The Major Project- II

On

Comparing Strength Properties of Polypropylene Concrete with Fly ash as Cement and/or Sand replacement

Submitted In Partial Fulfillment for the Award of the Degree of

MASTERS OF TECHNOLOGY

IN

CIVIL ENGNEERING

With Specialization In

STRUCTURAL ENGINEERING

By

Tikam Chand

(Roll No. 2K13/STE/19)

Under The Guidance of

Prof. A. K. Gupta

Department of Civil Engineering

DELHI TECHNOLICAL UNIVERSITY, DELHI

DELHI TECHNOLOGICAL UNIVERSITY, DELHI

CERTIFICATE

This is to certify that this report entitled **"Comparing Strength Properties of Polypropylene Concrete with Fly ash as Cement and/or Sand replacement"** is an authentic report of the major project part-II done by Mr. **Tikam Chand (Roll no. 2k13/STE/19)**. This is a bona fide record of students own work carried by him under my guidance and supervision in partial fulfillment of the requirement for the award of the Degree of Master of technology in Structural Engineering by Delhi Technological University of Delhi.

The matter embodied in this report has not been submitted for the award of any other degree

Dr. A. K. Gupta

ACKNOWLEDGEMENT

I take this opportunity to express my deep gratitude to all people who have extended their cooperation in various ways during the course of this study. It is my pleasure to acknowledge the help of those individuals.

I would like to express my sincere and heartfelt gratitude to my guide, well-wisher and supervisor Dr. **A.K.Gupta**, for his valuable guidance, inspiration and encouragement during various stages of this project work and immense assistance provided in the preparation of this report. I would like to thankful to my HOD of Civil Engineering Department Dr. **Nirendra Dev** for his valuable guideline, inspiration during project work.

Special thanks are extended to the D. T. U., College Bawana road, New Delhi, India, for providing materials and equipment for performing tests.

All cement, fly ash, polypropylene fiber chemical and microscopic studies were obtained from various journals, whose details are specifically provided.

The authors would like to acknowledge lab assistants for their assistances at Concrete lab and transportation lab, Department of Civil Engineering.

Finally, I would like to thank some seniors pass out and classmates) at D.T.U. who helped in this project. This project might not have been completed on schedule without their support.

TIKAM CHAND

(2K13/STE/19)

(ii)

DELHI TECHNOLOGICAL UNIVERSITY, DELHI

DECLARATION

I hereby declare that the work in this Project Report entitled "**COMPARING STRENGTH PROPERTIES OF POLYPROPYLENE CONCRETE WITH FLY ASH AS CEMENT AND/OR SAND REPLACEMENT"** is bona fide record of work carried out by me as a part of major project-II in partial fulfillment for the Master of Technology in Structural Engineering.

I have not submitted the matter presented in this report for the award of any other degree.

TIKAM CHAND
M.Tech (Structural Engineering)
2K13/STE/19
Civil Engineering Department,
D. T.U., Delhi
New Delhi 110042

Abstract

Research on Fly ash has been done more than 10 years. Though Several researches have been done on the utilization and use of the fly ash in various fields such as construction material, fertilizer, adsorbent, embankment, road pavement etc. But still there is huge amount of fly ash has been disposing on land area which is coming through Coal burning process in electricity generation and various process. We need more options and ways to utilize the fly ash. Fly ash has binding properties which helps to utilizing it with cement in concrete. fly ash can be added up to a limit proportion of cement in concrete. Beyond this limit if we add more fly ash in concrete, the strength of concrete will decrease.

Polypropylene fibers are widely using in concrete industry are going very useful. Polypropylene fiber in concrete gives improvement in form of toughness, fatigue, impact resistance, permeability, shrinkage, and wear resistance.

In this report the main parameters are investigated for M40 grade concrete with use of polypropylene fiber, fly ash as Cement replacement and sand replacement. In this study, the effect of both parameter polypropylene fiber and fly ash in concrete are evaluated. The combination of these parameters will give a new approach to more utilize the fly ash.
The result shows that along with 0.30% of popropylene fiber gives improved strength properties as The use of fly ash as sand replacement along with polypropylene fiber also gives better strength than other proportions. Hence it could provide a commercial feasibility for the fly ash disposal and useful for extra utilization of fly ash.

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CHAPTER 1

INTRODUCTION

1. Introduction

Human Safety is one of the considerations in the design of residential, public and industrial.

Currently in India, it is estimated that the annual consumption of cement concrete is to 1.6 billion metric tons. This will obviously cause a demand on the materials like sand, aggregates and other materials required to produce huge quantity of cement concrete. This will naturally cause depletion of all the natural resources connected in producing cement concrete every year. The production of huge quantities of cement requires large amount of energy, cause emission of CO_2 and make problems. Therefore we are concentrating on finding out the supplementary cementatious materials which can replace cement partially or fully and which can also replace sand and other ingredients. In this line of replacing cement partially some materials like fly ash, silica fume, furnace slag and metacaoline have shown improve results.

Gel. It is the Calcium Hydroxide $Ca(OH)_2$, Which is generally referred to as Free Lime in construction industry. This free lime is available for attacking by reactive environmental substances like water, sulphates, CO_2 and

So it can be useful as Pozzolanic effect. Once it is started, it can go on and on. In simple words, Fly ash is useful for much longer life for concrete structure.

However, increasing shortage of natural fine aggregates in concrete at present has lead to search for alternate sources for its replacement. From recent years fly ash is used as replacement of cement, as an admixture in concrete and in manufacture of cement. Thus there are some industrial wastes are effectively utilized in the production of concrete. Much more studies have been done on fly ash as cement replacement by earlier researchers.

Common physical problems of concrete like cracking, low tensile strength brittleness restrict their application in many places. To improve these problems, there are some materials which are added to concrete. This concrete is called as high performance concrete.

The performance, aestheticism, duration and strength of the concrete servicing or profiting capability are reduced.

Concrete is strong in compression and weak in tension. This is when the OPC is widely used in cement. if there is some possibilities of using fiber (reinforcement) in concrete, tensile strength can be increased.

Fibers which are used as reinforcement in concrete are very useful for controlling the paste contract. So it gives more duration and resistibility to concrete in the short time of structural utilization. This method is best for preventing cracks.

Whether in ordinary concrete, vibration is necessary. Among all type of fibers, Polypropylene fibers have hydrophobic levels to protect them against wetting with cement paste (which reduce workability) in fresh concrete. Due to this hydrophobic nature of polypropylene fiber, there is no need of extra amount of water in concrete.

The physical properties of different types of fibers are listed in Table 1.

Table 1.1 Properties of different fibers

“

Type	Specific gravity	Tensile strength(Mpa)	$E(GN/m^2)$	Elongation at failure	Common V (%)
Polypropylene	0.91	550-700	3.5-6.8	21	<2
Steel	7.86	400-1200	200	-3.5	<2
Glass	2.7	1200-1700	73	-3.5	4-6
Asbestos	2.55	200-2000	159	2-3	7-18
Concrete for comparison”	2.4	2-6	20-50		

CHAPTER 2

LITERATURE REVIEW

2. Literature review

2.1 Cement

The calcium oxide should be greater than 2 times of SiO_2. The MgO_2 content shall not exceed 5.0% by mass of cement.

In solid waste management, there is good option to solve problem by replace natural raw material of concrete. This utilization or consumption of waste product will give benefits to the industries. These benefits are technically and economically both.

In recent years, several studies gave the power or knowledge to civil construction as a suitable recipient of various types of recycled wastes like fly ash, blast furnace slag which are now considered secondary raw materials.

2.2 Polypropylene Fiber

Concrete have less spalling behavior, so this behavior can improve by using of fiber in concrete. Generally there are two type of fiber are used in concrete, one is Steel fiber and other one is Polypropylene fiber.

Paste contracting in fresh concrete is formed when movement of emulsion to the surface is lesser than acceleration of water evaporation from the surface of concrete. Due to this contracting, negative pressure is formed in capillaries. Tension stress is formed during the process of concrete strengthening (converting fresh concrete to hard concrete). At a particular point concrete will crack when strength of concrete is less than tension stress.

These cracks are form in first hours after pouring. Sometimes these cracks may harmful to the concrete and may cause a failure to concrete. These cracks may increase the process of corrosion of concrete and deteriorate the internal part of concrete.

Advantages of polypropylene fiber are easy process ability, almost zero water absorption, low specific gravity and good chemical resistance.

2.3 Fly Ash

Fly ash which is also known as flue-ash, is the residue generated in combustion of coal. This ash has fine particles that rise with gases. There is another type of gas in which ash does not rise, is called as bottom ash. Rise ash is generally captured by electric precipitator in chimney. This chimney has very long height for capturing residue of the combustion of coal. This ash is most probable generate at coal power plant so it is called as coal ash. In power plants both type of ashes bottom ash and fly ash are called as coal ash

The chemical and physical properties of fly ash vary according to source of coal and process of burning. But all types of sources have generally silicon dioxide (SiO2) and calcium oxide (CaO), so fly ash generally includes amorphous and crystalline form of silicon dioxide (SiO2). Both oxides are endemic ingredients in many coal-bearing rock strata.

Previous years before, waste product fly ash was generally released freely into the atmosphere, but now a day's pollution control equipment mandate that it be captured prior to release. It is essential requirement from the pollution control equipment mandate.

Fly ash is generating widely in India, from which about 55% is recycled. Generally this fly ash is recycled in concrete production as supplement of Portland cement. The recycling of fly ash has become an important to increase in recent years. This is because of increasing of the cost of landfill. Current interest in sustainable development is also cause of increasing recycling. According to detail of CEA annual report 2011, Coal-fired power plants in India producing nearby 135.1 million tons of fly ash (coal ash) per annum, from of which only 73 million tons were reused in various different applications like cement replace, road construction and bricks etc. If we try something to reuse of 100 million tons fly ash recycle, it would have reduced the need landfill space for 65,900,000 m3 approximately. It will reduce the demand for new and lack materials. Substitution of raw material will give energy to cement production. There are two type of fly ash which is described below.

2.3.1 Class F Fly ash

Class F fly ash is typically produce by burning of hard, old anthracite and bituminous coal. This type of fly ash is generally gives pozzolanic effect and it contains less amount of lime as compare to Class C fly ash. Lime in the Class F fly ash is less than 20%. Although there is high percentage amount of silica(SiO_2) and alumina($Al_2 O_3$) in class F fly ash. This type of fly ash (Class F) is not a self cementing ash. This type of ash need some other type of cementing agent like Portland cement, or hydrated lime (quick lime) for make cementing compound. This reaction takes place in presence of water. Alternatively, geopolymer is made by class F fly ash with the additions of a chemical substance activator such as sodium silicate or water glass.

The chemical and physical difference (which cannot see by naked eye) between fly ash and Portland cement can be found out under a microscope. From the microscope view it is noted that the Fly ash particles are spherical in shape. These spherical particles give workability to concrete to flow mix easily. That capability action is also one of the important properties making fly ash a one of the good admixture as water reducer for concrete.

2.3.2 Class C fly ash

First thing in Class C fly ash is that it has high amount of lime. Lime percentage are in this type of ash is more than 20 %. This type of ash is generally produced by burning of bituminous coal and young lignite. This type of ash does not need any other cementaneous substance as it already has some kind of pozzolonic properties. This can be said as self cementing qualities. It can be said that it has some kind of self-cementing properties. Due to its cementing nature this fly ash got hard (solid) and gain strength after some time in the presence of water. Due to production of this ash is gain from young lignite and bituminous so this type of ash has alkali in nature.

Many studies have been conducted with utilization and reuse of fly ash. Fly ash is a waste material of thermal coal power plants (generally). It is widely used in civil engineering. Currently fly ash is using in various sections in civil engineering like concrete production, as a replacement material for Sand and Portland cement. Fly ash is also useful for making pozzolana cement and it is used for filling purposes like Embankments and other structural fills like road construction. It is using for Stabilization of the waste and its solidification. It is using in production of cement clinker as clay replacement. Recently we noted that we are using fly ash as the reclamation of Coal mines and other mines. It is the Substitution for the clay in brick production and makes fly ash bricks. Fly ash is also used in many types of agricultural field as soil stabilization.

The mix use of fly ash as replacement and polypropylene fiber as various amounts in concrete also has been conducted/ studied recently. It is about fly ash is used as cement and sand replacement. Adding fiber is with respect to cement.

2.4 Previous Research

Andrade L.B and Rocha (2009) reported that porosity of fly ash is high so that the w/c ratio or w/b ratio of the concrete mix can't be taken as exact or fix.

"Chai Jaturapitakkul and Raungrut Cheerarot (2003) reported that fly ash has a high potential to convert to be a good pozzolanic material. RafatSiddique (2003) find out a brief investigation about mechanical properties of concrete in which fine aggregates was partially replaced with class F fly ash by weight.

Aggarwal P. and Aggarwal Y. (2007) reported that the workability of concrete decreased with the increase in bottom ash due to the increase in water demand. Trakool Aramraks (2006) reported that fly ash required water content 25 to 50% more than normal concrete to obtain suitable workability and permeability of fly ash concrete is better than normal concrete".

Qi and Weiss in 2003; Banthia and Gupta in 2006 have reported that finer Polypropylene fiber is more effective in reducing the width of plastic shrinkage cracking than coarser fiber. Kumar and his friends in 2012; Hasaba in 1984; Ramakrishnan in 1987 have reported that the compressive and tensile strength of the concrete reinforced with low volume of PP fiber are not significantly different from those of the unreinforced matrix. Some researchers (Hasaba in 1984; Banthia and Dubey in 1999; Banthia and Dubey in 2000 have reported that increase in flexural strength of concrete reinforced with PP fiber. There are Very limited works on concrete reinforced with fibrillated fibre are reported in literature.

2.5 Objective and approach

The purpose of this study was to check the effect of fly ash on concrete as a Cement replacement and sand replacement separately. The effects were to be checked with different properties of concrete like compressive strength, split tensile strength and impact strength. Fresh concrete property workability is to be checked whether it is decreasing or increasing.

The other purpose of this study was to investigate the effect of polypropylene fibers in concrete mixtures on material properties such as compressive strength, flexural strength, bond, toughness, and fatigue strength. The results of this investigation are used to develop recommended mixture proportions, construction procedure and quality control methods. The study includes an evaluation of current practice regarding the use of steel fibers in airport pavements as they pertain to the use of polypropylene fibers.

This study has done to investigate and inspect the combined effect of fly ash and polypropylene fiber in concrete mixtures and evaluate the strength and other properties of the concrete.

In present investigation, Workability and Strength Characteristics for Concrete mix of grade M40 by using with different fibers amounts varies from 0.20 %, 0.25%, 0.30% and admixture super plasticizer were investigated. With addition of fibers, the entrapped air voids increase and hence the increased air content reduces the workability causing difficulty in compaction of mixes. The fibers may also interfere and cause finishing problems. Fly ash is used as a cement or sand replacement in concrete for increase the performance of concrete. Fly ash is used as cement replacement as 5 %, 12.5%, 20% and fly ash sand replacement is were added 20%, 35%, 50%. Super plasticizer was also used. There is some difficulties may obtain while making concrete with fly ash as sand replacement in order to workability. This is due to water absorption of the fly ash in concrete which we are not assuming as blinder, so we are adding extra 8% water weight of fly ash added to concrete to incorporate the workability of fresh concrete.

The scope of the project involves various tests performed on the concrete.

- Test for compression of concrete in cube.
- Test for tensile as split tensile test.
- Test for impact as ACI Drop weight test

CHAPTER 3

EXPERIMENTAL WORK

3. Experimental work

3.1 Material

Cement for mix design M40, Ordinary Portland cement type I (OPC grade 43) was used. Polypropylene fiber is taken from Recron 3s from Reliance industries ltd. This polypropylene fiber has 12 mm length. Fly ash is taken from NTPC badarpur. Other Concrete constituets are taken from contractor at college main gate. The figure shows the sample of polypropylene fiber.

Figure 3.1 Sample Polypropylene fiber in laboratory

3.2 Experiments

3.2.1 Specific gravity test

Specific gravity of material is an important property which helps in determining the amount of material to be used. The specific gravity also affects the strength of concrete.

For example- specific gravity of cement would give us the proportion of cement to be used in the design mix. The specific gravity of cement is (mathematically) ratio of weight of a given volume of cement to the weight of equal volume of water. It is measured using density bottle. (Fig. 3.2)

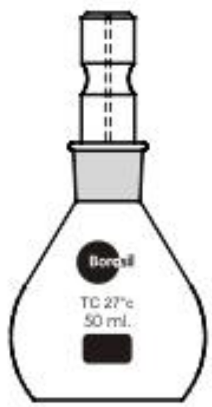

Figure 3.2 Density bottle for determine specific gravity

3.2.2 Sieve analysis

Sieve analysis of fine aggregates and coarse aggregates is very important for particle size distribution point of view. The code for sieve analysis is IS:2386(PartI)-1963. This code gives the information about performing the sieve analysis test, in which there are different numbers of sieve as standard sieve size. Aggregates are allow to pass through these sieves and give values of particle size and percentage finer.

3.2.3 Compression test machine

Testing Machine:

Figure 3.3 Compaction test machine

In the addition of Compression testing machine Split tensile test is also performed on compression test machine. This test is indirect test for determining tensile strength of concrete. This test is performed when direct tensile strength of sample of difficult to determine. So we preferred split tensile test.

In this test concrete cylinder is placed horizontally between two plates. A compressive line is allowed to apply constantly on the cylinder. Due to the compression loading near about uniform tensile stress is developed over 66% of the loaded diameter as obtained from an elastic analysis.

3.2.4 Impact test Machine (Drop weight test)

This test is performed under the provision of ACI-544(2r). The simple form of impact test in repeated impact is called as drop-weight test. This test can also be used to compare merits of different portions of fiber-concrete mixtures. In this test results are in form of number of blows required/need to cause prescribed levels of distress or stress/strain in the test sample (disk). The results shows estimate energy absorbed by the sample (disk) at levels of distress specified. Figure shows drop weight test machine.

Figure 3.4 Impact test Machine (Drop weight test)

Equipments:

(1) A hammer with weight of 4.54 kg use for compaction or impact load, it is used for 457-mm drop (ASTM D 1557),

(2) A steel ball (hardened steel) of approx. 63.5 mm diameter and a flat circular base plate with positioning bracket.

(3) In addition to this equipment, a mold to cast 152 mm diameter by 63.5 mm thick concrete specimens is needed.

3.3 Material properties

All materials coarse aggregate, fine aggregate and cement were tested for finding out their properties. Mix design is also prepared with M40.

3.3.1 Specific gravity tests

Specific Gravity of material used in concrete are given in following tables. It is property of material which is most useful to make mix design of concrete. We required specific gravity for OPC, fine aggregate and Coarse aggregate. We use pycnometer test for determining specific gravity of materials. For determining specific gravity of the fly ash we use density bottle test.

3.3.1.1 Specific gravity of fine aggregates

Specific gravity for fine aggregates are shown below table. Specific gravity of fine aggregate which is available in concrete lab is **2.66**

Table 3.1 Specific Gravity of fine aggregates

Sr. no.	Particulars	F.A. (gm)
1	Wt. of Pycnometer(W_1)	681.8
2	Wt. of pycnometer + material (W_2)	1150
3	Wt. of pycnometer + material+ distilled water W_3	1865.8
4	Wt. of pycnometer + distilled water(W_4)	1573.4
5	Specific gravity G = W_2-W_1 /[(W_2-W_1) – (W_3-W_4)]	2.66

3.3.1.2 Specific Gravity of Coarse aggregates

Specific gravity of Coarse aggregate is determined as **2.745**

Table 3.2 Specific Gravity of Coarse aggregates

Sr. no.	Particulars	C.A. (gm)
1	Wt. of Pycnometer(W_1)	681.8
2	Wt. of pycnometer + material (W_2)	1207
3	Wt. of pycnometer + material+ distilled water W_3	1907.27
4	Wt. of pycnometer + distilled water (W_4)	1573.4
5	Specific gravity G = W_2-W_1 /[(W_2-W_1) – (W_3-W_4)]	2.745

3.3.1.3 Specific Gravity of Cement

Specific gravity for the cement (OPC grade 43) is determined by pycnometer test with the help of kerosene. The specific gravity of Cement is shown in table.

Table 3.3. Specific Gravity of Cement

Sr. no.	Particulars	Cement(gm)
1	Wt. of Pycnometer(W_1)	681.8
2	Wt. of pycnometer + material (W_2)	1012.4
3	Wt. of pycnometer + material+ kerosene (W_3)	1471.74
4	Wt. of pycnometer + distilled water(W_4)	1250.5
5	Specific gravity $G = W_2 - W_1 / [(W_2 - W_1) - (W_3 - W_4)]$	3.170

3.3.1.4 Unit Weight of Bulk aggregates

The bulk unit weight of aggregates is required in mix design at some places. Bulk unit weight of fine aggregates and coarse aggregates is shown below table. Bulk unit weight of fine aggregate is determined as 1652 kg/m^3. Bulk unit weight of coarse aggregates is determined as 1608 kg/ m^3

Table 3.4 Unit Weight of Aggregates (Bulk)

Sr. no.	Particulars	Aggregate(gm)	Sand
1	Container with the material	14616	14840
2	Empty weight of container	6550	6550
3	Volume of container(cu cm)	5016.15	5016.15
4	Dry rodded density	1608	1652

Table 3.5 Specific gravity of Fly ash

Sr. no.	Particulars	Cement(gm)
1	Wt. of bottle(W_1)	22 gm
2	Wt. of bottle + flyash (W_2)	32 gm
3	Wt. of bottle + fly ash+ kerosene (W_3)	51.1 gm
4	Wt. of bottle + keorsine(W_4)	44.7 gm
5	Specific gravity G = W_2-W_1 /[(W_2-W_1) – (W_3-W_4)]	2.2

3.3.1.5 Specific Gravity of fly ash

Specific gravity of Fly ash is determined by bottle density test with the help of kerosene. The specific gravity of Fly ash is shown in table 3.5 above. The specific gravity of fly ash is determined as **2.2.**

3.3.2 Sieve Analysis Tests

Sieve analysis is required for determining fineness of aggregate. This also helps in determining % finer, C_u and C_c.

3.2.2.1 Sieve Analysis for Coarse aggregate

Sieve analysis for coarse aggregates is shown in table 3.6 below.

3.2.2.2 Sieve Analysis for Fine aggregate

Percentage finer and Sieve analysis for fine aggregate is shown 3.7 below.

Table 3.6 Sieve analysis for coarse aggregate

Sieve size (mm)	Wt. retained(gm)	% Wt. retained	Cumulative wt retained	% Finer	% passing ACI
20	260.1	5.2	5.2	94.8	92
16	1091.1	21.82	27.02	72.98	
12.5	2102.3	42.02	69.06	30.94	
10	1293.1	25.86	94.92	5.08	5
4.75	222.7	4.45	993.7	.63	0
Pan	30.7	.614	99.98		

Table 3.7 Sieve analysis for fine aggregate

Sieve size (mm)	Wt. retained(gm)	% Wt. retained	Cumulative wt retained	% Finer	Min limit ACI	Max limit ACI
4.75	30	3	3	97	95	100
2.36	124	12.4	15.4	84.6	80	100
1.18	255.6	25.5	40.9	59.10	50	85
600mic.	209.1	20.91	61.81	38.19	25	60
300mic.	164	16.40	78.21	21.79	10	30
150mic.	131.8	13.18	91.39	8.61	2	10
Pan	85	8.5	99.89			

3.4 Concrete Mix Design (Grade M40)

3.4.1 Design Stipulation:-

Target strength = 40 +(5*1.65) = 48.25Mpa

Max size of aggregate used = 20 mm

Dry rodded bulk density of fine aggregate = **1652Kg/m^3**

Dry rodded bulk density of fine aggregate = **1608 Kg/m^3**

Specific gravity of cement grade 43 = **3.16**

Specific gravity of fine aggregate (F.A.) is = **2.66**

Specific gravity of coarse aggregate (C.A.) is = **2.745**

Step-1 Calculation for Quantity of Water:

From **IS456- 2000** maximum water cement ratio can be taken as = 0.45

Let water cement ratio is = 0.36

From table no. 2 IS 456 maximum water content

for aggregate size 20mm is = 186 ltr(for slump of 25mm-50mm)

for 100 mm slump w = 197 ltr

From IS 10262-2009 as super plasticizer is used water reduced to 29%

W = 0.71*197 = 140 ltr

Step-2 Calculation for cement

From IS 456 Minimum Cement content is 320 kg and from water cement ratio cement content is taken 385 kg

Step-3 Calculation for weight of Coarse Aggregate:

Let Slump is 50 to 75mm and size of coarse aggregate is 20mm,

the Mixing water = 140 ltr.

As the water-cement ratio for mix is decrease by 0.10 due to above condition.

The proportion of volume of coarse aggregate is increased by 0.02 That's why corrected proportion of volume of coarse aggregate for the water-cement ratio of 0.36 is = 0.62

For pumping concrete value decrease by 10%

So volume of Coarse aggregate = 0.62*0.9* = 0.56

Volume of fine aggregate = 1 – 0.56 = 0.44

Step-4 Design Calculation for 1 m^3 Concrete Sample

Volume of Cement = 270 / 3.17*1000= 0.086

Volume of cementaneous material (if added) = 115/2.21*1000 = 0.052

Water = 140.28 / 1*1000= 0.1402

Volume of super plasticizer = 0.007

Volume of all aggregate = 1-(.0.086 + 0.140 + 0.052 + 0.007) = 0.715

Mass of coarse aggregate = 0.715*0.56*2.74 = 1097.09kg

Volume of Fine Aggregate= 0.715*0.44 = 0.3146

Weight of Fine Aggregate is = 0.2728*2.66*1000= 836.84 kg/m^3

3.4.2 Requirement of material for 1 m^3 Concrete Sample

Cement = 385 Kg/m^3

Fine Aggregate = 836.84 Kg/m3

Coarse aggregate = 1097.09 Kg/m^3

Water = 140 Kg/m^3

Super plasticizers = 7.7 ltr/m3

Amount of polypropylene fiber as % weight of cement

3.5 Sample Preparation with Different Proportion

In this research we made concrete of M40 grade. In which we add polypropylene fiber to make polypropylene concrete. In this polypropylene concrete fly ash was also added for improving strength and other properties. Fly ash class F was added in concrete as Cement and sand replacement separately.

3.5.1 Polypropylene concrete with fly ash as Cement replacement

Here table is showing different proportions of mixing polypropylene fiber and fly ash as cement replacements.

Table 3.8 Sample preparation of Polypropylene concrete with fly ash as Cement replacement

Fly ash % fiber %	0 % fly ash	5%	12.5%	20%
0.0 % fiber	C_{00}	C_{10}	C_{20}	C_{30}
0.20%	C_{01}	C_{11}	C_{21}	C_{31}
0.25%	C_{02}	C_{12}	C_{22}	C_{32}
0.30%	C_{03}	C_{13}	C_{23}	C_{33}

In this table C_{00}, $C_{01,}$ C_{02} and C_{03} has been prepared in major 1 project.

3.4.2 Polypropylene concrete with fly ash as sand replacement

Here table is showing different proportions of polypropylene fiber and fly ash as sand replacements. In the concrete with fly ash as sand replacement, we are facing difficulties in order to workability. So we add 8% extra water weight of the fly ash added to concrete. this will maintain workability and give strength as well as.

Table 3.9 Sample preparation of Polypropylene concrete with fly ash as Sand replacement

Fly ash % fiber %	0 % fly ash	20%	35%	50%
0.0 % fiber	S_{00}	S_{10}	S_{20}	S_{30}
0.20%	S_{01}	S_{11}	S_{21}	S_{31}
0.25%	S_{02}	S_{12}	S_{22}	S_{32}
0.30%	S_{03}	S_{13}	S_{23}	S_{33}

In this table S_{00}, S_{01}, S_{02} and S_{03} has been prepared in major 1 project. There are some samples of cubes, cylinders and disks are showing in figures which are casted in laboratory.

(a)

(b)

(c)

(d)

Figure 3.5. (a) Cube of code C_{61} (b) Cube of code C_{21} (c) Disk for impact test of code C_{23} (d) Cylinder for split tensile test of code C_{23}

(a) (b)

(c) (d)

Figure 3.6. (a) Curing tank for Cube and cylinders (b) failed cylinders by split testing (c) Cube test on Compression testing machine (d) Cube test on Universal Testing Machine

(a)

(b)

Figure 3.6. (a) failed sample of disk (b) failed or crushed sample of cube by UTM

Chapter 4

Results

4. Results

4.1 Compressive strength results

Results of Fly ash as cement replacement and fly ash as sand replacement separately are shown in tables below.

Compressive strength of cube in 28 and 56 days only for polypropylene fiber

Table 4.1 Compr

(28 and 56 days)

% use of polypropylene fiber	28 Days Compressive strength	56 days Compressive strength
0 %(S_{00} or C_{00})	48.1 N/mm^2	54.4 N/mm^2
0.20%(S_{01} or C_{01})	50 N/mm^2	57.12 N/mm^2
0.25%(S_{02} or C_{02})	51.4 N/mm^2	59.40 N/mm^2
0.30%(S_{03} or C_{03})	48.8 N/mm^2	55.2 N/mm^2

Highest compressive strength of concrete was 51.4 N/mm^2 (at 28 days), and 59.40 N/mm^2 (at 56 days), when polypropylene fiber added as 0.25 % weight of Cement.

Table 4.2 Compressive strength of concrete with fly ash as cement replacement only, (no fiber)

% use of fly ash as cement replacement	28 Days Compressive strength	56 days Compressive strength
0 % (C_{00})	48.1 N/mm^2	54.4
5% (C_{10})	50 N/mm^2	60.12
12.5% (C_{20})	53 N/mm^2	62.9
20% (C_{30})	51.1 N/mm^2	61.80

Highest compressive strength of concrete was 53 N/mm^2 (at 28 days), and 62.90 N/mm^2 (at 56 days), when only fly ash added as 12.5% weight of Cement.

Table 4.3 Compressive strength of concrete with fly ash as sand replacement only, no fiber at 28 days age

% use of fly ash as cement replacement	28 Days Compressive strength(cube)
0 %(S_{00} or C_{00})	48.1 N/mm^2
20%(S_{10})	50.5 N/mm^2
35%(S_{20})	52.8 N/mm^2
50%(S_{30})	53.5 N/mm^2

Highest compressive strength of concrete was 51.4 N/mm^2 (at 28 days), when fly ash added as 50 % weight of Sand.

4.1.1 Compressive strength of Polypropylene concrete with fly ash as Cement replacement

The compressive strength results of concrete with Polypropylene fiber and fly ash as cement replacement were evaluated. The compressive strength of concrete in 28 days and 56 days with various percentage use of fiber are shown in Figure 4.1 to 4.4.

The highest strength was obtained 53 N/mm^2 (at 28 days) and 62.9 N/mm^2(at 56 days) at 12.5% fly ash added as cement replacement.

Variations of strength with fly ash as Cement replacement (0% fiber) are shown below in figure 4.1.

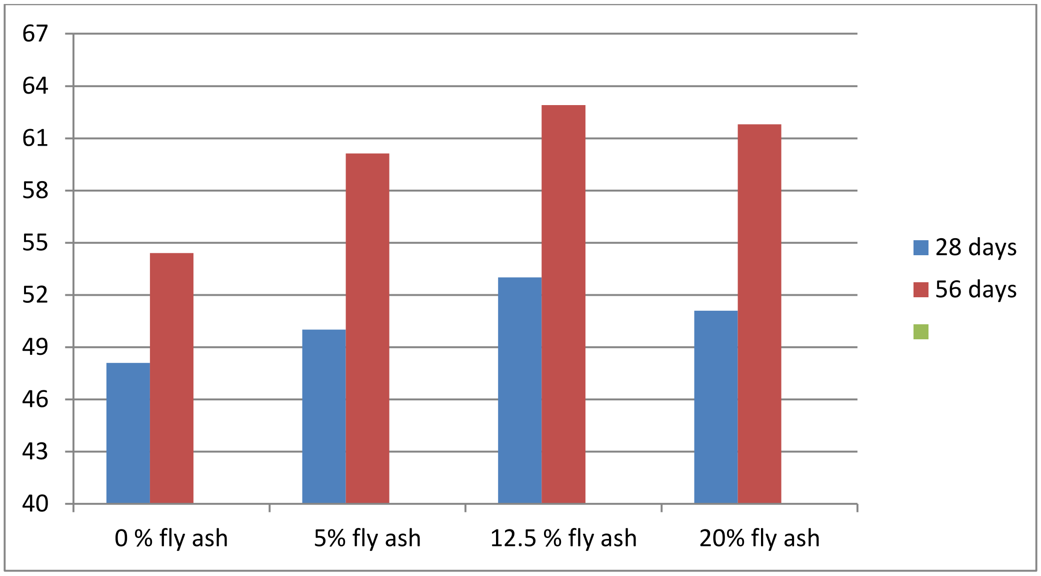

Figure 4.1. 0 % fiber and various fly ash replacements as cement in concrete

Figure 4.2 shows 0.20 % polypropylene fiber and various amount of fly ash content as cement replacement. The highest strength in this case was obtained as 52 N/mm^2 (at 28 days) at 12.5% fly ash as cement replacement, and 62 N/mm^2 (at 56 days) at 20% fly ash as cement replacement.

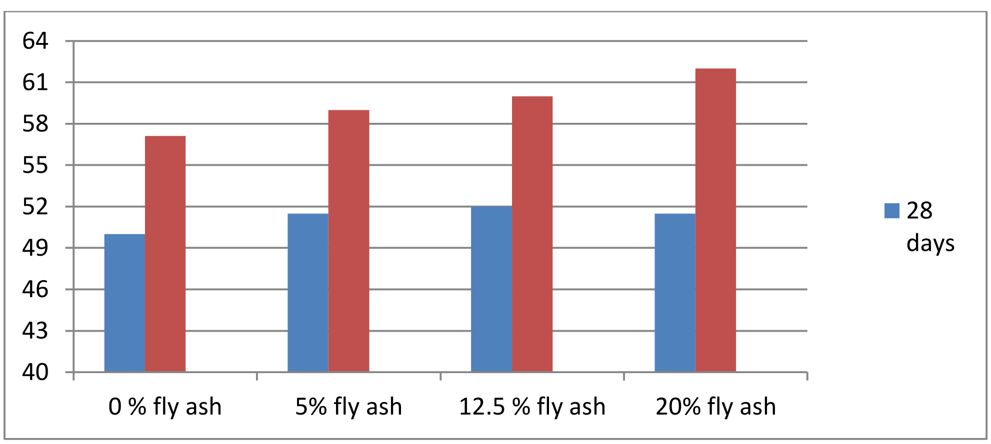

Figure 4.2 0.20 % fiber and various fly ash replacements as cement in concrete

Figure 4.3 shows 0.25 % polypropylene fiber and various fly ash contents as cement replacement. The highest strength was obtained as 54 N/mm^2 (at 28 days) and 63 N/mm^2 (at 56 days) at fly ash 20% as cement replacement.

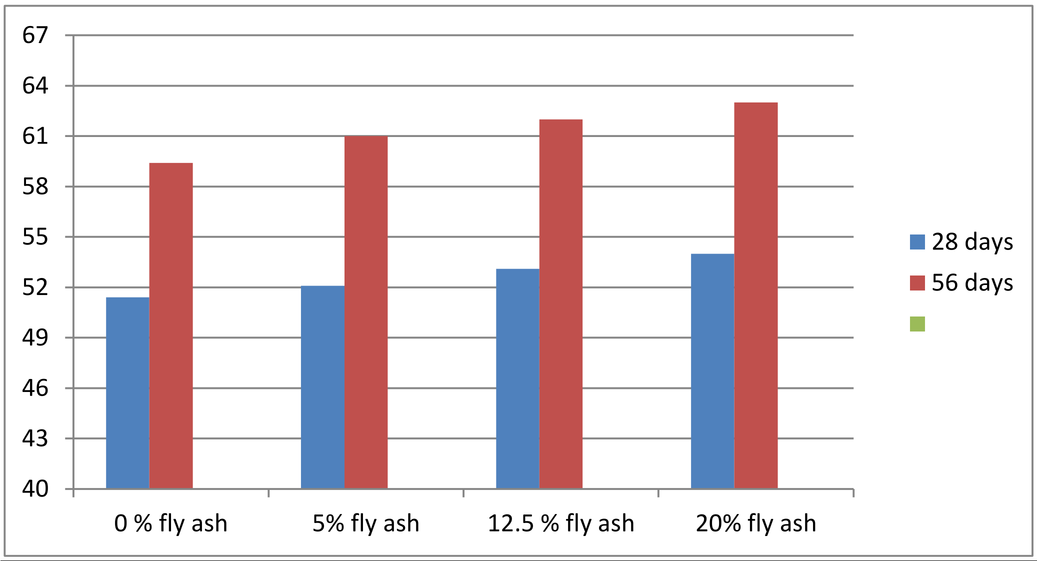

Figure 4.3 0.25 % fibers and various fly ash replacements as cement in concrete

Figure 4.4 shows 0.30 % polypropylene fiber and fly ash content as cement replacements. The highest strength was obtained as 53.5 N/mm^2 (at 28 days) and 66 N/mm^2 (at 56 days) at fly ash 20% as cement replacement.

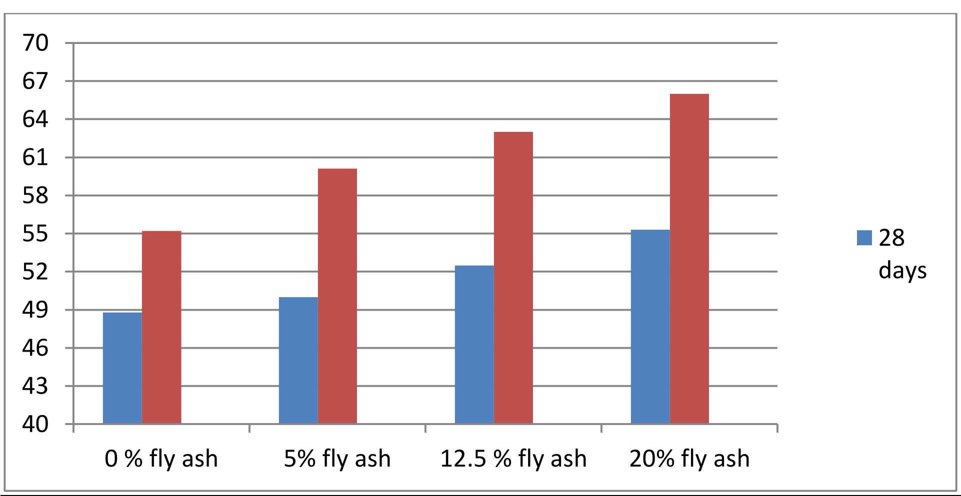

Figure 4.4 0.30 % fibers and various fly ash replacements as cement in concrete

4.1.2 Compressive strength of polypropylene concrete with fly ash as Sand replacement

The compressive strength results of concrete with Polypropylene fiber and fly ash as sand replacement were evaluated. The compressive strength of concrete in 28 days with various percentage use of fiber are shown in figure 4.5 below. The highest strength was obtained as 54.5 N/mm^2 (at 28 days) at the stage of 35% fly ash as sand replacement.

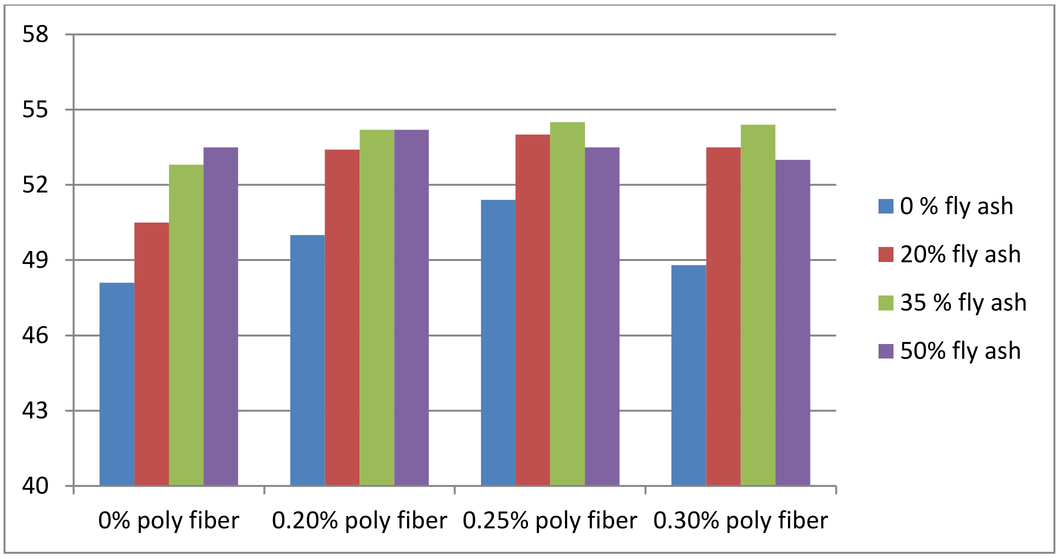

Figure 4.5 Compressive strength results for concrete with combination of fly ash as sand replacement and fiber at 28 days age

4.2 Split tensile test results

The split tensile strength was obtained with the help of split tensile test. Higher amount of polypropylene fiber and higher amount of fly ash as cement and/or sand replacement were taken. The results of Split tensile strength with polypropylene fiber, fly ash as cement replacement and fly ash as sand replacement, separately are shown below.

Split tensile strength when there is no fly ash added and polypropylene fiber is used. The highest Split tensile strength was obtained as 4.60 N/mm^2 at 0.25% of fiber added.

Table 4.4 Split tensile strength of concrete when using only polypropylene fiber

% use of polypropylene fiber	28 Days Split tensile strength
0 %(S_{00} or C_{00})	3.5 N/mm^2
0.20%(S_{01} or C_{01})	4.3 N/mm^2
0.25%(S_{02} or C_{02})	4.60 N/mm^2
0.30%(S_{03} or C_{03})	4.30 N/mm^2

Table 4.5 shows Split tensile strength results of samples with only fly ash as Cement replacement, no fiber. The highest Split tensile strength was obtained as 4.0 N/mm^2 at 12.5 % fly ash as cement replacement.

Table 4.5 Split tensile strength of concrete when using only fly ash as Cement replacement, no fiber

% use of Fly ash as Cement replacement	28 Days Split tensile strength
0 %(C_{00})	3.5 N/mm^2
5%(C_{10})	3.67 N/mm^2
12.5%(C_{20})	4.0 N/mm^2
20%(C_{30})	3.90 N/mm^2

Table 4.6 shows Split tensile strength results of samples with only fly ash as Sand replacement, no fiber. The highest Split tensile strength was obtained as 4.0 at 50% fly ash as sand replacement.

Table 4.6 Split tensile strength of concrete when using only fly ash as Sand replacement, no fiber

% use of Fly ash as Sand replacement	28 Days Split tensile strength
0 %(S_{00})	3.5 N/mm^2
20%(S_{10})	3.67 N/mm^2
35%(S_{20})	3.9 N/mm^2
50%(S_{30})	4.0 N/mm^2

The Split tensile strength of concrete in 28 days with various percentage uses of fiber and Fly ash as Cement replacements are shown figure 4.6 below. The highest strength was obtained as 5.05 N/mm^2 at 0.30% fiber and 20% fly ash as cement replacement.

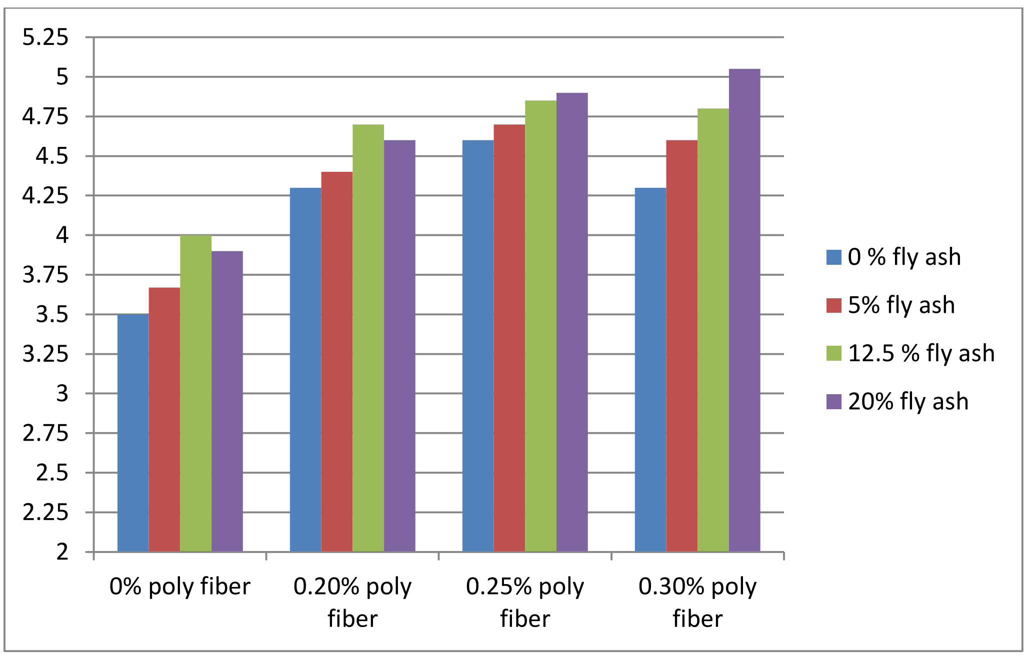

Figure 4.6 Split Tensile strength results for concrete with combination of fly ash as cement replacement and fiber at 28 days age

The Split tensile strength of concrete in 28 days with various percentage uses of fiber and Fly ash as Sand replacements are shown in figure 4.7 below. The highest strength was obtained as 5.0 N/mm^2 at 0.25% fiber and 35% fly ash as sand replacement.

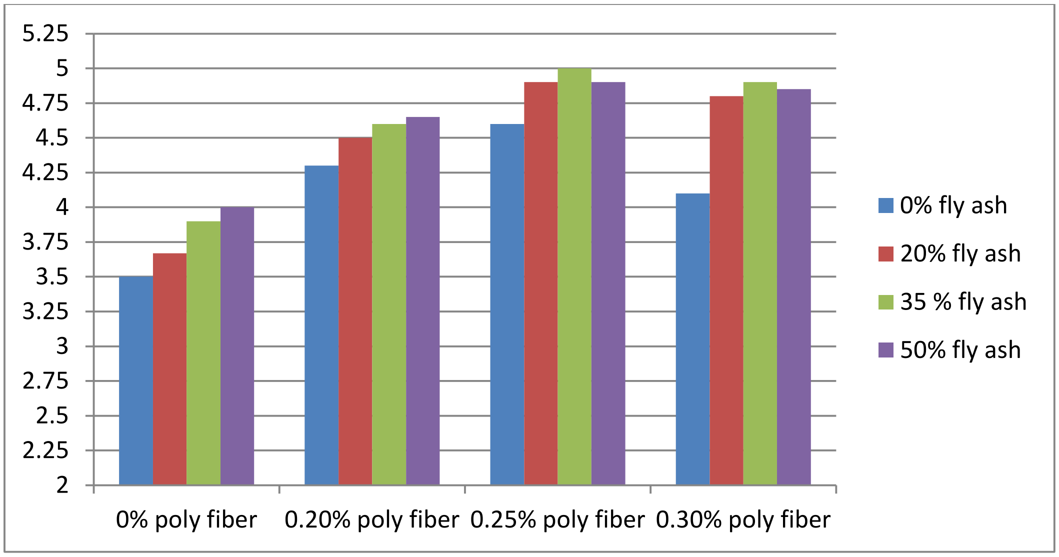

Figure 4.7 Split Tensile strength results for concrete with combination of fly ash as sand replacement and fiber at 28 days age

4.3 Impact strength test results

ACI drop weight test for determining impact resistance of concrete were used. The test results are in the form of number of blows fall on the disk. The impact strength results were obtained in form of number of blows required to make ultimate cracks.

In case of only fiber content highest strength (blows) was obtained as 845 blows at 0.30% fiber. And in case of combination of fiber content and fly ash as cement replacement, highest numbers of blows were obtained as 924 blows at 0.30 % fiber and 20% fly ash as cement replacement. The results are shown in table 4.7 below.

Table 4.7 Impact strength results for concrete with combination of fly ash as cement replacement and fiber at 28 days age

% of fly ash as Cement	% of polypropylene fiber	No. of blows for first crack (Average of 2 Specimens)	No. of blows for ultimate strength(Average of 2 specimen)
0%	0%	400	454
	0.20%	550	630
	0.25 %	650	750
	0.30%	740	845
5%	0%	424	470
	0.20%	600	670
	0.25%	690	800
	0.30%	750	860
12.5%	0%	500	550
	0.20%	633	740
	0.25%	744	830
	0.30%	800	889
20%	0%	459	510
	0.20%	599	720
	0.25%	720	843
	0.30%	775	924

In case of combination of fiber content and fly ash as sand replacement, highest numbers of blows were obtained as 905 blows at 0.25 % fiber and 35% fly ash as sand replacement.

The results for fly ash as sand replacement are shown table 4.8 below.

Table 4.8 Impact strength results for concrete with combination of fly ash as Sand replacement and fiber at 28 days age

% of fly ash as Cement	% of polypropylene fiber	No. of blows for first crack (Average of 2 Specimens)	No. of blows for ultimate strength(Average of 2 Specimens
0%	0%	400	454
	0.20%	550	630
	0.25%	650	750
	0.30%	740	845
20%	0%	440	490
	0.20%	610	710
	0.25%	700	790
	0.30%	760	876
35%	0%	510	564
	0.20%	696	780
	0.25%	787	850
	0.30%	833	905
50%	0%	547	590
	0.20%	640	700
	0.25%	685	766
	0.30%	703	750

Chapter 5

Conclusion and Discussion

5. Conclusion and Discussion

Compressive Strength

From the above results shown in the figures and tables, it justifies that fly ash and polypropylene fiber both are very useful for increasing the compressive strength of the concrete.

In case of fly ash as cement replacement, the highest strength in 28 days and 56 days was obtained in sample C_{33}. It means concrete gave highest strength in 28 days at fly ash as 20 % replacement, using with polypropylene fiber as 0.30 weight of the cement. The strength of sample C_{33} at 28 days was obtained as **55.3 N /mm^2**. The strength of normal M40 mix at 28 days was obtained **48.1 N/mm^2**. The sample C_{33} gave **14%** higher strength than normal concrete sample. The 56 days strength of concrete was also found highest in case of fly ash as 20% cement replacement and fiber as 0.30% as sample C_{33}. The strength of concrete normal M40 in 56 days was found **54.4 N /mm^2**, and where as highest for sample C_{33} was **66 N /mm^2**, which is **21 %** higher than normal concrete.

In case of fly ash as a sand replacement, test was performed only on 28 days age of concrete. Maximum compressive strength was obtain in sample S_{22}, means fly ash is 35 % as sand replacement and polypropylene fiber of 0.30 % weight of cement. The compressive strength of cube for sample S_{22} at 28 days was obtained as **54.4 N/mm^2** which is **13%** greater than normal concrete (**48.1 N/mm^2**). Beyond 35 % adding of fly ash workability of concrete got decrease, so it decreases the compressive strength.

Split tensile strength

From the results shown in the figures and tables for split tensile strength, it can be said that fly ash and polypropylene fiber both are very useful for increasing the split tensile strength of the concrete. Polypropylene was more effective as compared to only fly ash. Only 28 days tests were performed for split tensile test.

In case of fly ash as cement replacement, fly ash and polypropylene fiber both increases the split tensile strength of the concrete. The highest increment has occurred in case of sample C_{33}, means fly ash is 20 % replacement of cement and fiber is 0.30 % weight of cement. The split tensile strength for sample of C_{33} at 28 days was obtained as **5.05 N/mm^2** where as strength of normal concrete was obtained as **3.5 N/mm^2**. The increment was around **42 %**.

In case of fly ash as sand replacement, fly ash and polypropylene fiber both increase the split tensile strength, but with the addition of fiber at higher level of fly ash replacement the split tensile strength got decrease, this was due to decreasing workability of concrete. So the optimum level of contents for giving highest strength was in sample S_{22}, which gave highest strength than all other or normal concrete. The split tensile strength for sample S_{22} was obtained as **5 N/mm^2**, which was **41 %** higher than normal concrete (3.5 N/mm^2).

Impact strength test

Polypropylene fiber is very useful for giving impact strength to the concrete. In this research the impact strength was calculated in terms of numbers of blows required to make ultimate crack, which is called as ultimate strength. The combination of fly ash and fiber were giving increment to the impact resistance of the concrete.

In case of fly ash as cement replacement, the concrete became compact, so the numbers of blows for ultimate crack were increase. The higher numbers of blows were assumed as higher strength. Among all samples of fly ash as cement replacement in polypropylene concrete, the sample C_{33} gave the highest number of blows for the ultimate crack. C_{33}

means fly ash is 20% replacement of cement and fiber is 0.30% weight of cement. The numbers of blows of Sample **C_{33}** for ultimate crack were obtained as **924** blows, which were **103** % higher than normal concrete (**454** blows).

In case of fly ash as sand replacement the strength generally increases. But at higher level of fly ash and fiber the impact strength (number of blows) decreased due to reduction in the workability of the concrete. However impact strength increase at optimum level was much better than normal concrete. The highest numbers of blows required for ultimate crack was in sample **S_{22}** were obtained as **904** blows, which were **99 %** higher than normal concrete (**454** blows).

From all the above results and conclusions, it can be said that polypropylene fiber increases the strength individually or with combination of fly ash. The addition of both fly ash and fiber increases the consumption or utilization of fly ash. This results helps us to give an idea about to utilize **7.5%** more fly ash (20% in all) as cement replacement in concrete.

References

1. IS 456-2000 for “Indian Standard, Plane and reinforced concrete- Code of practice”, Bureau of Indian Standard, New Delhi, 2000.

2. IS 10262-2009 for “Indian Standard, recommended guidelines for concrete mix designs”, Bureau of Indian Standard, New Delhi

3. IS 516- 1959 for Methods of Tests for Strength of Concrete.

4. IS 383 -1970 “Specifications for Coarse and Fine Aggregates from Natural Sources for Concrete”, Bureau of Indian Standards, New Delhi.

5. ACI-544 for “ Measurement of properties of fiber reinforced concrete”

6. M. L. Gambhir, Concrete Technology (3rd Edition), Published by The McGraw-Hill Companies, New Delhi

7. M. S. Shetty, Concrete Technology Theory & Practice, Published by S. CHAND & Company, Ram Nagar, New Delhi

8. Gopalakrishna, S., Rajamane, N.P., Neelamegam, M., Peter, J.A. and Dattatreya, J.K. 2001. “ Effect of partial replacement of cement with fly ash on the strength and durability of HPC”. The Indian Concrete Journal, pp. 335-341.

9. Mindess S., Bentur, A., and Skalny, J., 1989 “Reinforcement of normal and high strength concrete with fibrillated polypropylene “

10. Zheng Z, Feldman D, Synthetic fibre-reinforced concrete, Progr Polymer Sci ,vol 20,No3,pp185–210,1995.

11. A. Naaman, T. Wongtanakitcharoen and G. Hauser, Influence of different fibers on plastic shrinkage cracking of concrete, *ACI Mater J*, vol 32,2,pp. 102-107,2005

12. Soroushian P., and Mirza, F. " Permeability and resistance to Impact and abrasion of polypropylene fiber reinforced concrete". Edited by R.N.Swamy, 1982 published by E & FN 2-6 boundary row, London SE1 SHN, ISBN 0419 18130, pp.218-233.

13. M. Zeiml, D. Leithner, R. Lackner and H. Mang, How do Polypropylene fibers improve the spalling behavior of in situ concrete, *Cem Concr Res*, vol 36 , pp. 929–941,2006.

14. Nagarkar P, Tambe S, Pazare D. Study of fibre reinforced concrete; 1987