Study on Partial Replacement of Cement by Fly Ash, Natural Fine Aggregates by Sawdust and Coir as a Fibre in Concrete

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Of the degree of

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by

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DECLARATION

I Mainkupar Kharbuki bearing registration number(11209657), hereby declare that this thesis report entitled **“Study on Partial Replacement of Cement by Fly-Ash, Natural Fine Aggregates by Sawdust and Coir as a Fibre in Concrete”** submitted in fulfilment of the requirements for the award of degree of Master of Civil Engineering, Lovely Professional University, Phagwara, is my own work.

This matter embodied in this report has not been submitted in part or full to any other university or institute for the award of any degree.

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ABSTRACT

This paper focuses at the replacement effects brought by Fly Ash, Sawdust and Coir as a substitution in concrete. Fly-ash and sawdust fragmentally replaced Cement and Natural Fine Aggregates, respectively. Coir, here acts as a fibre in the concrete. The experiment is carried out by finding the slump value, compressive strength, split tensile strength and flexural strength. Natural Fine Aggregates are replaced by Sawdust in 5%, 10%, 15%, 20%, 25% and 30% by weight in the concrete. Fly Ash and coir are kept constant at 20% and 4% respectively to the weight of the cement throughout the mix. Fly Ash presents good pozzolonic properties, Sawdust shares similar properties as Natural Fine Aggregates and Coir provides good split-tensile and flexural strengths to the concrete. The results are compared with the control mix of design mix M25. The specimens are tested after 7 and 28 days of curing. It is observed that while keeping Fly-Ash and Coir constant at 20% and 4% respectively, up to 20% replacement of Natural Fine Aggregates by Sawdust can be carried out in concrete without decreasing the strength both for 7 and 28 days curing. The value of slump decreases with the increase in the amount of Sawdust. The cost of a concrete reduced up to 105.73 per cubic metre of concrete which comes as 2.7% to the total cost per cubic metre of a concrete. It was found that up to 8.67% reduction in weight for cubes when 30% of natural fine aggregates is replaced by sawdust. Using these waste products will also benefit the environment as normally such products end up in land-fills and increase the carbon footprints.

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CHAPTER 1

INTRODUCTION

1.1. General Introduction

Concrete is the most widely used construction material in the world. The demand for it goes up tremendously day by day. To meets such demands, it requires lots of natural resources to be exploited which on the other hand pose a great threat to the environment. So this work aims at introducing the use of fly ash, sawdust and coir in construction as an addressing solution to the environmental problems i.e. reduction in the disposal of these by products to the landfills which pose a great threat to the environment and reduction in the emission of carbon dioxide to atmosphere which cause one of the leading problems of the world today, Global warming. Fly-ash is obtained from combustion of coal and consist of silicon dioxide, aluminum oxide and calcium oxide. Fly-ash presents good Pozzolonic properties and react easily with water, so therefore it can be used to partially replace cement in the concrete. Sawdust is the waste product obtained from sawmills, having the size similar to that of Natural Fine Aggregates and also shows a superior adhesion when mixing in concrete, hence it can be used as a partial replacement of Natural Fine Aggregates. Coir being a hard and long fiber, in nature is used in concrete so as to impart good tensile and flexural properties in concrete.

The use of waste and by-product provides lot of Advantages. They are (1) Reduce the emission of CO2 which the cement is always account for it (2) reduces the amount of waste and by-product to entered the landfill sites without proper disposal (3) reduces the exploitation of natural resources, which in the other hand provides a positive impacts to the environment, serves as a renewable source of construction material. For economic and environmental reasons and due to the increase amount of recycled aggregates, there has been a growing interest in global as a whole to maximizing the use of waste and by-materials in the construction. Since it proved successful, hence we can say that waste and by-product can be substituted for natural in many concrete application.

1.2. Fly-ash

They are the by-product from combustion of coal. It is of two types: Class-C and Class-F. The difference is based upon the chemical content present in them. Class-C fly-ash have more lime content as compared to Class-F. The two most properties check upon fly ash are fineness and lime content because these two have a great effect upon the demand of air content and water absorption by the concrete which greatly affect the strength and durability of concrete. The properties of Fly-ash as per IS1727-1967, Specification IS 3812(Part1)- 2013 is shown in table below:

Sl.no	Property	Test Result
1	Lime reactivity	8Mpa
2	Fineness(Blaine)	$316m^2/Kg$
3	Compressive Strength as percentage strength of corresponding plain mortar cubes	92.33%
4	Soundness by autoclaves expansion	0.0233%
5	Particle shape	Spherical

Table 1: Physical Properties of Fly-Ash

Chemical Components	Fly ash % by mass
Cao	0.37-27.68
Sio_2	27.88-59.40
Al_2O_3	5.23-33.99
Fe_2O_3	1.21-29.63
MgO	0.42-8.79
SO_3	0.04-4.71
Na_2O	0.20-6.90
K_2O	0.64-6.68
TiO_2	0.24-1.73
LOI	0.21-28.37

Table 2: Chemical Properties of Fly ash

1.3. Sawdust

Sawdust is a by-product of a wood by mean of cutting, grinding or sanding with saw or other industrials tool. They are in the formed of fine particles. Sawdust need to be keep properly and stored away from heat because they can catch heat easily when exposed closed to heat. Saw dust is present abundantly especially in tropical areas and they are also very cheap in prices. The properties of sawdust is shown in the Table below

Properties	Sawdust
Maximum size(mm)	4.75
Specific Gravity	0.27
Absorption (%)	2

Table 3: Physical Properties of Sawdust:

1.4. Coir

Coir is one of the toughest natural fibres. Coir are basically the fibres that lie just beneath the cover. They are long, hard and durable. Coir when dried contains organic compound such as cellulose, complex organic polymer such as lignin and ash with varying percentage. It may be acting as one of the good material if used in lightweight concrete structures. Using of coir enhances the split tensile and flexural strength of a concrete. The properties of coir is shown in the table below

Fibres	**Parameter**
Color	Brown
Length	10-15cm
Diameter	0.2-0.35mm
Bulk Density	140-150Kg/m^3
Ultimate tensile strength	80-120N/mm^2
Modulus of elasticity	18-25N/mm^2
Water absorption	30-40 %

Table 4: Physical Properties of Coir

Fig 1: Fly-ash

Fig 2: Sawdust

Fig 3: Coir

CHAPTER 2

TERMINOLOGY

2.1. Abbreviations

SD: This termed denoted the short form of Sawdust

FA: This termed denoted the short form of Fly-Ash

Coir: This is another name of Coconut Fibre but in Engineering field is well known as Coir.

%: This termed denoted the short form of percentages.

Fragmentary: This termed refer to partial replacement of some material.

Fct: The mathematical termed denoted for split-tensile strength.

Fb: The mathematical termed denoted for flexural strength.

Control mix: This refers to that mix with no replacement.

Fig: This denoted the short form of figure.

OPC: This termed denoted the short form of Ordinary Portland Cement.

CA: This termed denoted Natural Coarse aggregates

Comp.: This termed denoted the compressive strength

CHAPTER 3

LITERATURE REVIEW

3.1. Fresh properties of concrete

3.1.1 Workability

3.1.1.1 Slump Test

A) Fly Ash

P. R. Wankhede et al (2014) performed a study on Fly ash how it influence the behavior of the mix concrete. Fly ash is a material which is pozzolonic in nature and it is improving the properties of concrete like compressive strength and workability. Here the concrete design used is M25 with the ratio 1:1:2 and the cement used is OPC grade53.He performed the test to study about the slump loss and workability of concrete slump i.e. variation in slump for different proportion of fly ash He used replacement here as 0%, 10%, 20%, 30% replacement by fly ash on cement. From the table below he concluded that with more the fly ash proportion, slump values also increase. It is shown are as follows:

%Fly ash with weight of cement	0%	10%	20%	30%
Slump in mm	00	00	16	24

Table 5 : Slump with different proportion of fly ash

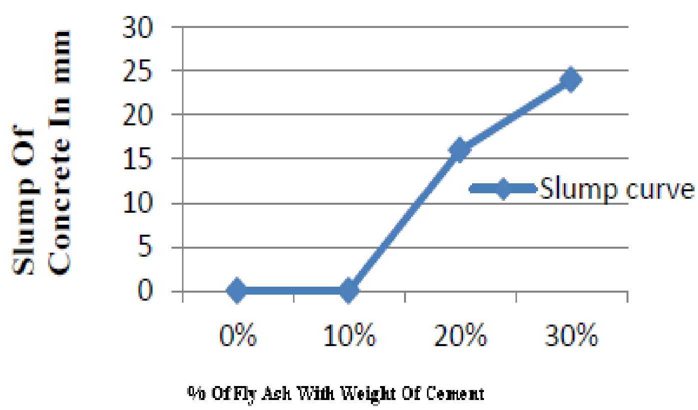

Fig 4: Slump with different proportion of fly ash

B) Saw dust

Olugbenga Joseph Oyedepo et al (2014) studied the workability of concrete mixes with different percentages of fine aggregates by saw dust. Here he introduced 0%, 25% and 50% replacement of fine aggregates by saw dust. He found that the workability of concrete decreases with the increase in the percentages of saw dust in fine aggregates. Slump obtained is 40mm, 9mm and 5mm at 0%, 25% and 50% addition of saw dust in fine aggregates. Hence with 75 percent substitution of sand by sawdust the concrete feasible grows to 6mm along 15mm for 100percent of sand substitution by saw dust. Here the mix of 1:2:4 prepared of 0.65 cement water ratio.

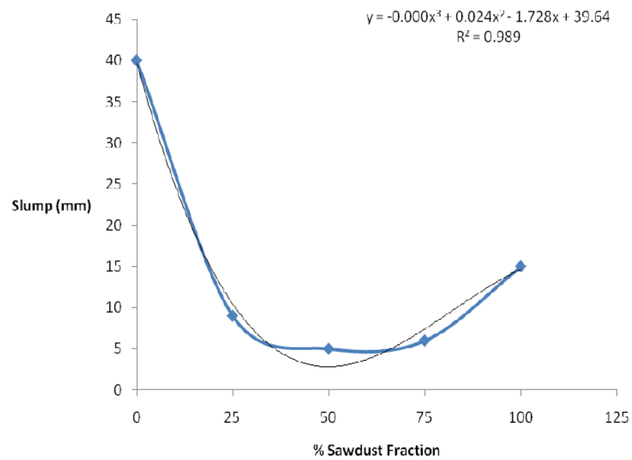

Fig 5: Variation in slump with sawdust replacement at 0.65 water/cement ratio

Dr.suji.D et al (2016) performed a study on limited substitution of fine aggregates by quarry dust (QD) along sawdust (SD). In this experimental study the tests was performed for M30 mix design. Quarry dust with 0%, 10%, 20%,30% and 40% altogether with sawdust ranging from 0%,5%,10%,15% and 30% and the leftover part river sand is used. He found that the slump of normal mix is from 120mm to 135mm whereas 110mm and 120mm for slump of quarry dust and sawdust concrete. The slump values indicates that the workability of quarry dust and sawdust is more or less equal to that of control mixed. It is shown in the table below. The slightly decrease is due the quarry dust and saw dust they absorb lot of water.

Normal Mixed (mm)	**Replacement by Quarry dust and Sand dust (mm)**
120-135	110-120

Tables 6 : Slump of Normal mix vs. QD and SD

C) Coir

D.M. Parbhane et al (2014) in his report he study about the strength properties of coir. He used M20 concrete in this study. The split tensile strength and workability is taken at 7days, 14 days and 28 days. Based on the result obtain he says that the feasible and tension forces becomes more when the coir is more. The Concrete* is added with 1, 2, 3, 4, 5 percentages of coir. From the tables is showing below we see that the more the amount of coir is, the more the feasible the concrete is. This proved that Coconut shells Concrete is also applicable to be used in building construction which also act as the initiative steps for the utilization of eco-friendly.

The tables of slump values is shown are as follows:

Substitution	0%	1%	2%	3%	4%	5%
Slump (mm)	85	61	67	73	79	84

Table 7: Slump of coir for different percentage replacement

3.2. Hardened Properties of Concrete

3.2.1. Mechanical Properties

3.2.1.1. Compressive Strength

A) Fly-Ash

T.G.S KIRAN et al (2014) studied about the partial replacement of cement by fly ash. With fly ash replacement of 0%, 5%, 10%, 15% and 20% by weight of cement in concrete. He performed the compressive strength at the age of 28 days, 60 days and 90 days for cubes cured in water. He found that there is an increase of compressive strength at 5% and 10% addition of fly ash and the gradually decreases when following 15% and 20% addition. Hence because of the pozzolonic reaction the FA concrete achieves significant improvement in the mechanical properties at later ages. The concrete mix here is M40.From the values obtained below he concludes that all of the replacement meets the minimum requirements of compressive strength.

Sample	% of Fly Ash	Compressive strength at 28 days F1(cu)	Compressive strength at 60 days F1(cu)	Compressive strength at 90 days F1(cu)
W1	0	46.19	56.82	57.98
W2	5	47.53	57.83	58.69
W3	10	48.67	58.27	60.23
W4	15	45.67	53.33	59.16
W5	20	44.33	54.16	56.23

Table 8: Compressive strength for cubes cure in water.

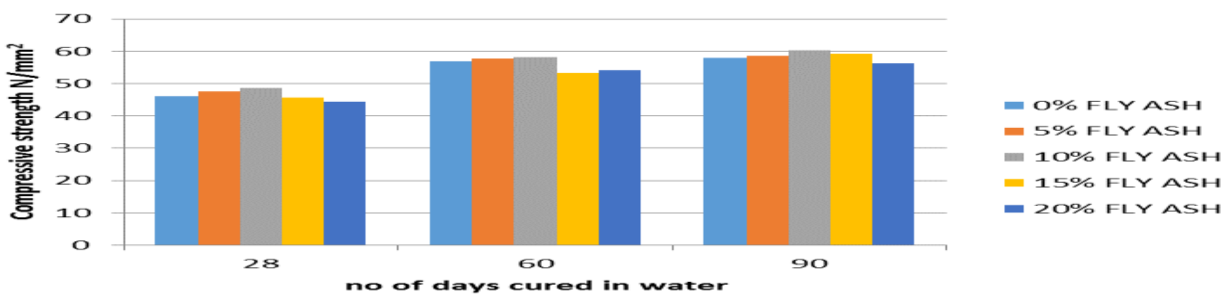

Fig 6: Compressive strength results of Fly ash concrete cured in normal water.

Prof. Jayeshkumar Pitroda et al (2012) performed an experimental investigation on partial replacement of cement with fly ash in design mix concrete. Here cement is fragmentally substitute by Fly ash at 0, 10%, 20%, 30% and 40% to the weight of cement. Mix using is M25 and M40. The tests is carried out for curing at the age of 28 days. For M25 mix he named A1, B1, B2, B3, B4 for 0%, 10%, 20%, 30% and 40% respectively fly ash replacement of cement. Similarly for M40 mix he named A2, B5, B6, B7, B8 for 0%, 10%, 20%, 30% and 40% respectively fly ash replacement of cement. From the result obtained in the tables below he conclude that with the increase of the fly ash addition there is a decrease in the compressive strength. The compressive strength results shown in table below for M25 and M40.

Concrete Grade	Concrete Type	Average Ultimate compressive strength at			% change in compressive strength at		
		7days (N/mm^2)	14days (N/mm^2)	28days (N/mm^2)	7days	14days	28days
M25	A1-M25	28.77	32.00	44.59	0	0	0
	B1-M25	21.33	30.96	34.67	(-)25.86	(-)3.25	(-)22.24
	B2-M25	16.15	23.70	24.30	(-)43.86	(-)25.93	(-)45.50
	B3-M25	13.04	15.11	22.22	(-)54.67	(-)52.78	(-)50.16
	B4-M25	9.93	14.81	17.33	(-)65.48	(-)53.71	(-)61.13
M40	A2-M40	34.81	49.04	52.74	0	0	0
	B5-M40	29.33	34.93	38.22	(-)15.74	(-)28.77	(-)27.53
	B6-M40	13.78	27.26	27.56	(-)60.41	(-)44.41	(-)47.74
	B7-M40	13.04	18.37	21.48	(-)62.66	(-)48.66	(-)59.27
	B8-M40	8.59	13.48	20.00	(-)74.51	(-)72.51	(-)62.07

Table 9: Compressive strength and % change of strength at 7days,14 days, 28days for M25 and M40

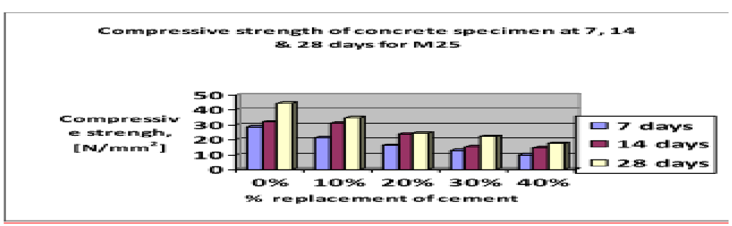

Fig 7: Compressive strength of concrete specimen at 7,14 and 28 days for M25

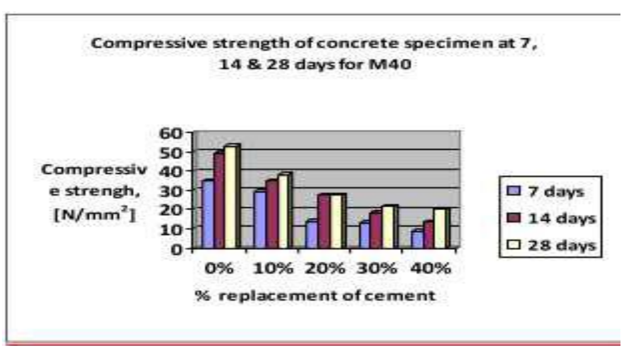

Fig 8: Compressive strength of concrete specimen at 7, 14,28 days for M40

T.Subramani et al (2015) performed a study of fragmental substitution of cement by Fly ash and fully substitution of sand by Msand. A Fly ash of 25%, 30% and 35% here is used to replace cement. Fine aggregates is 100% replaces by Msand in all the three cases. The design mix used here is M30.The compressive strength of cube cure at 7days, 14 days and 28 days is shown as in following tables:

Control Mix	**Compressive strength in N/mm^2 7days**			
	Cc	25% fly ash	30% fly ash	35% fly ash
M30	17.8	20.80	21.65	22.80

Tables 10: Compressive strength of cube 7days

Control Mix	**Compressive strength in N/mm^2 14 days**			
	Control Mix	25% Fly Ash	30% Fly ash	35% Fly ash
M*30	17.95	21.03	21.95	23.41

Tables 11: Compressive strength of cube14day

Control Mix	Compressive strength in N/mm^2 28days			
	Cc	25% fly ash	30% fly ash	35% fly ash
M30	18.33	21.56	22.34	21.77

Tables 12: Compressive strength of cube at 28 days

Carolyne Namagga et al (2009) studied upon the optimization of Fly ash in concrete by using high lime fly ash as a partial replacement of cement and filler material. In this studied he work upon how to replace cement by fly ash at larger proportion. Fly ash of Class-C is used this is because of it high silica content. The test is done for the compressive strength and the test is carried out for 3, 7, 14, 28 and 56 days. Here he introduced 15, 20, 25 30, 35, 40, 45 and 50 percent replacement of cement by fly ash. The design mix strength for 28 days is 31MPa and the target mean strength is 39MPa with a water ratio of 0.525. From the result he obtained he conclude that replacement of cement between 25-35% of fly ash gives the best strength result and beyond 35% there is a decreases in the rate of gain in compressive strength but still they maintain the values above the design mix strength

D Suresh et al (2015) performed an experimental studies on Compressive Strength of M20 Grade of Concrete with Partial Replacement of Cement by Fly-ash, Fine Aggregate by Waste Glass Powder and Coarse Aggregate by E-Plastic Waste. He work on M20 design mix. In this work a glass is crushed to a size of 1.18 mm and e-plastic to a size of 20mm. Cement is replace with 10% of fly ash throughout the mix. Fine aggregates by 20% waste glass and coarse aggregates is replaced by 4%, 8%, 12% 16% e-plastic. The mix proportion is given in table below:

Constituents of concrete	**Binding Material**		**Fine Aggregates**		**Coarse Aggregates**	
Mix types	Cement	Fly Ash	Sand	Waste Glass powder	20mm metal	E-Plastic
A	100%	0%	100%	0%	100%	0%
B	90%	10%	100%	0%	100%	0%
C	90%	10%	80%	20%	100%	0%
D_1	90%	10%	80%	20%	96%	4%
D_2	90%	10%	80%	20%	92%	8%
D_3	90%	10%	80%	20%	88%	12%
D_4	90%	10%	80%	20%	84%	16%

Table 13: Replacement of cement by fly-ash, Sand by waste glass and CA by 20mm metal and E-Plastic

The strength obtained for various mix are as follows:

Age(Days)	**A**	**B**	**C**	**D_1**	**D_2**	**D_3**	**D_4**
3	13.38	14.56	19.08	9.46	9.86	17.25	12.17
7	33.76	37.22	25.30	13.32	15.17	22.06	20.67
28	41.75	45.56	38.99	27.25	18.22	36.55	20.93

Table 14: Strength of various mix for 3, 7 and 28 days

From the results he conclude that upto to 12 percent e-plastic can be used for replacement because at 12% eplastic gives the optimum results for all the curing days.

A. Oner et al (2004) performed an experimental studies on strength development of concrete containing fly ash and optimum usage of fly ash in concrete. In this work he replaced cement by 15%, 25%, 33%, 42%, 50%,and 58% of fly ash. The mix is cure for 28 and 180 days. He prepared a total of 28 mixtures with different replacement out of which four is prepared as control mix with 200, 300, 350 and 400 Kg/m^3. All these mixtures have slump values of 120 $^{+}_{-}$ 10 mm. Based upon the result obtained he conclude that there is an increasing in strength with an increase in the fly ash content up to the optimum values and then gradually decreases with further addition of fly ash. The optimum values obtained here is 40%. This is because when cement content in concrete is high hydration products $Ca(OH)_2$ increases and the amount of fly fly-ash enter also will increase.

Aman Jatale et al (2013) performed an experimental study on the effect of compressive strength when cement is partially replaced by fly ash. Here he take the replacement of cement with 20, 40 and 60 percent of sawdust. He studied upon the workability, setting time, density, air content, compressive strength and modulus of elasticity. He performed a studied how the compressive strength varies with water cement ratio. The mix of M15, M20, M25 are used in this studied. High range super plasticizer is introduced to all the mixes. Slump of 200+mm is maintain in all the mix so that to ensure that the mix can be placed at any time when there is congested. The result obtained is summarized in the table below:

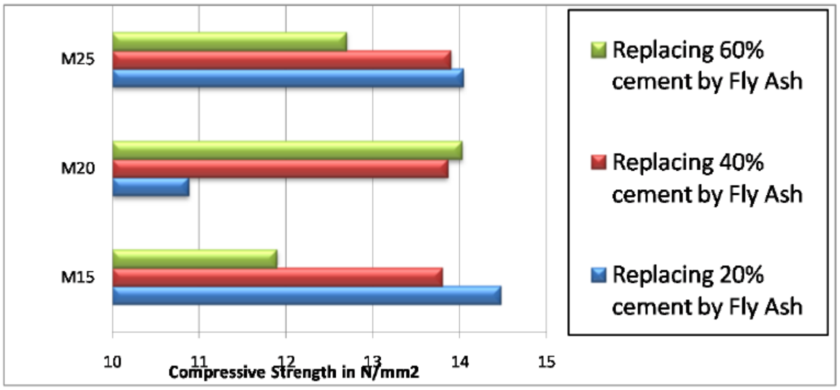

Fig 9: comparison of compressive strength of difference grade of concrete with difference fly ash percentage.

Based on the result obtained he conclude that for grade M15 and M25 give the optimum values at 20% replacement while for M20 it gives at 60% replacement. Fly ash concrete shows less bleeding and improves the characteristics like cohesiveness, pumping and surface finish. Slow gain of strength at early age as compared to later age. This is because secondary hydration due to pozzolanic action is going slower at early age. Fly ash concrete is more durable than OPC concrete.

B) Saw Dust

Albert M Joy et al (2016) performed a study on the partial replacement of fine aggregates by sawdust. Sawdust as a sand replacement becomes a turning point and help to make use of industrial waste in the construction. His aim is to develop a sawdust cement mix gravel equivalent to sand cement mix gravel Here he replaced sand with 15, 20, 25, 30 % of Sawdust. The specimen was tested for 7days and 28 days. The standard mix here is M25. Cement used is PPC 53. The target mean strength is 31.6 N/mm^2. The strength of cubes for 7 and 28days is shown in table below:

MIX	7TH days strength	28TH days strength
Normal mix	21.48	30.37
15% replacement	21.48	30.08
20% replacement	21.33	30.08
25% replacement	20.01	30.08
30% replacement	19.11	29.48

Table 15: Strength of cubes for 7and 28 days

From the results obtained above he conclude that the compressive strength obtained for the replacement of fine aggregates by 25% sawdust gives the optimum mix for the M25 concrete mix. With the introduction of sawdust help in reducing the weight of a concrete and also helps in making the concrete more economical.

Daniel Yaw Osei et al (2016) performed a study on the effect of replacing sand by sawdust in the concrete. The mix used here is 1:2:4 and sand is replaced by 25%, 50%, 75% and 100% of sawdust. There is lot of reduction in density with the increase in the percentage replacement and there is also a decrease in the compressive strength with higher the percentage of sand replacement. The results obtained for compressive strength for 7, 14, 21 and 28 days is shown as below:

Percentage replacement	**Age(days)**			
	7	14	21	28
0	23.36	25.12	26.87	28.64
25	9.54	9.61	10.40	12.13
50	5.85	7.78	8.33	9.15
75	2.92	3.44	4.00	4.66
100	2.47	2.87	3.22	3.37

Table 16: Compressive strength for 7, 14, 21 and 28days

Based upon the results obtained above he conclude that upto 14% sawdust can be replaced sand for producing structural concrete and up to 16% replacement of sand for lightweight structural concrete.

C Freeda Christy et al (2010) studied upon the effects of Class- F fly ash as a partial replacement with cement and fine aggregates in mortar. In this paper represent the result of mix proportion 1:3, 1:4.5 and 1:6. Cement is replaced by 0, 10, 20, 25 and 30 percent replacement by fly ash. Based upon the result obtained that at 10% fly ash replacement of cement gives higher values of compressive strength as compared to that control cement mortar mix. Mortar replaced with 20% fly ash for fine aggregates gives higher compressive strength than control mortar mix. So fly ash added in cement mortar mix not only it improve the strength but also it makes the mortar more cohesive which in the other hand saving the Portland cement. Mortar of cement replaced by 10% flyash can be made used for brickwork with range of strength between 3-9 N/mm^2 while 20% flyash as fine aggregates replacement is used for brickwork of strength range 8-20 N/mm^2.

K. Gopinath et al (2015) in his study on utilization of sawdust in cement mortar and cement concrete. In this work he introduced sawdust ash ash partial replacement for cement and sawdust as partial replacement for fine aggregates. The mix used here is M20 with 1:1.5:3 proportion. The specimen is name as I1, J1, K1 and L1 for 7 days, I2, J2, K2, L2 for 21 days and I3, J3, K3, L3 for 28 days. The tests is performed for 7, 21 and 28 days. The results for the respective days is shown as below:

Sl.no	**Sawdust ratio**	**7th days com. Strength**
I1	0	18.763
J1	10	14.122
K1	30	13.786
L1	50	3.222

Table 17: 7th days result comp. strength

Sl.no	**Sawdust ratio**	**21th days com. Strength**
I2	0	20.136
J2	10	17.229
K2	30	15.513
L2	50	9.650

Table 18: 21th days result comp. strength

Sl.no	**Sawdust ratio**	**28th days com. Strength**
I3	0	24.15
J3	10	19.322
K3	30	18.092
L3	50	11.469

Table 19: 28th days result comp. strength

From the result he conclude that For M20 grade concrete, design mix ratio of1:1.5:3,Compressive strength of Dry Sawdust concrete after28 days of curing is achieve 80%, 75% and 47% of strength for 10%, 30% and 50% replacement of Dry Sawdust for fine aggregate respectively. For same grade, Compressive strength achieve 91%, 80% and 78% for 5%, 10% and 15% replacement of Sawdust Ash respectively, after 28 days of curing. From the results density of Dry Sawdust (DSD) is90% less than normal river sand and density of Sawdust Ash (SDA) is 60% to80% less than Ordinary Portland Cement (OPC).

Dr. P. Sri Chandana, Ph.D. et al (2015) performed an experimental studies on strength of concrete by partial replacement of fine aggregate with sawdust and robosand. Here he prepared five mixes for the investigation, increasing the replacement percentages from 0-100% with saw dust and robosand in proportion. For saw dust replacement is done with 0%, 5%, 10%, 15% and 20% replacement of river sand. Whereas for robosand is 0%, 20%,40%, 80% replacement of river sand, which the total of both of them give 100% replacement of river sand. He found that for M20 mix the optimum values is 10% of sawdust and 40% of robosand which account to 50% replacement of river sand. The 25% replacement gives the compressive strength of 25.24 N/mm^2 and 50% replacement results in 21.42 N/mm^2.Both mixes achieve the means target strength of 20 N/mm^2.There is 7% weight reduction achieve of the concrete and 2% cost reduction per cubic metre of concrete. The mixed proportion is given in table below:

Sl.no	**Mix**	**River sand**	**Sawdust**	**Robosand**	**Combined Replacement**	**Compressive strength at 7days**	**Compressive strength at 28 days**
1	M0	100%	0%	0%	0%	19.55	27.78
2	M1	75%	5%	20%	25%	17.78	25.24
3	M2	50%	10%	40%	50%	15.02	21.42
4	M3	25%	15%	60%	75%	11.64	16.44
5	M4	0%	20%	80%	100%	7.33	10.58

Table 20: Compressive strength at various percentage sawdust and robosand replacement for 7days and 28 days

3.2.2. Split Tensile Strength

A) Fly Ash

Prof. Jayeshkumar Pitroda et al (2012) performed an experimental investigation on partial replacement of cement with fly ash in design mix concrete. Here the cement is replaced by Fly ash in the range of 0% (without fly ash), 10%, 20%, 30% and 40% by weight of cement for M25 and

M40 Mix. The tests is carried out for curing at the age of 56 days. For M25 mix he named A1, B1, B2, B3, B4 for 0%, 10%, 20%, 30% and 40% respectively fly ash replacement of cement. Similarly for M40 mix he named A2, B5, B6, B7, B8 for 0%, 10%, 20%, 30% and 40% respectively fly ash replacement of cement. From the result obtained in the tables below he conclude that with the increase of the fly ash addition there is a decrease in the split tensile strength. The Split tensile strength results is shown in table below for M25 and M40.

Concrete Type	**Average split tensile strength for cube at 56 days N/mm^2**	**%change in split tensile strength at 56 days**
A1-M25	3.44	0
B1-M25	3.52	2.32
B2-M25	3.21	-6.68
B3-M25	2.55	-25.87
B4-M25	2.41	-29.94
A2-M40	3.96	0
B5-40	4.10	3.50
B6-40	2.78	-29.79
B7-40	2.69	-32.07
B8-40	2.04	-48.48

Table 21: Split-tensile strength of fly ash at 56days

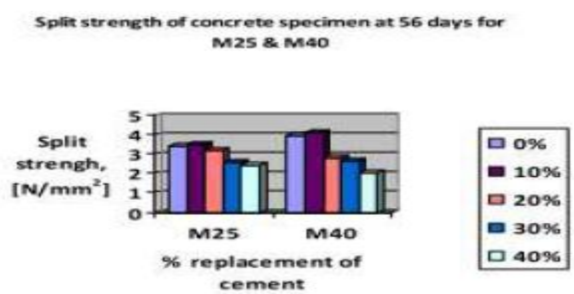

Fig 10: Split tensile strength at 56 days for M25 and M40

Dr.H.Sudarsana Rao et al (2011) published a report on strength and workability of fly ash based glass fibre reinforced high fibre concrete. The replacement of cement by fly ash here is 0%, 10%, 20%, 30% fly ash. The glass fibre here used is 0%, 0.5%, 1% and 1.5% with the used Glass Fibre Reinforced High-Performance-Concrete (GFRHPC).The test is performed at 28 days of curing age. The change in split tensile strength with respect to percentage of fly ash added is shown below

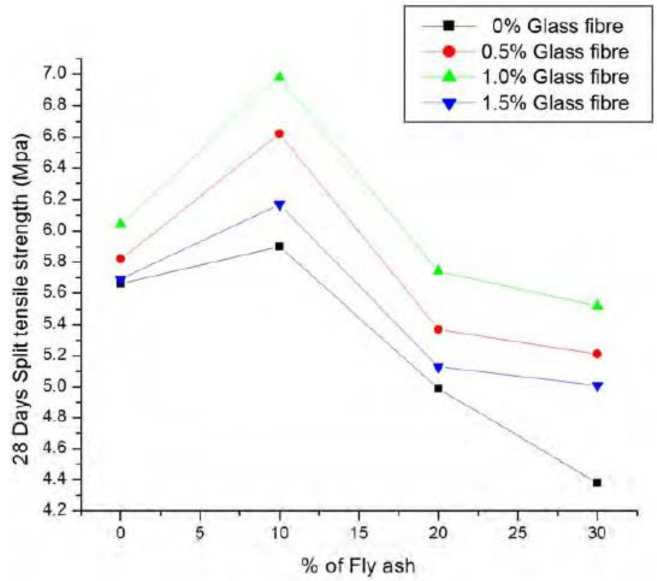

Fig 11: 28 Days split tensile strength vs. % of fly ash

From the graph above conclude that there is an increase in tensile strength with the addition of fly ash as the admixture. From graph we can see that there is a huge increase at 10% addition of fly ash. The reason for the increase in tensile strength is due to the pozzolonic active pozzolonic fly ash.

B) Sawdust

Dr.suji.D et al (2016) performed a research work on limited substitution of fine aggregates by quarry dust along sawdust. In this experimental study the tests was performed for M30 mix design. Quarry dust with 0%, 10%, 20%,30% and 40% altogether with sawdust ranging from 0%,5%,10%,15% and 30% and the leftover part river sand is used. The test is taken at 7days and 28 days.

From the table below it is seen that there is only a slight change of the replacement with that of the tensile strength of control mix.

	Weight in Kg	7^{TH} days Test(N/mm^2)	28^{th} days Test(N/mm)
Control mix	13.3	3.57	4.37
Replacement 10% quarry dust and 5% saw dust	12.6	3.48	4.24
20%QD 10%SD	12.4	3.20	3.90
30%QD 15%SD	12.3	3.45	4.00
40%QD 20%SD	11.2	2.97	3.82

Table 22: Tensile strength of 7^{th} and 28^{th} day of QD and SD

C) Coconut fibres (coir)

D.M. Parbhane et al (2014) in his report he study about the strength properties of coir. He used M20 concrete in this study. The split tensile strength and workability is taken at 7days, 14 days and 28 days. Based on the result obtain he says that the feasible and tension force become more when the coconut fibers is more. The combined concrete of 1%, 2%, 3%, 4% &5% substitution of coir at 28 days tension force shows the values as 2.68, 2.90, 3.11, 3.25, 2.33 respectively. This proved that Coconut fibers is also applicable to be used in building construction which also act as the initiative steps for the utilization of eco-friendly. . The tables is shown as below:

	Tensile strength at various replacement					
Curing Days	0%	1%	2%	3%	4%	5%
7	1.76	1.81	1.93	2.10	2.23	1.58
14	2.31	2.45	2.63	2.83	2.95	2.17
28	2.54	2.68	2.90	3.11	3.25	2.33

Table 23: Tensile strength at various % replacement by coir

D.J. COOK et al (1978) performed a study on coir fibre reinforced cement as a low cost roofing material. Fibre length of 37.5mm is used. It has been shown in his paper that coir fibres can be made as a satisfactory material for short randomly distributed in a cement matrix which has good potential for roofing. In the short term, tests have indicated that coir fibres has attain the adequate durability but longer term results are required. Based on a material cost, he conclude that coir is cheap and priceless can be considered a low cost alternative to replaced galvanized iron and asbestos cement sheeting. Therefore coir need to be introduced for using, however, that the viability of any material, irrespective of how promising it appears in the laboratory, must be subjected to prototype production and full scale testing before it will become a potential replacement for existing roofing materials.

Majid Ali et al (2012) in his study on mechanical and dynamic properties of coconut fibres reinforced concrete describes coconut fibres as the one of the toughest natural fibres. They can be made used as the reinforcement in the low cost housing structural especially in the earthquake prone areas. In this work he work not only on mechanical properties but he also extend his work in damping ratio, fundamental frequency of reinforced CFRC beams. Here he introduced 1, 2, 3 and 5 percent fibres contents to the mass of cement. The fibres length used is 2.5, 5 and 7.5 cm. Cement used is Ordinary Portland Cement (OPC). The design mix ratio is 1:2:2 i.e one for cement, 2 for sand and 2 for coarse aggregate. The water cement ratio adopted is 0.48. From the result obtained he conclude that CFRC with 5cm long fibres having 5% fibres content gives an increase in compressive strength, split tensile strength, modulus of rupture, total toughness index. The result is shown as below:

Concrete type	Compressive strength, T_C (MPa)	Split-Tensile strength STS(MPa)
Plain concrete	34.7	3.82
CFRC with minimum values	31.3(3%, 7.5cm)	3.42(5%, 2.5cm)
CFRC with maximum values	43.2(1%, 5cm)	4.27(1%,7.5cm)
Recommended CFRC	36.1(5%, 5cm)	3.74(5%,5cm long)

Table 24: Behavior of CFRC for dynamic properties

3.2.3. Flexural strength

A) Fly ASH

T.Subramani et al (2015) in his research works of fragmented substitution of cement by Fly ash and fully substitution of sand by Msand. A Fly ash of 25%, 30% and 35% here is used to replace cement. Fine aggregates is 100% replaces by Msand in all the three cases. The design mix used here is M30.The test here is taken for flexural strength of beams for 28 days shown. The mix is performed into three ratio names as Proportion 1, Proportion 2 and Proportion 3. For proportion 1 is of 25% fly-ash and 100% Msand. Proportion 2 of 30% Fly-ash and 100% Msand and Proportion 3 35% Fly-ash and 100% Msand. It is shown in the tables below:

Control Mix	Best flexural strength in N/mm2 at 28 days beam			
	Control Mix	25% of fly ash	30% of fly ash	35% of fly ash
		Proportion 1	Proportion 2	Proportion 3
M30	2.42	3.23	4.27	4.17

Table 25: Flexural strength at 28 days of fly ash replacement

B) Saw dust

Dr.suji .D et al (2016) performed a research work on limited substitution fine aggregates by quarry dust along sawdust. In this experimental study the tests was performed for M30 mix design. Quarry dust with 0%, 10%, 20%,30% and 40% altogether with sawdust ranging from 0%,5%,10%,15% and 30% and the leftover part river sand is used. The testing is done at 7 days and 28days respectively. Flexural strength test is conducted on specimen with dimension 100x100x500, both control concrete and replacement 30% quarry dust and 15 % saw dust. Flexural strength of quarry dust and saw dust mix was observed to marginally less than the control concrete. The flexural strength for 7days and 28days are as follows:

	Weight in Kg	**Weight in 7days Test N/mm^2**	**Weight in 28days test N/mm^2**
Control Mix	12.9	6.16	7.50
30% QD And 15% SD	11.3	5.9	6.90

Table 26: Flexural strength for 7 days and 28 days of sawdust replacement

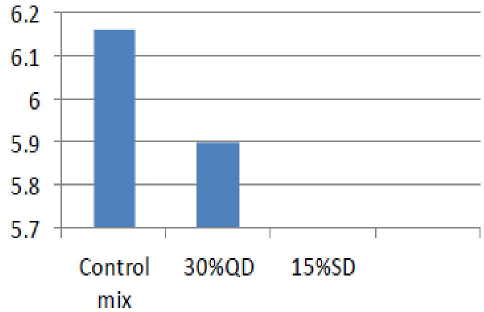

Fig 12: 7th Flexural strength of 30%QD And 15% SD

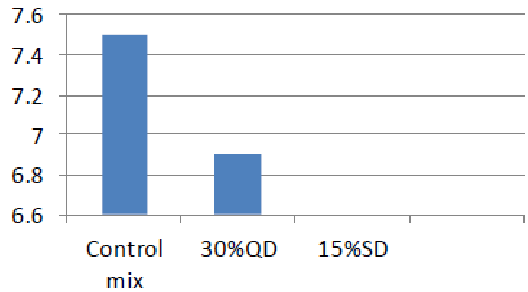

Fig13:28th Flexural strength of 30%QD And 15% SD

C) Coconut fibre (Coir)

C.Kodiarasan et al (2016) studied upon the effect of coconut fibre in concrete. In this experiment he carried out to determined the compressive strength, split tensile strength and flexural strength. The coir length used here are 7 and 15 cm. The curing for concrete is done at the age of 7 and 28 days. Coconut fibres is replaced cement by 2, 4 and 6 percent. The design mix used here is M25 and water cement ratio used is 0.48. 2% of 10 to 15 cm long is casted and then 4% and 6% respectively of 10 to 15cm is also casted. From the result he coclude that coir improves the compressive strength to a certain level because coir expansion captures the mininiaturized scale break present in the solids. Fibres of 25 mm long gives the greatest compressive strength and provides 0.75% expansion of coir fibres.

Faisal Shabbir et al (2015) studied about the effect of Coir and marble waste on concrete strength. He used Different percentages of Marble waste and Coir Fibre in formation of beams in flexure strength. He used a replaced of 0%, 2% and 2.5% of Coir Fibre(CF) and 0%, 2.5% and 3% of marble waste(WD).Cement used is OPC. From the table below it is observed that tensile strength increases (up to 10.2%) with replacement of 5% in proportion of2.5% CF and 2.5% MD. The testing is done for 28days beams and it is shown in the table below:

Sample	**OPC (%)**	**CF (%)**	**MD (%)**	**Flexural strength at 28days (MPa)**
S1	95	2.5	2.5	2.15
S2	95	2	3	2.11
S3	100	0	0	1.95

Table 27: Flexural strength at 28 days replacement of Coir

CHAPTER 4

RATIONALE and SCOPE OF STUDY

4.1 Rationale of the study

This work is carried out by partial replacement of cement with Fly-Ash, Natural Fine Aggregates by Sawdust and Coir as a fibre in the concrete. The main aim of this work is to check how these replacement brought out the positive effect on the fresh and hardened properties of the concrete.

The feasible of using this waste and by product as a partial replacement in a concrete will helps to reduce the illegal disposed into the landfills and also to reduce the carbon dioxide emission into the atmosphere.

4.2 Scope of the study

This work focus on the study of the effects of the addition of Fly Ash, Sawdust and coir in concrete as a partial replacement of Cement and Sand respectively. Coir here acts as a fibres in the concrete. The success of using this waste and by-product will not only reduce the emission of green gases emitted but also help in prevent the depletion of natural resources. It also acts as a small initiative steps of how to utilized waste and recycle products instead of totally depending on natural resources.

The goal here is to check the properties of concrete when fly ash, sawdust and coir is used. Those properties are Workability, Compressive strength, Split-Tensile strength and Flexural Strength.

CHAPTER 5
OBJECTIVES

5.1 Objective

The main objectives of this work is to find the optimum percentages of sawdust that can be used as a replacement of natural fine aggregates, provided fly-ash and coir constant which shows good strength as compared to those of normal concrete.

To meets and reach my objectives, following steps have to be taken into account:

- To find out the slump values of normal concrete and concrete containing fly ash, saw dust and coir and compare them.
- To find out the hardened behavior of concrete such as Compression, Split- tension and bending.
- To make the concrete economical
- To make concrete light-weight

CHAPTER 6

MATERIALS AND RESEARCH METHODOLOGY

6.1 General

Before the work is being carried out, the properties of materials is first examined. These materials are Cement of Ordinary Portland cement (OPC) of grade 43, Natural Fine Aggregates, Natural Coarse Aggregate, Fly-Ash of class-C, Sawdust and Coconut Fibre (Coir).

6.2 Materials

6.2.1. Ordinary Portland cement

Following are the properties of cement have been examined:

Type of cement used =Ordinary Portland cement (OPC) of Grade 43

Initial setting time=39minutes

Final setting time=3hours and 10 minutes=190 minutes

Fineness Modulus =1%

Specific gravity=3.18

Normal consistency=27%

6.2.2. Natural Fine aggregate

A) Sieve analysis of fine aggregate:

1Kg of the weight of fine aggregates is taken and the procedures is followed as per IS383.

Sieve seize	Weight of fine aggregate retained(gm.)	Percentage retained	Cumulative percentage retained	Percentage Passing	Permissible percentage as per Is 383
10mm	0	0	0	100	100
4.75mm	0	0	0	100	90-100
2.36mm	0	0	0	100	75-100
1.18mm	760	76.0	76.0	24	55-90
600Mm	164	16.4	92.4	7.6	35-59
300Mm	30	3.0	95.4	4.6	8-30
150Mm	44	4.4	99.8	0.2	0-10
Pan	2	0.2	100	0	

Table 28: Sieve analysis of Fine Aggregates

Hence natural fine aggregates is of zone 2 as per IS 383(1970)

B) Water absorption and specific gravity of fine aggregate

Weight of fine aggregate used = 500 grams (w_3)
Flask +Water +Fine aggregate = 1830 grams (w_1)
Flask+ Water = 1510 grams (w_2)
Weight of fine aggregate after oven dry = 494grams (w_4)

Water absorption = $(w_3-w_4)/w_4$= (500-494)/494 = 1.2%

Specific gravity = $w_4 /[w_3-(w_1-w_2)]$=494/[500-(1830-1510)] = 2.74

6.2.3. Natural Coarse aggregate

A) Sieve analysis of coarse aggregate

The weight of sample of coarse aggregate tested was=3.480Kg and the procedure was followed as per IS 383 as shown in table below:

IS sieve size in(mm)	Weight of aggregate retained in(gm.)	Percentage of weight retained	Cumulative percentage of total weight retained	Percentage Passing	Permissible value as per Is 383
20	60	1.73	1.73	98.27	85-100
16	1438	41.63	43.36	56.64	
12.5	1404	40.64	84	16	
10	468	13.54	97.54	2.46	0-20
4.75	84	2.46	100	0	0-5
Pan	0	0			

Table 29: Sieve analysis of Coarse Aggregates

Aggregate is single sized of 20mm size

B) Water absorption of coarse aggregate

Weight of coarse aggregate after surface dry (w_1) = 2.998 Kg

Weight of coarse aggregate after oven dry (w_2) = 2.984Kg

Water absorption formula= $(w_1-w_2)/w_1$ = [(2.998-2.984)/2.998]x100 = 0.47%

The water absorption of coarse aggregate used is 0.47%

C) *Specific gravity of coarse aggregate

Specific gravity is defined as the ratio of the mass of a substance to the mass of a reference substance for the same given volume.

In my project the reference substance used was water.

Weight of aggregate used = 3.60Kg
(Basket +coarse aggregate) in air = 4.8 Kg
Basket only suspended in air = 0.9Kg
Aggregate only in air = 4.8kg-0.9kg = 3.9kg
Aggregate with basket fully submerged in water = 2.9 Kg (w_3)
Empty basket fully submerged in water=0.8 Kg (w_2)
Weight of coarse aggregate after oven dry = 3.454kg
Specific gravity=w_4/ [w_4-(w_3-w_2)] =3.454kg /[3.454kg-(2.9kg-0.8kg)]=2.55

The specific gravity of coarse aggregate used is 2.55

6.2.4. Water

Water used all along this research work either in casting or in curing process was free from any detrimental contaminant and was as per IS 456-2000 requirements.

6.2.5. Fly-Ash

Fly Ash of class-C collected and sieved through a sieve size of 90 microns.

6.2.6. Sawdust

Sawdust was collected and free from those small bark or any lump pieces of wood. It was sieved through a sieve size of 1.18 mm.

6.2.7. Coir

Coir collected was soaked in water for 2 hours and then slashed to various length and allowed to dry for 24 hours.

6.3. Design Mix of M25

- Grade of concrete=M 25
- Cement type=OPC 43 grade
- Max size of coarse aggregate=20mm
- Max water/cement ratio=0.5
- Exposure condition=severe
- Maximum cement content=450kg/m^3

Data required for design mix obtained from testing are:

- Specific gravity of cement=3.18
- Specific gravity of CA=2.55
- Specific gravity of FA=2.74
- Water absorption for CA=0.47%
- Water absorption for FA=1.2%

- Fine aggregate zone=2

Design mix steps:

1. Target mean strength

$F'_{ck} = Fck + t.s$

F'_{ck} = 25+ (1.65x4) = 31.6 N/mm^2

2. Selection of water cement ratio

From table 5 of IS456-2000, water/cement = 0.5

3. Selection of water content

From table 2 of IS 10262-2009 for CA 20mm

Water 186 Kg (slump 50-75)

For 100 mm slump, follow clause 4.2 of IS 10262-2009

Water=186+ (0.06x186) = 197.16 liters

1) Cement content calculation

W/C ratio=0.5

Cement=197.16/0.5=394.32kg

2) Proportioning of CA and FA

W/c ratio = 0.5

Volume of 20mm CA in concrete=0.56

W/c ratio used =0.5

Volume of FA in concrete=1-0.56=0.44

3) Mix calculations

Cement volume = mass of cement/ (specific gravityx1000) = 438.13/ (3.18x1000) = 0.124m^3

Water volume=mass of water/ (specific gravityx1000) =197.16/ (1x1000) = 0.197 m^3

Volume of all in aggregate (e) =1-(0.124+0.197) = 0.679

Mass of CA=0.679x0.56x2.55x1000=969.612kg

Mass of FA=0.679x0.44x2.74x1000=818.60kg

4) Mix proportion
Cement=394.32/394.32=1

FA=818.60/394.32= 2.07

CA=969.612/394.32=2.45

Ratio of Mix= 1:2.07:2.45 (i.e. of cement, fine aggregates and coarse aggregates respectively).

6.4. Methodology

Fly Ash was sieved through a sieve size of 90 microns, Sawdust was sieved through a sieve size of 1.18 mm, and Coir was soaked in water for 2 hours and then slashed to various length and allowed to dry for 24 hours.

In this experiment M25 grade of concrete was used, made with Ordinary Portland Cement (OPC) of Grade 43 with water cement ratio of 0.5, Natural Fine Aggregates, 10 mm and 20 mm Coarse Aggregates. Slump test was performed to check the workability of the concrete and the slump value for control mix was obtained as 85 mm.

Here Fly ash and Coir were kept constant at 20% and 4% per weight of cement, respectively and only Sawdust was varied with respective %ages. The work was carried out in ten batches:

Batch 1 was normal concrete without replacement or the Control Mix

Batch 2 was concrete with 20% replacement of cement by fly ash

Batch 3 was concrete with 4% coir

Batch 4 was concrete with 20% fly ash replacement and 4% coir to quantity of cement added

Batch 5 concrete with 20% fly ash replacement, 4% coir and 5% sawdust replacement

Batch 6 concrete with 20% fly ash replacement, 4% fibre and 10% sawdust,

Batch 7 concrete with 20% fly ash, 4% coir and 15% sawdust

Batch 8 with 20% fly ash, 4% coir and 20% sawdust

Batch 9 with 20% fly Ash, 4% coir and 25% sawdust

Batch 10 with 20% fly ash, 4% coir and 30% sawdust.

In this work three cubes, three cylinders and three beams were casted for each Batch. Casted for 7 days and 28 days of curing. Cubes of standard size 150*150*150 mm dimension were used, Cylinders of diameter 100 mm and Height 200 mm were used and beams size of 500 mm length, 100 mm breadth and 100 mm depth were used. The rate of testing for cubes was 5.2 KN/sec, cylinders 2.1KN/sec and for beams is 0.1KN/sec.

CHAPTER 7

RESULTS AND DISCUSSION

7.1. Fresh Properties of concrete

7.1.1 Workability:

Workability is defined as the ease with which the concrete is placed and compacted homogeneously without showing any bleeding or segregation. Here we checked the workability from slump and it was found to be 85 mm. The value of slump decreases with the increase in the amount of Sawdust.

7.2. Hardened Properties of concrete

7.2.1. Compressive Strength: For 7 and 28 days

The compressive strength tests for 7 and 28 days result show that up to 15 % replacement by Sawdust, provided 20 % Fly Ash and 4 % coir addition shows good compressive strength than control mix and then it gradually decreases with the increase in the %ages replacement of sawdust, as shown in figures. This is because of the superior adhesive properties of sawdust that provide a better strength to the concrete. Maximum load applied in Newton at which the cubes failed divided by the cross sectional areas of the cubes in mm^2 gives the compressive strength of that particular cubes in N/mm^2 or MPa. Concrete is good in compression and the following are the average of 7 and 28 days result for cubes as shown in the table and summarized in figure.

S.No	Mix	7days Compressive strength (N/mm^2)	28 days Compressive strength (N/mm^2)
1	Normal Mix	25.45	32.8
2	Normal mix +20% replacement of Fly Ash(FA)	25.89	33.7
3	Normal Mix+4% coir addition	25.3	32.0
4	Normal mix+20% Fly Ash(FA)+4% coir	25.7	33.36
5	20%Fly Ash(FA)+4%coir+5%sawdust(SD)	26.14	34.19
6	20%Fly Ash(FA)+4%coir+10%sawdust(SD)	26.29	34.37
7	20%Fly Ash(FA)+4%coir+15%sawdust(SD)	27.23	34.52
8	20%Fly Ash(FA)+4%coir+20%sawdust(SD)	24.01	29.86
9	20%Fly Ash(FA)+4%coir+25%sawdust(SD)	23.6	29.78
10	20%Fly Ash(FA)+4%coir+30%sawdust(SD)	22.56	28.72

Table 30: Test result for 7 and 28 days Compressive Strength of Cubes

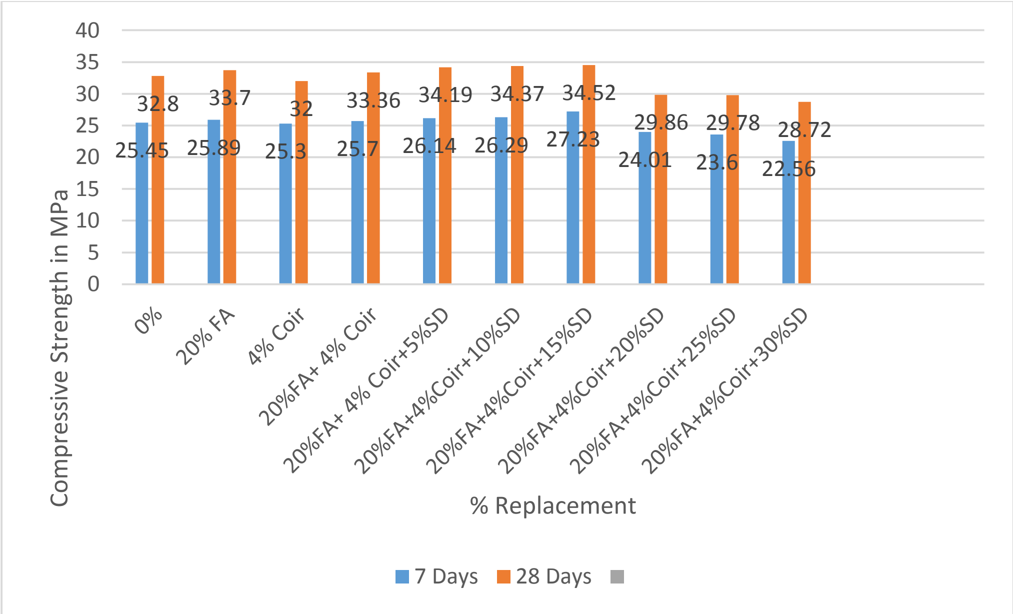

Figure 14: Test results of cubes for 7 and 28 days Compressive Strength

7.2.2. Split Tensile Strength: For 7 and 28 Days

The split tensile strength tests show that up to 20 % of sawdust replacement provided 20 % Fly Ash and 4% coir shows good split tensile strength than Control Mix and then gradually decreases with increases in percentage replacement of sawdust. Split tensile strength is measured as per IS 5816:1999. To find such strength, we follows formula fct = 2p/ πld where p is the maximum load applied to cylinders, π is a constant, l is the height and d is the diameter of the cylinder. Average result of cylinders for 7 and 28 days are shown in table and summarized in figure below.

S.No	Mix	7days Split-Tensile Strength (N/mm2)	28days Split Tensile Strength (N/mm^2)
1	Normal Mix	1.96	2.57
2	Normal mix +20% replacement of Fly Ash(FA)	2.1	2.68
3	Normal Mix+4% coir addition	2.18	2.74
4	Normal mix+20% Fly Ash(FA)+4% coir	2.19	2.78
5	20%Fly Ash(FA)+4%coir+5%sawdust(SD)	2.2	2.82
6	20%Fly Ash(FA)+4%coir+10%sawdust(SD)	2.28	2.88
7	20%Fly Ash(FA)+4%coir+15%sawdust(SD)	2.29	2.93
8	20%Fly Ash(FA)+4%coir+20%sawdust(SD)	2.34	3.01
9	20%Fly Ash(FA)+4%coir+25%sawdust(SD)	1.92	2.43
10	20%Fly Ash(FA)+4%coir+30%sawdust(SD)	1.86	2.38

Table 31: 7 and 28 days result split tensile strength

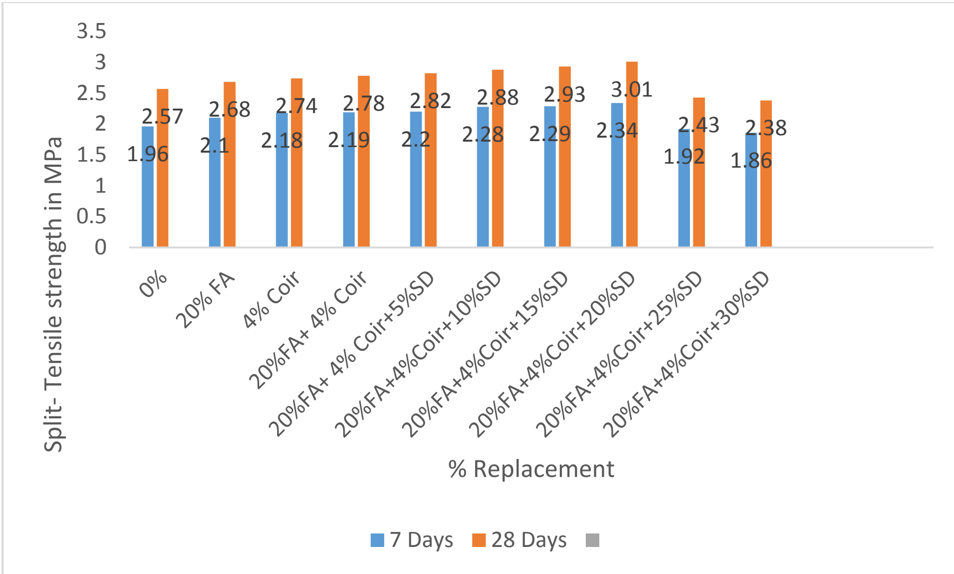

Figure 15: Test result of cylinders for 7 and 28 days Split-Tensile strength

7.2.3. Flexural Strength: For 7 and 28 Days

The flexural strength tests of beams up to 15% replacement sawdust provided 20% Fly Ash, 4% coir show good flexural strength than Control Mix and gradually decreases with increase in the percentage sawdust replacement. This is because of the high fibre content which captured and minimized the splits present in the solids and hence improved the flexural strength of the beams. Flexural strength is measured following Indian Codes 516:1959. $Fb = pl/bd^2$ is the formula adopted to calculate bending strength, where p is the maximum load applied to which the beam failed, l is the length of a beam, b is the breadth and d is the depth of a beams. Average result for 7 and 28 days flexural strength are shown in table and summarized in figure.

S.No	Mix	7days Flexural Strength (N/mm^2)	28days Flexural Strength (N/mm^2)
1	Normal Mix	5.55	8.75
2	Normal mix +20% replacement of Fly Ash(FA)	6.35	8.95
3	Normal Mix+4% coir addition	6.6	9.3
4	Normal mix+20% Fly Ash(FA)+4% coir	6.7	9.45
5	20%Fly Ash(FA)+4%coir+5%sawdust(SD)	7.1	9.85
6	20%Fly Ash(FA)+4%coir+10%sawdust(SD)	7.25	9.95
7	20%Fly Ash(FA)+4%coir+15%sawdust(SD)	7.45	10.15
8	20%Fly Ash(FA)+4%coir+20%sawdust(SD)	5.2	8.6
9	20%Fly Ash(FA)+4%coir+25%sawdust(SD)	4.95	8.2
10	20%Fly Ash(FA)+4%coir+30%sawdust(SD)	4.75	7.6

Table 32: 7 and 28 days result flexural strength

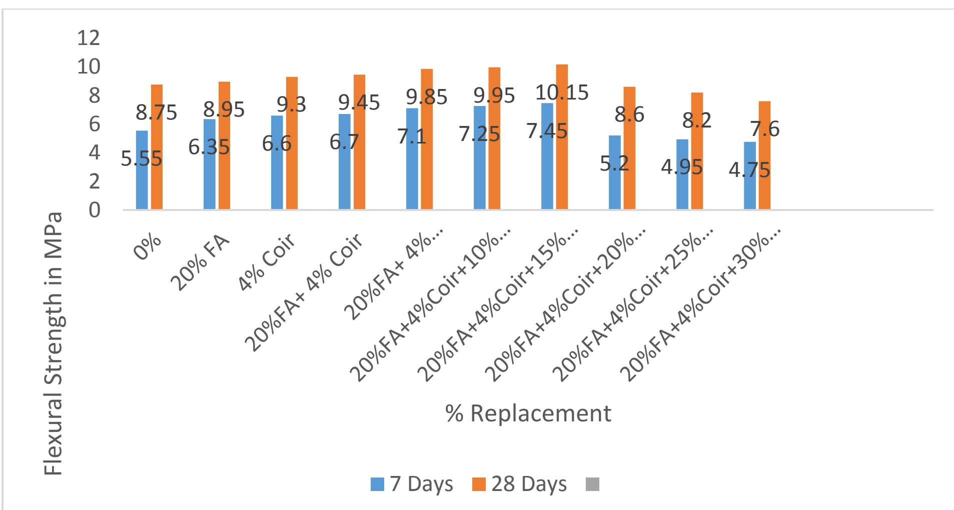

Figure 16: Test result of Beams for 7 and 28 Days Flexural strength

7.3. Weight Reduction

The weight of a concrete cubes is taken for recording the concrete reduction properties in a concrete when various percentages of replacement material is added. It is found that upto8.67% reduction in weight when 30% of natural fine aggregates is replaced by sawdust. The weight reduction of cubes for various percentage replacement is shown as in table and also is summarized in figure below. From figure shown that weight of a concrete decreases with more replacement added.

S.No	Mix	Weight of 1 cube in Kg	Weight reduction in %
1	Normal Mix	8.54	0
2	Normal mix +20% replacement of Fly Ash(FA)	8.4	1.64
3	Normal Mix+4% coir addition	8.32	2.6
4	Normal mix+20% Fly Ash(FA)+4% coir	8.30	2.82
5	20%Fly Ash(FA)+4%coir+5%sawdust(SD)	8.27	3.17
6	20%Fly Ash(FA)+4%coir+10 %sawdust(SD)	8.22	3.75
7	20%Fly Ash(FA)+4%coir+15%sawdust(SD)	8.13	4.81
8	20%Fly Ash(FA)+4%coir+20%sawdust(SD)	8.07	5.51
9	20%Fly Ash(FA)+4%coir+25%sawdust(SD)	7.89	7.62
10	20%Fly Ash(FA)+4%coir+30%sawdust(SD)	7.80	8.67

Table 33: Weight Reduction of a Concrete

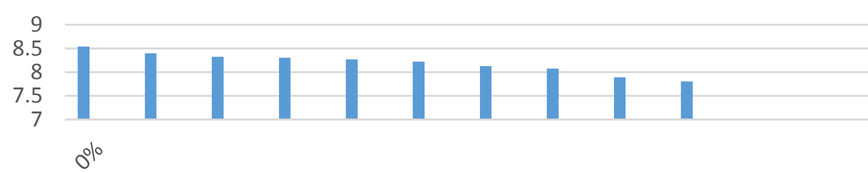

Fig 17: weight reduction vs. % replacement

7.4. Cost Analysis

The cost of a concrete is reduced up to 105.73 per cubic metre of concrete which comes as 2.7% to the total cost per cubic metre of a concrete. It is found that with more the percentages replacement, the prices also decreases. This will helps in making the concrete more eco-friendly and especially in tropical areas where sawdust is present abundantly at a very cheap in prices. Hence it also make the concrete more economical. The cost analysis for concrete with replacement is shown in table 34 and for concrete with no replacement is shown in table 35.

S.No	Material	Weight(Kg)/m^3	Cost per Kg	Total cost of concrete/m^3
1	Cement	215.62	6	1293.72
2	Natural Fine aggregates	465.31	2	930.62
3	Natural Coarse aggregates	582.12	2.5	1455.3
4	Fly-Ash	21.97	3	65.91
5	Sawdust	26.52	0.5	13.26
				Total=Rs.3758.81

Table 34: Cost analysis of concrete with replacement

S.No	Material	Weight(Kg)	Cost per Kg	Total cost
1	Cement	237.60	6	1425.6
2	Natural Fine aggregates	491.83	2	983.66
3	Natural Coarse aggregates	582.12	2.5	1455.3
4	Fly-Ash	0	3	0
5	Sawdust	0	0.5	0
				Total=Rs.3864.54

Table 35: Cost analysis of concrete without replacement

7.5. Laboratory Investigation

7.5.1 Investigation for cement

Ordinary Portland cement (OPC) of grade 43 is adopted in this research work. Following are the laboratory equipment adopted for testing the properties of cement:

- Vicat apparatus: Consistency test, initial and final setting time of cement is carried out using this apparatus
- Weighing balance: Used for weighing cement sample
- Trowel: Used for collecting cement, mixing cement

7.5.2 Investigation for fine aggregate and coarse aggregate

The fine aggregate and coarse aggregate adopted to use in this study were first tested and these are some of the following laboratory equipment used for testing them:

- Thermostatically controlled oven machine: Used for drying the sample
- Pycnometer: specific gravity of fine aggregate is tested by using this apparatus
- Weighing balance: to measure the sample used
- IS Sieve : sample is sieve to the desired size by these standard sieve size

7.5.3. Investigation for Fly-Ash, Sawdust and Coir

Fly-Ash of class-C were collected and sieves with a sieve size of 90microns.

Sawdust collect from mills, brought and is free from those bark or small lump of a tree. It is sieve with a standard sieve size of 1.18mm.

Coir was soaked in water for 2 hours and then slashed to various length and allowed to dry for 24 hours.

7.6. Testing Investigation

7.6.1. Investigation test for Compressive Strength

Cubes specimen is undergo testing by Compression Testing Machine (CTM). The load capacity of this machine used is of 1000 KN. Specimen are placed and the procedure follows as per IS 516. Rate of testing is set 5.1 KN/sec. Compressive strength is calculated as Maximum load applied in Newton at which the cubes failed divided by the cross sectional areas of the cubes in mm^2 gives the compressive strength of that particular cubes in N/mm^2 or MPa .The setting of specimen is shown in Figure below

Fig 18: Compressive strength testing

7.6.2. Investigation test for Split-Tensile Strength

Split-tensile strength is determine using the formula $f_{ct}=2p/\pi ld$, where p is the maximum load applied to cylinders, π is a constant, l is the height and d is the diameter of the cylinder. Split tensile strength is measured as per IS 5816:1999. The setting of specimen is shown in fig below:

Fig 19: Split-Tensile strength testing alignment

7.6.3. Investigation test for Flexural Strength

Flexural strength is calculated using formula $f_b=pl/bd^2$, where p is the maximum load applied to which the beam failed, l is the length of a beam, b is the breadth and d is the depth of a beams.

Flexural strength is measured as per IS 516:1959. The setting of specimen is shown in figure below:

Fig 20: Flexural Strength testing

CHAPTER 8

CONCLUSION and FUTURE SCOPE

8.1. Conclusion

Based on the experimental work it can be concluded that for 7 and 28 days curing up to 20 % of sawdust can be used in concrete because it provides good strength. For Compressive and flexural strengths up to 15 % sawdust shows good results whereas for split tensile strength, up to 20 % sawdust replacement can be made in concrete.

The cost of a concrete is reduced up to 105.73 per cubic metre of concrete which comes as 2.7% to the total cost per cubic metre of a concrete. It was found that upto8.67% reduction in weight when 30% of natural fine aggregates is replaced by sawdust.

The good strength shown by sawdust is due to its superior adhesion which captures and minimizes the splits occurring in the solid and also, the good pozzolonic property of the Fly Ash aids in this mechanism. The concrete also presents better ease of compaction as compared to that of control mix.

Furthermore, the introduction of sawdust in the concrete also helps to reduce the improper disposing of the solid waste into landfills and thereby making the concrete more eco-friendly.

8.2. Future Scope of the Study

For further research and future studies I would like to recommend that following of the test need to be performed.

- Fire Resistance
- The use of Plastic Aggregates of a different type than HDPE
- Micro-structure Analysis using Scanning Electron Microscopy
- The use of Plastic Aggregates in Self Compacting Concrete
- Torsion Resistance
- Shear Resistance
- Impact Resistance
- Rapid Chloride Permeability Test
- Porosity
- X-Ray Diffraction

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Appendix

1. Fly-ash is categories into Class-C and Class-F. They are classified based upon the chemical composition. Fly-ash with high quantity of lime is categorized as Class-C fly-ash. The two most properties check upon fly ash are fineness and lime content because these two pose a great effect upon the demand of air content and water absorption by the concrete which on the other hand greatly affect the strength and durability of concrete.

2. The Ordinary Portland cement are mainly used in construction when there is absence exposure to sulphates in the soil or groundwater. They are manufacture from those of calcareous material like limestone or chalk and argillaceous materials such as shale or clay. To turn these material into a fine cement they need undergoes crushing, milling and following are the components contained in OPC cement:

- . Gypsum ($CaSO_4.2h_2O$): found together with lime stone.
- Aluminum Oxide ($Al_2 O_3$): from bauxite, recycled aluminum, clay.
- Silica Oxide(SiO_2): from sand, old bottles, clay or argillaceous rock
- Lime or Calcium oxide (Cao): from limestone, chalk, shells, shale or calcareous rock.
- Iron Oxide (Fe_2O_3): from clay, iron ore, scrap iron and fly ash.

3. Sawdust is a by-product of a wood by mean of cutting, grinding or sanding with saw or other industrial tool. They are in the formed of fine particles. Sawdust need to be keep properly and stored away from heat because they can catch heat easily when exposed closed to heat.

4. Coir is commonly known as coconut fibres. They are brown in color. Apart from providing a good tensile and flexural strength they also making the concrete light concrete.