strength with the conventional concrete for 3, 7, 28 days.

It is found that, 50% of fly ash and 10% of silica fume can be replaced and strength obtained is comparable to the conventional concrete.

Chatterjee, et al (2011) reported that about 50 % of fly ash generated is utilized with present efforts. He also reported that, one may achieve up to 70% replacement of cement with fly ash when high strength cement and very high reactive fly ash is used along with the sulphonated naphthalene formaldehyde super plasticizer. He reported improvement in fly ash property could be achieved by grinding and getting particles in sub microcrystalline range.

Namagg et al (2009) described early stages of a project to study the use of large volumes of high lime fly ash in concrete. Authors used fly ash for partial replacement of cement and fine aggregates. Replacement percent from 0% to 50% was tested in their study. They reported that concrete with 25% to 35% fly ash provided the most optimal results for its compressive strength. They concluded that this was due to the pozzolanic action of high lime fly ash.

III. MATERIAL AND EXPERIMENTAL METHODOLOGY

A. Cement

The Ordinary Portland cement of 43-grade was used in this study conforming to IS: 12269-1987. The specific gravity of cement is 3.15. The initial and final setting times were found as 35 minutes and 178 minutes respectively. Standard consistency of cement was 30.5%

B. Fine Aggregate

The river sand is used as fine aggregate conforming to the requirements of IS: 383-1970, having specific gravity of 2.62 and fineness modulus of 2.86 has been used as fine aggregate for this study. Fineness modulus of above fine aggregate is 2.82, which indicate that it is medium Sand.

C. Coarse Aggregate

Coarse aggregate is stone which are broken into small sizes and irregular in shape. Aggregate which has a size bigger than 4.75 mm or which retrained on 4.75 mm IS Sieve are known as coarse aggregate.

The coarse aggregate was locally available having size passing through 20mm sieve and its fineness modulus was 2.89, specific gravity and water absorption of coarse aggregate was 0.8 and 2.62 respectively.

D. Fly Ash (FA)

Fly ash is produced from burning of coal in thermal power stations. It is the lighter material and collected either by mechanical or by electrostatic precipitator.Fly ash is a fine gray powder include mostly of spherical, glassy particles that are produced as a byproduct in coal-fired power stations. Fly ash acts with lime to form cementitious compounds. It is commonly known as additional cementitious material.

Table 3.4.1: Physical properties of fly ash

S. No.	Property	Value
1.	Mean grain Size (microns)	20
2	Specific gravity	2.38
3	Color	Greenish

E. Silica Fume (SF)

Silica fume (SF) is a derivative of the smelting process in the silicon and ferrosilicon industry. The by-product of the production of ferrosilicon alloy having 50% silicon has much lower silica content and is less pozzolanic. Therefore, SiO2 content of the silica fume is related to the type of alloy being produced. Silica fume has been acknowledged as a pozzolanic admixture that is effective in increasing the mechanical properties to a great extent. Silica Fume was obtained from Elkem India (P) Ltd., Indore conforming to ASTM C 1240 as mineral admixture in dry densified form. The specific gravity of silica fume is 2.2.It consists of 0.1 to 1 micron sized fine, smooth spherical glassy particles with fineness of $20m^2/gm$ conforming to ASTM C1240-1999 standards.

F. Water

Potable water used for casting specimens according to IS: 456-2000. Tap water of Base Camp was used for casting the specimens. The temperature of water at the time casting was approximate 27^0c.

G. Experimental Methodology

Mix Proportions

In this study, control mix specimen was designed as per IS: 10262:2009 to achieve M30 (1:1.173:2.418) grade of concrete mixes of different Fly ash levels (0% to 60% replacement of cement) and silica fume of 10% with w/c ratio of 0.45 were prepared. A total of 27 concrete cubes and 27 cylinders were casted for the different percentages of replacement of cement with fly ash and Silica Fume. The specimens were demoulded after 24 hours and curing was done for different age of testing. After that the test results were obtained at 7 and 28 days

Table 3.7.1: Details of Mix Proportion of M30 Grade of Concrete

Grade Designation	Cement Replacement (%)	Cement (kg)	Coarse aggregate(kg)	Fine Aggregate(kg)	Fly ash (kg)	Silica Fume (kg)
Control Mix	0	479	1158.7	561.96	0	0
10FA10SF	10	426.31	1158.7	561.96	47.9	4.79
20FA10SF	20	373.62	1158.7	561.96	95.8	9.58
30FA10SF	30	320.93	1158.7	561.96	143.7	14.37
40FA10SF	40	268.24	1158.7	561.96	191.6	19.16
50FA10SF	50	215.55	1158.7	561.96	239.5	23.95
60FA10SF	60	162.86	1158.7	561.96	287.4	28.74

IV. RESULT ANALYSIS AND DISCUSSION

A. Compressive Strength Test Result

The compressive strength of concrete cube was determined based on IS: 516-1959(2). The specimen was placed in the compressive testing machine in such a manner that the load applied should be to the opposite sides of the cubes as cast, that is not to the top and bottom. The compressive strength test is conducted in the compressive testing machine of 2000kN capacity. The specimen used was 150 mm x 150 mm x 150 mm cube. The test result was performed at 7 & 28 days. The following figure and table shows the compressive strength of cube and figure shows the compressive strength results after 7 Days.

Table 4.1: Compressive strength of cubes 7 and 28 Days (N/mm^2)

Grade Designation	% Replacement of fly ash	Compressive Strength at 7 Days	Compressive Strength at 28 Days
Control Mix	0	25.85	37.56
10FA10SF	10	31.57	35.87
20FA10SF	20	25.37	38.13
30FA10SF	30	28.80	40.79
40FA10SF	40	25.89	38.92
50FA10SF	50	21.68	33.45
60FA10SF	60	14.79	25.46

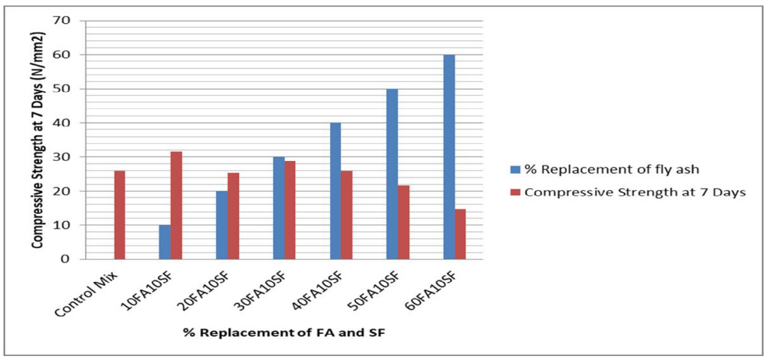

Fig 4.1.1: Graphical Arrangement of Compressive Strength at 7 Days (N/mm2)

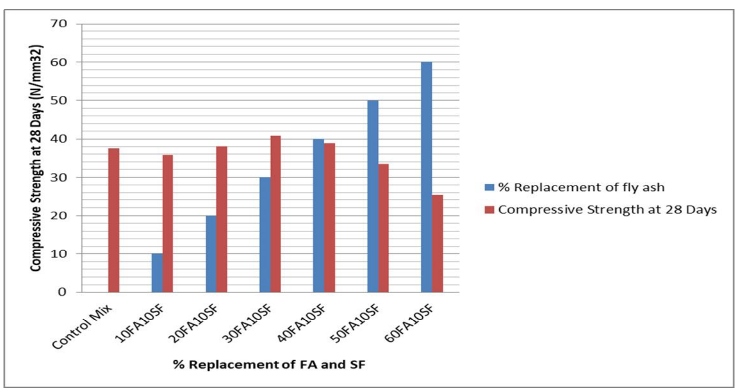

Fig 4.1.2: Graphical Arrangement of Compressive Strength at 28 Days (N/mm2)

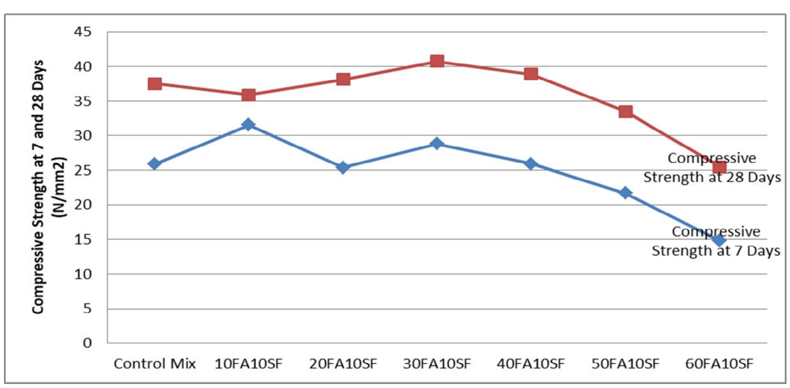

Fig 4.1.3: Graphical Arrangement of Compressive Strength at 7 and 28 Days (N/mm2)

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue VIII August 2022- Available at www.ijraset.com

B. Split Tensile Test

The split tensile strength results of mixes at the age of 7 and 28 days for different replacement levels such as 0%, 10%, 20%, 30%, 40%, 50% and 60% of cement with Fly ash and 10% Silica Fume with Cement. Split tensile strength test, a loading rate of 2.5 kN/s was applied as per IS: 516-1959(2). The specimen used was 150 mm diameter and 300 mm height. The test was performed at 7 and 28 days.

Table 4.2: Split Tensile Strength after 7 and 28 days (N/mm2)

Grade Designation	% Replacement of fly ash	Split Tensile Strength at 7 Days	Split Tensile Strength at 28 Days
Control Mix	0	16.48	20.35
10FA10SF	10	15.25	18.85
20FA10SF	20	13.95	18.05
30FA10SF	30	11.55	15.05
40FA10SF	40	10.47	13.87
50FA10SF	50	9.48	10.49
60FA10SF	60	7.84	7.98

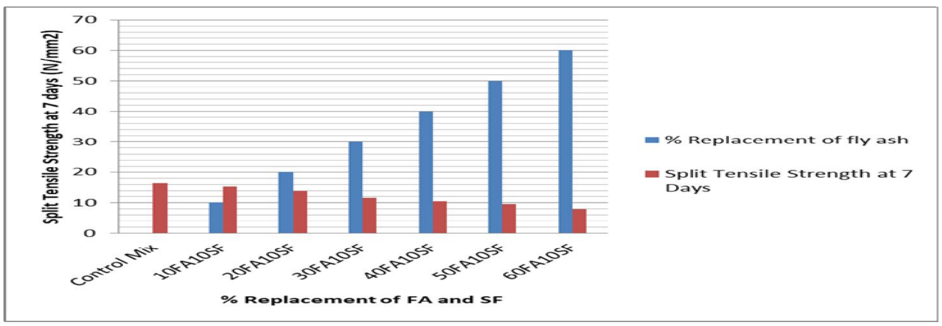

Fig 4.2.1: Graphical Arrangement of Split Tensile Strength at 7 Days (N/mm2)

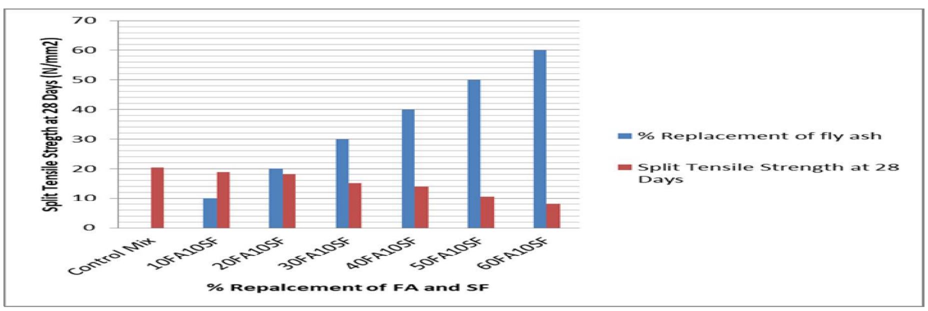

Fig 4.2.2: Graphical Arrangement of Split Tensile Strength at 28 Days (N/mm2)

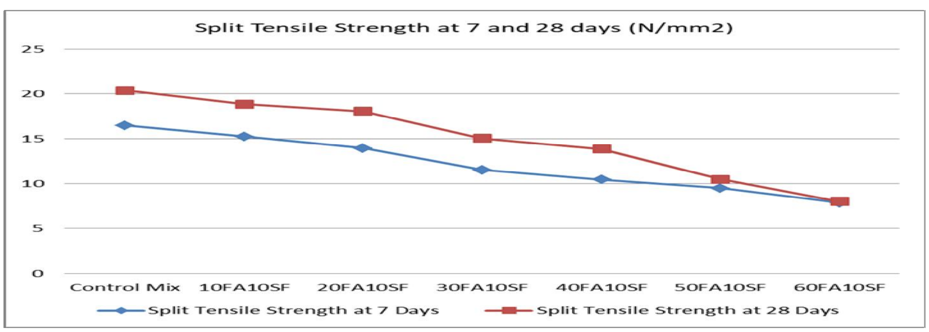

Fig 4.2.3: Graphical Arrangement of Split Tensile Strength at 7 and 28 Days (N/mm2)

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue VIII August 2022- Available at www.ijraset.com

V. CONCLUSION

The experimental work on the partial replacement of cement with fly ash and Silica Fume in the M30 grade of concrete with different replacement levels such as 0%, 10%, 20%, 30%, 40%, 50% and 60% of cement with Fly ash and 10% Silica Fume with Cement. The compressive strength graph shows that as the fly ash content increases the compressive strength also increases up to 20 to 30% and above 30%, it decreases.

Based on the experimental work the percentage of fly ash replaced to cement with varying percentage from 10% to 60% and 10 % Silica Fume replaced to cement the following results were drawn.

1) With 10% of fly ash the compressive strength at the end of 7 and 28 days 31.57 and 35.87 N/mm2 respectively.
2) A similar increase in the compressive strength was observed when the fly ash is increase till 30% (40.79N/mm2 at 28 days).
3) The compressive strength at the end of 28 days decreases when the fly ash percentage is increased upto 30%. However the compressive strength of M30 concrete at the end of 28 days for 50% replacement of fly ash is 33.45 N/mm2
4) The compressive strength showed a steep decrease when the fly ash percentage is increased beyond 50%
5) With 10% of fly ash the split tensile strength at the end of 7 and 28 days 15.25 and 18.25 N/mm2 respectively.
6) A similar increase in the split tensile strength was observed when the fly ash is increase till 30% (15.05 N/mm2 at 28 days).
7) The split tensile strength at the end of 28 days decreases when the fly ash percentage is increased beyond 30%. However the split tensile strength of M30 concrete at the end of 28 days for 50% replacement of fly ash is 10.49 N/mm2

REFERENCES

[1] Updated on: 19/07/2016, ENVIS Centre on Fly ash, http://cbrienvis.nic.in/Database/flyashgeneration.html.
[2] Report on fly ash generation at coal/lignite based thermal power stations and its utilization in the country for the year 2015-16, Central Electricity Authority, New Delhi, October, 2016
[3] Department of Forests, Ecology and Environment, Government of Karnataka. Parisara Envis News Letter 2 (2007) 6.
[4] N.S. Pandian, S. Balasubramonian, J. Testing Eval. 28 (2000) 44.
[5] Kaviya, K., & Chamundeeswari, J. (2015). Utilisation of fly ash and fibre in concrete. Indian Journal of Science and Technology, 8(32), 1–7.
[6] Rohman, Rosyid, K., & Aji, S. (2014). Effect of fly ash on compressive strength of concrete containing recycled coarse aggregate. 020097-1-020097–6.
[7] AbhijeetBaikerikar, “A Review on Green Concrete,” Journal of Emerging Technologies and Innovative Research,”vol. 1, Issue 6, Nov. 2014, pp. 472-474.
[8] Jayeshkumar Pitroda, L.B. Zala and F.S. Umrigar, “Experimental Investigations on Partial Replacement of Cement with Fly Ash in Design Mix Concrete,” International Journal of Advanced Engineering Technology, vol. 3, Issue 4, Oct.-Dec. 2012, pp. 126-129.
[9] Karma Wangchuk, KelzangTsheten, KingaYezer, Loday, “Green Concrete for Sustainable Construction,” International Journal of Research in Engineering and Technology, vol. 2, Issue 11, Nov. 2013, pp. 142-146.
[10] A. Krishnamoorthi, and G. Mohan Kumar, “Properties of Green Concrete Mix by Concurrent use of Fly Ash and Quarry Dust,” IOSR Journal of Engineering, vol. 3, Issue 8, Aug. 2013, pp. 48-54.
[11] Monica C. Dhoka, “Green Concrete: Using industrial waste of marble power, quarry dust and paper pulp,” International Journal of Engineering Science Invention, vol. 2, Issue 10, Oct. 2013, pp. 67-70.
[12] Nabil Bouzoubaa, Benoit Fournier, V. Mohan Malhotra, and M. Golden, “Mechanical properties and durability of concrete made with high volume fly ash blended produced in cement plant,” ACI Material Journal, vol.99, pp. 560- 567.
[13] M. Shahulhameed and A. S. S. Sekar, “Properties of Green Concrete Containing Quarry Dust and Marble Sludge Powder as Fine Aggregate,” APRN Journal of Engineering and Applied Sciences, vol. 4, Issue 4, June 2009, pp. 83- 89.
[14] K. Perumal, R. Sundararajan, “Effect of partial replacement of cement with silica fume on the strength and durability characteristics of high performance concrete”29th Conference on Our World In Concrete & Structures, Singapore 2004.
[15] Dr.S.Sundararaman1, S.Azhagarsamy, “Partial Replacement of Cement with Fly Ash and Silica Fume for Sustainable Construction” International Research Journal of Engineering and Technology (IRJET) Volume: 03 Issue: 05, May-2016
[16] I.S: 10262 – 2009, Indian standard recommended guidelines for concrete mix Design, B.I.S., New Delhi.
[17] I.S: 1199-1959, Indian Standard Methods of Sampling and analysis of concrete. Bureau of Indian Standards, New Delhi.
[18] I.S: 2386-1963, Methods of Test for aggregates for concrete - Part 3: Specific gravity, Density, Voids, Absorption and Bulking, Bureau of Indian Standard, New Delhi.
[19] I.S: 5816: 1999, methods of tests for splitting tensile strength of concrete.
[20] ACI 211.4R-93 ‘Guide for Selecting Proportions for High-Strength Concrete with Portland Cement and Fly Ash’, Reported by ACI Committee 211.
[21] Indian Standard Designation IS 516-1959, ‘Methods of Test For Strength of Concrete’ BIS, New Delhi, 2002.
[22] Indian Standard Designation IS 13311 (Part 1)- 1992, ‘Methods of Non Destructive Testing of Concrete’ BIS, New Delhi,2002
[23] Ramezanianpour .A.A, Mazloom .M and Brooks .J.J (2004) ‘Effect of silica fume on mechanical properties of high-strength concrete’, Cement & Concrete Composites, Vol.26, pp.347–357.
[24] Vahid Afroughsabet .A and Togay Ozbakkaloglu (2015) ‘Mechanical and durability properties of high-strength concrete containing steel and polypropylene fibers’, Construction and Building Materials, Vol.94, pp.73–82.
[25] Brooks .J.J, Megat Johari .M.A and Mazloom.M(2000) ‘Effect of admixtures on the setting times of highstrength concrete’, Cement and Concrete Composites, Vol. 22, pp. 293-301.

[26] Limbachiya .M.C, Leelawat .T and Dhir.R.K(2000) 'Use of recycled concrete aggregate in high-strength concrete', Materials and Structures/Matiaux et Constructions, Vol. 3, pp 574-580
[27] ACI 211.4R – 93, "Guide for selecting proportions for High Strength Concrete with Portland cement and Flyash", Reported by ACI Committee 211, (Reapproved 1998).
[28] A.R. Hariharan, A.S. Santhi, and G. Mohan Ganesh, "Study on Strength Development of High Strength Concrete containing Fly ash and Silica fume", International Journal of Engineering Science and Technology, Vol.3, No.4, pp. 2955-2961, 2011.
[29] IS: 516-1959, "Methods of Tests for Strength of Concrete", Bureau of Indian Standards, New Delhi, India, (Reaffirmed 1997).
[30] IS 383-1970, "Specification for Coarse and Fine Aggregate from Natural Sources for Concrete." Bureau of Indian Standards, New Delhi, India, (Reaffirmed 1997).
[31] IS 9103-1999, "Concrete Admixtures – Specification." Bureau of Indian Standards, New Delhi, India.
[32] Joshi, "Evolution of HPC mixes containing silica fume." The Indian Concrete Journal, Vol.75, No.10, pp. 627-633, 2001.
[33] R. Malathy, K. Subramanian, and M. Rameshkumar, "Effect of Glass fibres on Restrained Plastic Shrinkage Cracking of HPC with Silica Fume." Journal of Scientific & Industrial Research, Vol.66, pp. 748-751, 2007.
[34] Neville, Properties of Concrete, 4th and final edition, Pearson education Asia Private Limited, England, 2000.
[35] P. Vinayagam, "Experimental Investigation on High Performance Concrete using Silica fume and Superplasticizer", International Journal of Computer and Communication Engineering, Vol.1, No.2, pp. 168-171, 2012.
[36] S. Kou, C. Poon, and F. Agrela, "Comparisons of natural and recycled aggregate concretes prepared with the addition of different mineral admixtures," Cem. Concr. Compos., vol. 33, no. 8, pp. 788–795, 2011, doi: 10.1016/j.cemconcomp.2011.05.009.
[37] M. Valipour, F. Pargar, M. Shekarchi, and S. Khani, "Comparing a natural pozzolan, zeolite, to metakaolin and silica fume in terms of their effect on the durability characteristics of concrete: A laboratory study," Constr. Build. Mater., vol. 41, pp. 879–888, 2013, doi: 10.1016/j.conbuildmat.2012.11.054.
[38] Ö. Eren and T. Çelik, "Effect of silica fume and steel fibers on some properties of high-strength concrete," Constr. Build. Mater., vol. 11, no. 7–8, pp. 373–382, 1997, doi: 10.1016/S0950-0618(97)00058-5.
[39] M. . Alexander and B. . Magee, "Durability performance of concrete containing condensed silica fume," Cem. Concr. Res., vol. 29, no. 6, pp. 917–922, 1999, doi: 10.1016/S0008-8846(99)00064-2.
[40] M. Mazloom, A. A. Ramezanianpour, and J. J. Brooks, "Effect of silica fume on mechanical properties of high-strength concrete," Cem. Concr. Compos., vol. 26, no. 4, pp. 347–357, 2004, doi: 10.1016/S0958-9465(03)00017-9.