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"Experimental Investigation of Reinforced Pre-cast Wall Panels by using Sisal fiber"

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Abstract*— A research project was conducted to develop concrete material that contains with 0%, 30%, 40% & 50% of 'class F' fly ash as partial replacement of cement incorporating with 0.0%, 0.10%, 0.20% & 0.30% of sisal fiber by volume of concrete, having length 25 mm to 30 mm would be suitable for precast concrete wall panels. By identifying and utilizing the special properties of fly ash concrete incorporating with sisal fiber materials, it is also possible to produce concrete elements with improved strength and durability properties used in construction industries having low cost products such as precast wall panels. Test were performed for that concrete mixture is for Compressive strength, Splitting tensile strength, Pullout (bond stress) strength, Flexural strength and Impact strength at age of 7th and 28th day. The all tests were performed for fresh concrete properties used for precast wall panels. Also for each series the cost analysis as compared to strength is also determined.

Index terms: **Compressive strength, Flexural strength, 'F class' fly ash, Impact strength, Ordinary portland cement, Pullout strength, Sisal fiber, splitting tensile strength.**

I. INTRODUCTION

It is the action of human beings that determines the worth of any material. Materials having potential for gainful utilization remain in the category of waste until its potential is understood and put to right use. Fly ash is one such example, which has been treated as a waste material in India, till a decade back, and has now emerged not only as a resource material, but also as an environment as savior. The Indian market is extremely receptive to Clean Development Mechanism (CDM), with a fair amount of appreciation both by the government and the industry. Developed countries like USA account for 30% of global emissions, while India contributes about 3% of the global Green House Gases (GHG) against the global average of 5.2 %. Use of fly ash in various products and partly substituting cement at current annual levels in India saves generation of CO_2 by 25 million tones, good quality lime by 35 million tones and coal by 15 million tons a year. Building materials sometimes account for as much as 75% of the cost of low cost houses. India has vast resource of different natural fibers viz. jute sisal, banana, coir and so and so forth, which are abundantly available in many parts. Fiber reinforced concrete (FRC) may be defined as a composite materials made with Portland cement, aggregate, and incorporating discrete discontinuous fibers. Plant fibers are light compared to glass, carbon and aramid fibers. The biodegradability of plant fibers can contribute to a healthy ecosystem while their low cost and high performance fulfills the economic interest of industry. When natural fiber-reinforced plastics are subjected, at the end of their life cycle, to combustion process or landfill, the released amount of CO_2 of the fibers is neutral with respect to the assimilated amount during their growth. These materials should not pollute the environment.

PROBLEM STATEMENT

Fly ash is one, which has been treated as a waste material in India Also large amount of agricultural waste is disposed off in most of the tropical countries especially in Asian developing countries such as India, Thailand, Philippine and Malaysia. If waste cannot be disposed properly it will lead to social environmental problem like waste disposal has become one of the major problems.

OBJECTIVES AND SCOPE

In the present proposal it is planned to conduct lab investigation properties of high volume fly ash concrete incorporating sisal fiber used for making pre-cast wall panels are presented in this paper. For this investigation, initially four number of concrete mixtures were made with 0%, 30%, 40%, & 50% of 'class F' fly ash as partial replacement of ordinary portland cement incorporating with 0.0%, 0.10%, 0.20% & 0.30% of sisal fiber by volume of concrete having length 25 mm to 30 mm. Comparing the control concrete mix (Ordinary Portland cement concrete) with various percentage fly ashes concrete incorporating with sisal fiber, effect of fly and sisal fiber on concrete properties. The all relevant properties of fresh concrete performed for above series concrete mixture is compressive strength, Splitting tensile strength, Pullout strength, Flexural strength and Impact strength at the ages of 7th day and 28th day curing .

AIM OF RESEARCH [FUTURE ENHENCEMENT]

Large volume of fly ash produced globally and Percentage utilization in concrete is still not much probably because of strength reduction of concrete with influence of fly ash at early ages. Also Natural fibers are found almost in every country and locally available in that area, it's processing not energy intensive as compared to carbon fiber. It having low cost in processing and it available in large amount, it also disposed in most of the tropical countries as agriculture waste. So present research aims is to investigate the effect of using high volume fly ash incorporating with sisal fiber in ordinary Portland cement concrete used for constructing pre-cast wall panels.

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II. LITERATURE REVIEW

The use of fly ash in concrete at proportions ranging from 30% to 60% of total cementious binder has been studied extensively over the last twenty years and the properties of blended concrete are well documented. Not much research has been reported on the effects of natural fibers on the properties of mortar, concrete, fly ash concrete.

One of the major developments in the area of fly ash utilization in concrete has been the technology of high performance, high volume fly ash concrete by Malhotra and his associates [1, 2]. High volume fly ash concrete has emerged as a construction material in its own right. These concrete generally contain more than 40% fly ash by mass of total cementious material [1 to 7]. Mehta has reported extensively on high volume fly ash concrete. Concrete contain high volumes of class F fly ash exhibited excellent mechanical properties and good durability [8]. Siddique have explored the possibility of using Class F fly ash in concrete in high volume, either as partial replacement of cement of cement or fine aggregate. Results have indicated that Class f fly ash could be suitable used in concrete for certain applications [9 to 11]. Berry has reported about the hydration process in high volume of concrete [12] and Zhang indicated the microstructure, crack propagation and mechanical properties of concrete made with high volumes of fly ashes [13]. Lewis G., Mirihagalia P. conducted test on mortar reinforced with natural fibers such as water reed, elephant grass, plantain and musamba. Based on the test results they concluded that among the four types of natural fibers, elephant grass showed greatest promise as a reinforcing material [14]. Castro J., Naaman A.E. used natural fibers Lechuguilla and Maguey of agave family have tensile strength up to 552 MPa, and fibers did not had significant difference in either mechanical properties or the reinforcing efficiency of Lechuguilla and Maguey fibers[15]. Mawenya A.S. reviewed the literature on sisal fiber reinforced concrete, and concluded that sisal fibers have significant mechanical properties that make them eligible as reinforcement for concrete [16]. Fageiri O.M.E. reported that the results of an experimental investigation on the possibility of using Kenaf fibers to reinforce rich cement sand mortar to produce corrugated sheets. He has concluded that the tensile properties of Kenaf fibers are comparable to those of some natural fibers Sisal and synthetic fibers polypropylene that are used to reinforce a low tensile strength matrix, and addition of Kenaf fibers enhances the bending and impact resistance of sheets [17]. Mwamila B.L.M. has proposed the idea of reinforcing concrete beams with the twines made of sisal fibers [18]. Siddique R. extensively reported the effects of natural San fibers on the properties of concrete and fly ash concrete [19].

III. MATERIALS AND TESTING

A. Cement

Locally produced Ordinary Portland Cement (OPC) Ultratech cement limited make that confirmed to IS 8112:1989 [20] is used in the investigation of the sisal fiber reinforced pre-cast wall panel.

B. Sand

Local river sand used as fine aggregate in concrete mixtures make that confirmed to IS:383-1970 [21].

C. Fly ash

Pozzocrete 60 is used as fly ash. P60 is obtained from Dirk India Pvt. Ltd. Maharashtra, India confirming to IS-3812-part-I [24]

D. Sisal fiber

Sisal fibers were used in the investigation. Fibers were obtained and brought from the sisal leaf from the Nakane Dam area in Dhule Taluka and Dist. Dhule.

IV. MIXTURE PROPERTION

Initially, four high-volume fly ash concrete mixtures containing 0%, 30%, 40% and 50% of 'class F' fly ash as replacement of ordinary portland cement were proportioned as per Indian Standard Specifications IS: 10262-1982 [23] incorporating with various percentages of sisal fibers (0.0%, 0.10%, 0.20% & 0.30%) by volume of concrete were added in each concrete mix. Mix proportions of various percentage of fly ash (0%, 30%,40% & 50%) and sisal fiber were given in Table 1, Table 2, Table 3 and Table 4.

Table 1: Casting chart for Series A

Series	A			
Mix number	A-1	A-2	A-3	A-4
Identification mark	Colorless	Colorless	Colorless	Colorless
Fly ash %	0	0	0	0
Sisal fiber %	0	0.10	0.20	0.30
Cement Kg/m3, C	368.00	368.00	368.00	368.00
Fly ash Kg/m3, FA	-	-	-	-
Sisal fiber Kg/m3	-	1.37	2.74	4.11
Water Kg/m3, W	191.36	191.36	191.36	191.36
W/ (C+FA)	0.52	0.52	0.52	0.52
Fine agg. Kg/m3	736.00	736.00	736.00	736.00
Coarse agg. 20 mm Kg/m3	668.00	668.00	668.00	668.00
Coarse agg. 10 mm Kg/m3	445.00	445.00	445.00	445.00
Super plasticizer, L/m3	-	-	-	-
Slump mm	65.00	60.00	50.00	50.00
Air Temperature °C	24	25	25	24
Concrete Temperature °C	26	26	27	26
Concrete Density Kg/m3	2408.36	2409.73	2411.10	2412.47

Table 2: Casting chart for Series B

Series	B			
Mix number	B-1	B-2	B-3	B-4
Identification mark	Blue color	Blue color	Blue color	Blue color
Fly ash %	30	30	30	30
Sisal fiber %	0	0.10	0.20	0.30
Cement Kg/m3, C	258.00	258.00	258.00	258.00
Fly ash Kg/m3, FA	110.00	110.00	110.00	110.00
Sisal fiber Kg/m3	-	1.37	2.74	4.11
Water Kg/m3, W	187.68	191.36	191.36	191.36

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W/ (C+FA)	0.51	0.51	0.51	0.51
Fine agg. Kg/m3	736.00	736.00	736.00	736.00
Coarse agg. 20 mm Kg/m3	668.00	668.00	668.00	668.00
Coarse agg. 10 mm Kg/m3	445.00	445.00	445.00	445.00
Super plasticizer, L/m3	-	-	-	-
Slump mm	90.00	85.00	80.00	75.00
Air Temperature °C	25	25	24	25
Concrete Temperature °C	26	26	25	26
Concrete Density Kg/m3	2404.68	2406.05	2407.42	2408.79

Table 3: Casting chart for Series C

Series	C			
Mix number	C-1	C-2	C-3	C-4
Identification mark	Red Color	Red Color	Red Color	Red Color
Fly ash %	40	40	40	40
Sisal fiber %	0	0.10	0.20	0.30
Cement Kg/m3, C	221.00	221.00	221.00	221.00
Fly ash Kg/m3, FA	147.00	147.00	147.00	147.00
Sisal fiber Kg/m3	-	1.37	2.74	4.11
Water Kg/m3, W	184.00	184.00	184.00	184.00
W/ (C+FA)	0.50	0.50	0.50	0.50
Fine agg. Kg/m3	736.00	736.00	736.00	736.00
Coarse agg. 20 mm Kg/m3	668.00	668.00	668.00	668.00
Coarse agg. 10 mm Kg/m3	445.00	445.00	445.00	445.00
Super plasticizer, L/m3	-	-	-	-
Slump mm	98.00	95.00	90.00	85.00
Air Temperature °C	24	25	26	27
Concrete Temperature °C	26	26	27	28
Concrete Density Kg/m3	2401.00	2402.37	2403.74	2405.11

Table 4: Casting chart for Series D

Series	D			
Mix number	D-1	D-2	D-3	D-4
Identification mark	Yellow Color	Yellow Color	Yellow Color	Yellow Color
Fly ash %	50	50	50	50
Sisal fiber %	0	0.10	0.20	0.30
Cement Kg/m3, C	184.00	184.00	184.00	184.00
Fly ash Kg/m3, FA	184.00	184.00	184.00	184.00
Sisal fiber Kg/m3	-	1.37	2.74	4.11
Water Kg/m3, W	180.32	180.32	180.32	180.32
W/ (C+FA)	0.49	0.49	0.49	0.49
Fine agg. Kg/m3	736.00	736.00	736.00	736.00
Coarse agg. 20 mm Kg/m3	668.00	668.00	668.00	668.00
Coarse agg. 10 mm Kg/m3	445.00	445.00	445.00	445.00
Super plasticizer, L/m3	-	-	-	-
Slump mm	105.00	95.00	95.00	90.00
Air Temperature °C	26	26	27	27
Concrete Temperature °C	27	28	28	28
Concrete Density Kg/m3	2397.32	2398.69	2400.06	2401.43

V. RESULT AND DISCUSSION

COMPRESSIVE STRENGTH TEST

7 Day Test

Results for Compression strength of the composite for all the series at age of 7th day is presented Bar chart figure 5.1 present graphically.

Concrete mixture of 0%, 30%, 40% and 50% fly ash incorporating with 0.0% sisal fiber i.e. control section of series A1, B1, C1 and D1 achieved compressive strengths of **16.15, 15.15, 14.20** and **13.05** MPa respectively, incorporating with 0.10% sisal fiber having compressive strength of respectively Series mixtures A2, B2, C2 and D2 achieved was **16.90, 15.60, 15.17** and **14.13** MPa respectively, incorporating with 0.20% sisal fiber having compressive strength of respectively Series mixtures A3, B3, C3 and D3 achieved was **17.10, 16.10, 15.47** and **14.25** MPa respectively and incorporating with 0.30% sisal fiber having compressive strength of respectively Series mixtures A4, B4, C4 and D4 achieved was **16.40, 15.35, 14.30** and **14.17** MPa respectively.

It is evident from Bar chart Figure 5.1 that for a particular fly ash percentage, compressive strength of fly ash concrete mixtures decreased with increases in fly ash percentage for control section A1, B1, C1 and D1. Also the increase in fiber percentage at 7th day compressive strength increased with increased in sisal fiber percentage up to 0.20% but after addition of sisal fiber more than 0.20% compressive strength decreases at 7th day. In control section there decreases in compression strength with increase in fly ash percentage because there was no pozzolonic reaction of fly ash take place at 7th Day. But at later ages after 28th day the pozzolonic reaction of fly ash takes place and increases in compressive strength. However, for all control section of respective series A1, B1, C1 and D1 decreases in compressive strength was **19%** with increases in percentage of fly ash content from 0% to 50% at the age of 7th day.

For series A, B, C and D, the increased in compressive strength up to 0.20% sisal fiber was **5.88%, 6.27%, 8.94%** and **9.20%** and after addition of sisal fiber beyond 0.20% was decreases suddenly of respective series. But mainly note that the increase in percentage of compressive strength was increased nearly up to **56%** with increases in fly ash percentage from 0% to 50% with incorporating sisal fiber 0.20% at the age of 7th day.

28th Day Test

Results for Compression strength of the composite for all the series at age of 28th Day is presented in Bar chart figure 5.2 present graphically.

Concrete mixture of 0%, 30%, 40% and 50% fly ash incorporating with 0.0% sisal fiber i.e. control section of series A1, B1, C1 and D1 achieved compressive strengths of **27.95, 26.60, 24.20** and **23.10** MPa respectively, incorporating with 0.10% sisal fiber having compressive strength of respectively Series mixtures A2, B2, C2 and D2

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achieved compressive strengths of **28.30, 26.95, 24.80 and 23.90** MPa respectively, incorporating with 0.20% sisal fiber having compressive strength of respectively Series mixtures A3, B3, C3 and D3 achieved compressive strengths of **28.70, 27.50, 25.30** and **24.50** MPa respectively and incorporating with 0.30% sisal fiber having compressive strength of respectively Series mixtures A4, B4, C4 and D4 achieved compressive strengths of **28.05, 26.90, 24.40** and **23.45** MPa respectively.

It is evident that for a particular fly ash percentage, compressive strength of fly ash concrete mixtures decreased with increases in fly ash percentage for control section A1, B1, C1 and D1. Also the increase in fiber percentage at 28th day compressive strength increased with increased in sisal fiber percentage up to 0.20% but after addition of sisal fiber more than 0.20 % compressive strength decreases at 28th day. In control section there decreases in compression strength with increase in fly ash percentage because there was no pozzolonic reaction of fly ash take place at 28th Day. But at later ages after 28th day the pozzolonic reaction of fly ash takes place and increases in compressive strength. However, for series A, B, C and D, the increased in compressive strength up to 0.20% sisal fiber was **2.68%, 3.00%, 4.55%** and **6.06%,** after addition of sisal fiber beyond 0.20% was decreases suddenly of respective series.

For all control section of respective series A1, B1, C1 and D1 decreases in compressive strength was **17%** with increases in percentage of fly ash content from 0% to 50% at the age of 28th day. But mainly note that the increase in percentage of compressive strength was increased nearly up to **126%** with increases in fly ash percentage from 0% to 50 % with incorporating sisal fiber 0.20% at the age of 28th day.

SPLITTING TENSILE STRENGTH TEST

7th Day Test

Results for splitting tensile strength of the composite for all the series at age of 7th Day is presented in Bar chart Figure 5.3 present graphically.

Concrete mixture of 0%, 30%, 40% and 50% fly ash incorporating with 0.0% sisal fiber i.e. control section of series A1, B1, C1 and D1 achieved Splitting tensile strengths of **2.30, 2.14, 1.73** and **1.49** MPa respectively, incorporating with 0.10% sisal fibre having splitting tensile strength of respectively Series mixtures A2, B2, C2 and D2 achieved was **2.40, 2.25, 1.90** and **1.60** MPa respectively, incorporating with 0.20% sisal fibre having compressive strength of respectively Series mixtures A3, B3, C3 and D3 achieved was **2.55, 2.45, 1.95** and **1.75** MPa respectively and incorporating with 0.30% sisal fibre having compressive strength of respectively Series mixtures A4, B4, C4 and D4 achieved was **2.65, 2.50, 2.05** and **1.80** MPa respectively.

It is evident that for a particular fly ash percentage, splitting tensile strength of fly ash concrete mixtures decreased with increases in fly ash percentage for control section A1, B1, C1 and D1. Also the increase in sisal fibre percentage up to 0.30% increases the splitting tensile strength, it increases due to the transferring the load of randomly sprayed sisal fiber having length 20 mm to 30 mm, also increased due to the bonding action between sisal fiber and the cementious material**.** In control section there decreases in splitting tensile strength with increase in fly ash percentage because there was no pozzolonic reaction of fly ash take place at 7th Day. But at later ages after 28th day, the pozzolonic reaction of fly ash takes place and increases in splitting tensile strength. However, for all control section of respective series A1, B1, C1 and D1 decreases in splitting tensile strength was **35%** with increases in percentage of fly ash content from 0% to 50% at the age of 7th day.

For series A, B, C and D, the increased in splitting tensile strength incorporating with sisal fiber percentage from 0.0% to 0.30% was **15.22%, 16.82%, 18.50%** and **20.81%.** But mainly note that the increase in percentage of splitting tensile strength was increased nearly up to **37%** with increases in fly ash percentage from 0% to 50% with incorporating sisal fiber percentage from 0.0% to 0.30% at the age of 7th day.

28th Day Test

Results for splitting tensile strength of the composite for all the series at age of 28th Day is presented in Bar chart Figure 5.4 present graphically.

Concrete mixture of 0%, 30%, 40% and 50% fly ash incorporating with 0.0% sisal fiber i.e. control section of series A1, B1, C1 and D1 achieved Splitting tensile strengths of **3.40, 2.92, 2.47** and **2.28** MPa respectively, incorporating with 0.10% sisal fibre having splitting tensile strength of respectively Series mixtures A2, B2, C2 and D2 achieved was **3.65, 3.20, 2.75** and **2.30** MPa respectively, incorporating with 0.20% sisal fibre having compressive strength of respectively Series mixtures A3, B3, C3 and D3 achieved was **3.90, 3.35, 2.90 and 2.40** MPa respectively and incorporating with 0.30% sisal fibre having compressive strength of respectively Series mixtures A4, B4, C4 and D4 achieved was **3.95, 3.45, 2.95 and 2.74** MPa respectively.

For series A, B, C and D, the increased in splitting tensile strength incorporating with sisal fiber percentage from 0.0% to 0.30% was **16.18%, 18.15%, 19.43%** and **20.18%.** But mainly note that the increase in percentage of splitting tensile strength was increased nearly up to **25%** with increases in fly ash percentage from 0% to 50% with incorporating sisal fiber percentage from 0.0% to 0.30% at the age of 28th day.

PULLOUT STRENGTH TEST

7th Day Test

Results for pullout strength (bond stress) of the composite for all the series at age of 7th Day is presented in Bar chart figure 5.5 present graphically.

Concrete mixture of 0%, 30%, 40% and 50% fly ash incorporating with 0.0% sisal fiber i.e. control section of series A1, B1, C1 and D1 achieved pullout strength (bond stress) of **7.72, 7.25, 6.35** and **5.70** MPa respectively, incorporating with 0.10% sisal fibre having pullout strength

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(bond stress) of respectively Series mixtures A2, B2, C2 and D2 achieved was **8.09, 7.43, 6.57** and **6.16** MPa respectively, incorporating with 0.20% sisal fibre having pullout strength (bond stress) of respectively Series mixtures A3, B3, C3 and D3 achieved was **8.28, 7.71, 6.82** and **6.38** MPa respectively and incorporating with 0.30% sisal fibre having pullout strength (bond stress) of respectively Series mixtures A4, B4, C4 and D4 achieved was **7.83, 7.28, 6.63** and **5.95** MPa respectively.

It is evident that for a particular fly ash percentage, pullout strength (bond stress) of fly ash concrete mixtures decreased with increases in fly ash percentage for control section A1, B1, C1 and D1. Also the increase in fibre percentage at 7th days pullout strength (bond stress) increased with increased in sisal fiber percentage up to 0.20% but after addition of sisal fiber more than 0.20% pullout strength (bond stress) decreases. In control section there decreases in pullout strength (bond stress) with increase in fly ash percentage because there was no pozzolonic reaction of fly ash take place at 7th Day. But at later ages after 28th day the pozzolonic reaction of fly ash takes place and increases in pullout strength (bond stress). However, for all control section of respective series A1, B1, C1 and D1 decreases in pullout strength (bond stress) was **27%** with increases in percentage of fly ash content from 0% to 50% at the age of 7th day.

For series A, B, C and D, the increased in pullout strength (bond stress) up to 0.20% sisal fiber was **5.88%, 6.34%, 7.40%** and **11.93%** and after addition of sisal fiber beyond 0.20% was decreases suddenly of respective series. But mainly note that the increase in percentage of pullout strength (bond stress) was increased nearly up to **103%** with increases in fly ash percentage from 0% to 50% with incorporating sisal fiber 0.20% at the age of 7th day.

28th Day Test

Results for pullout strength (bond stress) of the composite for all the series at age of 28th Day is presented in Bar chart figure 5.6 present graphically.

Concrete mixture of 0%, 30%, 40% and 50% fly ash incorporating with 0.0% sisal fiber i.e. control section of series A1, B1, C1 and D1 achieved pullout strength (bond stress) of **14.75, 14.00, 13.04** and **11.74** MPa respectively, incorporating with 0.10% sisal fibre having pullout strength (bond stress) of respectively Series mixtures A2, B2, C2 and D2 achieved was **15.00, 14.15, 13.32 and 12.01** MPa respectively, incorporating with 0.20% sisal fibre having pullout strength (bond stress) of respectively Series mixtures A3, B3, C3 and D3 achieved was **15.03, 14.34 , 13.53** and **12.26** MPa respectively and incorporating with 0.30% sisal fibre having pullout strength (bond stress) of respectively Series mixtures A4, B4, C4 and D4 achieved was **14.71, 14.12, 13.19** and **11.98** MPa respectively.

It is evident that for a particular fly ash percentage, pullout strength (bond stress) of fly ash concrete mixtures decreased with increases in fly ash percentage for control section A1, B1, C1 and D1. Also the increase in fibre percentage at 28th days pullout strength (bond stress) increased with increased in sisal fiber percentage up to 0.20% but after addition of sisal fiber more than 0.20% pullout strength (bond stress) decreases. In control section there decreases in pullout strength (bond stress) with increase in fly ash percentage because there was no pozzolonic reaction of fly ash take place at 28th Day. But at later ages after 28th day the pozzolonic reaction of fly ash takes place and increases in pullout strength (bond stress). However, for all control section of respective series A1, B1, C1 and D1 decreases in pullout strength (bond stress) was **20%** with increases in percentage of fly ash content from 0% to 50% at the age of 28th day.

For series A, B, C and D, the increased in pullout strength (bond stress) up to 0.20% sisal fiber was **1.90%, 2.43%, 3.76%** and **4.43%** and after addition of sisal fiber beyond 0.20% was decreases suddenly of respective series. But mainly note that the increase in percentage of pullout strength (bond stress) was increased nearly up to **133%** with increases in fly ash percentage from 0% to 50 % with incorporating sisal fiber 0.20% at the age of 28th day.

FLEXURAL STRENGTH TEST

7th Day Test

Results for flexural strength of the composite for all the series at age of 7th Day is presented in Bar chart figure 5.7 present graphically.

Concrete mixture of 0%, 30%, 40% and 50% fly ash incorporating with 0.0% sisal fiber i.e. control section of series A1, B1, C1 and D1 achieved flexural strengths of **2.58, 2.30, 1.90** and **1.55** MPa respectively, incorporating with 0.10% sisal fibre having flexural strength of respectively Series mixtures A2, B2, C2 and D2 achieved was **2.70, 2.35, 1.95** and **1.65** MPa respectively, incorporating with 0.20% sisal fibre having flexural strength of respectively Series mixtures A3, B3, C3 and D3 achieved was **2.75, 2.47, 2.10** and **1.70** MPa respectively and incorporating with 0.30% sisal fibre having flexural strength of respectively Series mixtures A4, B4, C4 and D4 achieved was **2.80, 2.60, 2.20** and **1.80** MPa respectively.

It is evident that for a particular fly ash percentage, flexural strength of fly ash concrete mixtures decreased with increases in fly ash percentage for control section A1, B1, C1 and D1. Also the increase in sisal fibre percentage up to 0.30% increases the flexural strength, it increases due to the transferring the load of randomly sprayed sisal fiber having length 20 mm to 30 mm, also increased due to the bonding action between sisal fiber and the cementious material**.** In control section there decreases in flexural strength with increase in fly ash percentage because there was no pozzolonic reaction of fly ash take place at 7th Day. But at later ages after 28th day the pozzolonic reaction of fly ash takes place and increases in splitting tensile strength. However, for all control section of respective series A1, B1, C1 and D1 decreases in flexural strength was **40%** with

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increases in percentage of fly ash content from 0% to 50% at the age of 7th day.

For series A, B, C and D, the increased in flexural strength incorporating with sisal fiber percentage from 0.0% to 0.30% was **8.53%, 13.04%, 15.79%** and **16.13%.** But mainly note that the increase in percentage of flexural strength was increased nearly up to **89%** with increases in fly ash percentage from 0% to 50% with incorporating sisal fiber percentage from 0.0% to 0.30% at the age of 7th day.

28th Day Test

Results for flexural strength of the composite for all the series at age of 28th Day is presented in Bar chart figure 5.8 present graphically.

Concrete mixture of 0%, 30%, 40% and 50% fly ash incorporating with 0.0% sisal fiber i.e. control section of series A1, B1, C1 and D1 achieved flexural strengths of **3.87, 3.40, 3.32** and **3.10** MPa respectively, incorporating with 0.10% sisal fibre having flexural strength of respectively Series mixtures A2, B2, C2 and D2 achieved was **3.90, 3.50, 3.45** and **3.20** MPa respectively, incorporating with 0.20% sisal fibre having flexural strength of respectively Series mixtures A3, B3, C3 and D3 achieved was **3.95, 3.60, 3.50** and **3.30** MPa respectively and incorporating with 0.30% sisal fibre having flexural strength of respectively Series mixtures A4, B4, C4 and D4 achieved was **4.05, 3.65, 3.60** and **3.40** MPa respectively.

For series A, B, C and D, the increased in flexural strength incorporating with sisal fiber percentage from 0.0% to 0.30% was **4.65%, 7.35%, 8.43%** and **9.68%.** But mainly note that the increase in percentage of flexural strength was increased nearly up to **108%** with increases in fly ash percentage from 0% to 50% with incorporating sisal fiber percentage from 0.0% to 0.30% at the age of 28th day.

IMPACT STRENGTH TEST

7th Day Test

Results for Impact strength of the composite for all the series at age of 7th Day is presented in Bar chart figure 5.9 present graphically.

Concrete mixture of 0%, 30%, 40% and 50% fly ash incorporating with 0.0% sisal fiber i.e. control section of series A1, B1, C1 and D1 achieved Impact strength of **81.67, 65.33, 49.00** and **49.00** N-M respectively, incorporating with 0.10% sisal fibre having Impact strength of respectively Series mixtures A2, B2, C2 and D2 achieved was **98.00, 81.67, 65.33** and **49.00** N-M respectively, incorporating with 0.20% sisal fibre having Impact strength of respectively Series mixtures A3, B3, C3 and D3 achieved was **114.33, 98.00, 81.67** and **65.33** N-M respectively and incorporating with 0.30% sisal fibre having Impact strength of respectively Series mixtures A4, B4, C4 and D4 achieved was **130.67, 114.33, 98.00** and **98.00** N-M respectively.

For series A, B, C and D, the increased in Impact strength incorporating with sisal fiber percentage from 0.0% to 0.30% was **60.00%, 75.00%, 100.00%** and **100.00%.** But mainly note that the increase in percentage of Impact strength was increased nearly up to **67%** with increases in fly ash percentage from 0% to 50% with incorporating sisal fiber percentage from 0.0% to 0.30% at the age of 7th day.

28th Day Test

Results for Impact strength of the composite for all the series at age of 28th Day is presented in Bar chart figure 5.10 present graphically.

Concrete mixture of 0%, 30%, 40% and 50% fly ash incorporating with 0.0% sisal fiber i.e. control section of series A1, B1, C1 and D1 achieved Impact strength of **147.00, 130.67, 114.33** and **98.00** N-M respectively, incorporating with 0.10% sisal fibre having Impact strength of respectively Series mixtures A2, B2, C2 and D2 achieved was **163.33, 147.00, 130.67** and **130.67** N-M respectively, incorporating with 0.20% sisal fibre having Impact strength of respectively Series mixtures A3, B3, C3 and D3 achieved was **179.67, 163.33, 163.33** and **147.00** N-M respectively and incorporating with 0.30% sisal fibre having Impact strength of respectively Series mixtures A4, B4, C4 and D4 achieved was **212.33, 196.00, 179.67** and **163.33** N-M respectively.

It is evident that for a particular fly ash percentage, Impact strength of fly ash concrete mixtures decreased with increases in fly ash percentage for control section A1, B1, C1 and D1. Also the increase in sisal fibre percentage up to 0.30% increases in the Impact strength tremendously i.e. this increases in impact strength shows that the incorporating sisal fiber absorb the energy blows with increase in sisal fiber percentage up to certain limit**,** over addition of sisal fiber loss in impact energy due to the presence of fibres induces porosity, which affect on strength and reduces it. So, up to 0.30% sisal fiber increases the Impact strength of concrete due to the transferring the load of randomly sprayed sisal fiber having length 20 mm to 30 mm, also it increased due to the bonding action between sisal fiber and the cementious material**.** In control section there decreases in Impact strength with increase in fly ash percentage because there was no pozzolonic reaction of fly ash take place at 28th Day. But at later ages after 28th day the pozzolonic reaction of fly ash takes place and increases in splitting tensile strength.

However, for all control section of respective series A1, B1, C1 and D1 decreases in Impact strength was **33.33%** with increases in percentage of fly ash content from 0% to 50% at the age of 28th days.

For series A, B, C and D, the increased in Impact strength incorporating with sisal fiber percentage from 0.0% to 0.30% was **44.44%, 50.00%, 57.15%** and **66.66%.** But mainly note that the increase in percentage of Impact strength was increased nearly up to **50%** with increases in fly ash percentage from 0% to 50% with incorporating sisal fiber percentage from 0.0% to 0.30% at the age of 28th day.

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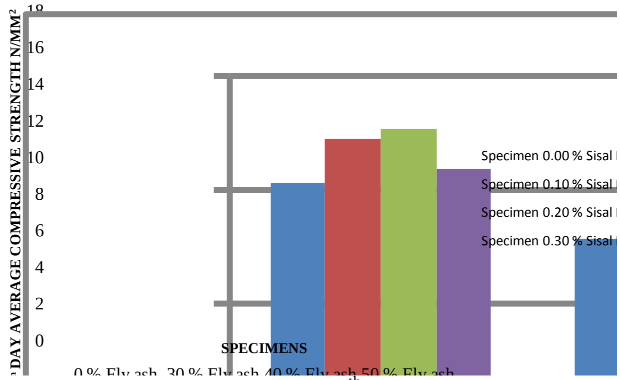
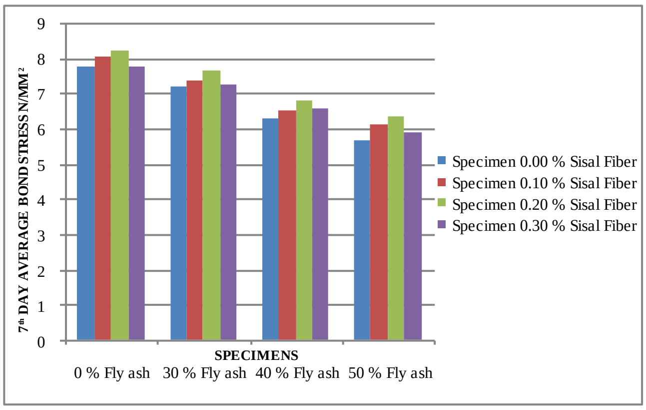
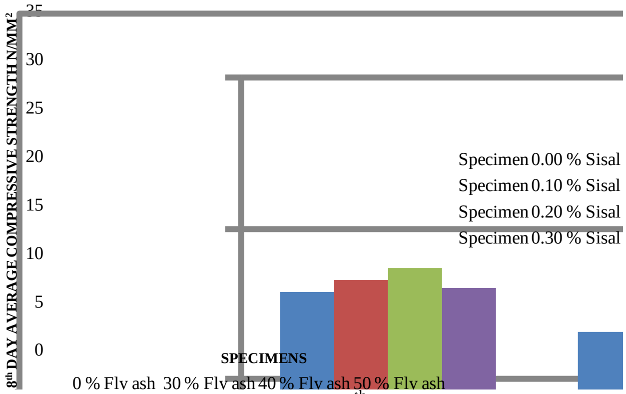


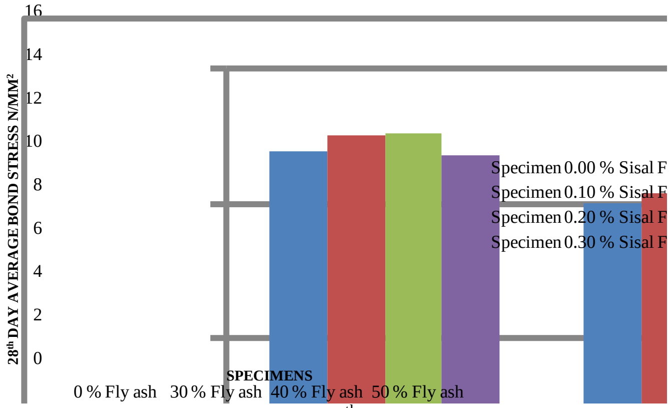
Bar chart Figure 5.1: Bar chart for 7th day average compressive strength



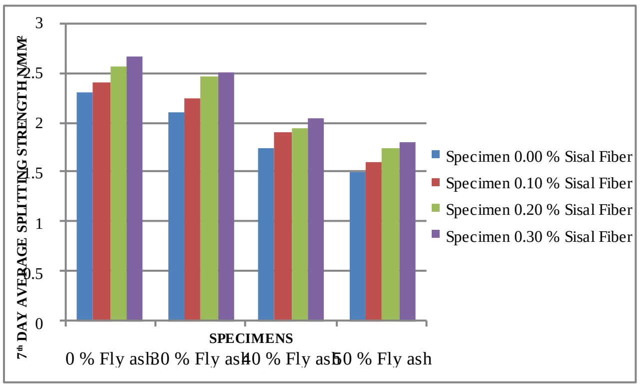
Bar chart Figure 5.5: Bar chart for 7th day average pullout strength



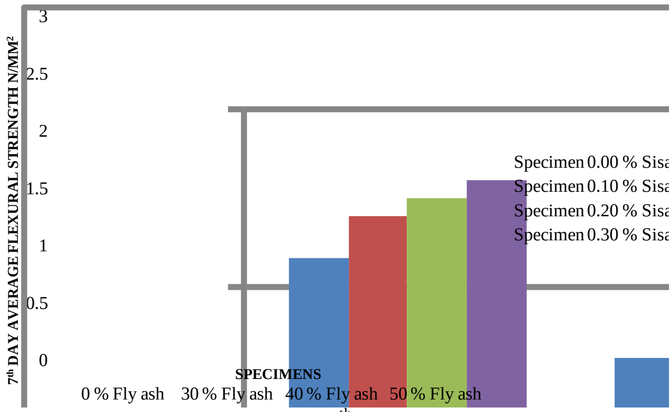
Bar chart Figure 5.2: Bar chart for 28th day average compressive strength



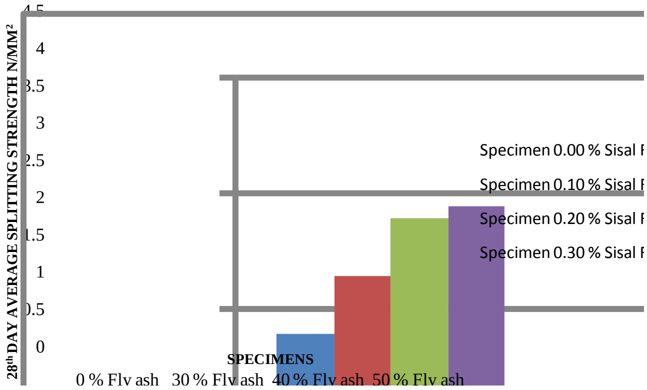
Bar chart Figure 5.6: Bar chart for 28th day average pullout Strength



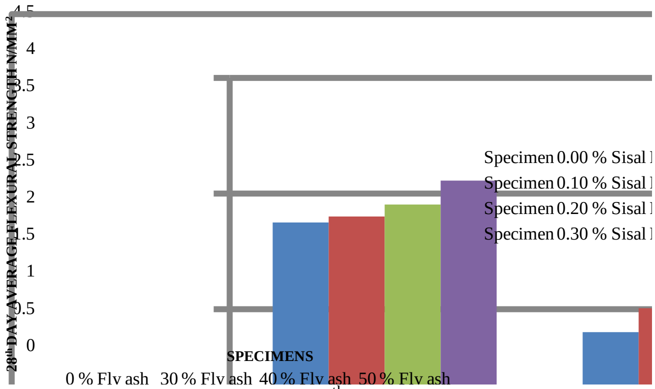
Bar chart Figure 5.3: Bar chart for 7th day average splitting strength



Bar chart Figure 5.7: Bar chart for 7th day average flexural strength



Bar chart Figure 5.4: Bar chart for 28th day average splitting strength



Bar chart Figure 5.8: Bar chart for 28th day average flexural strength

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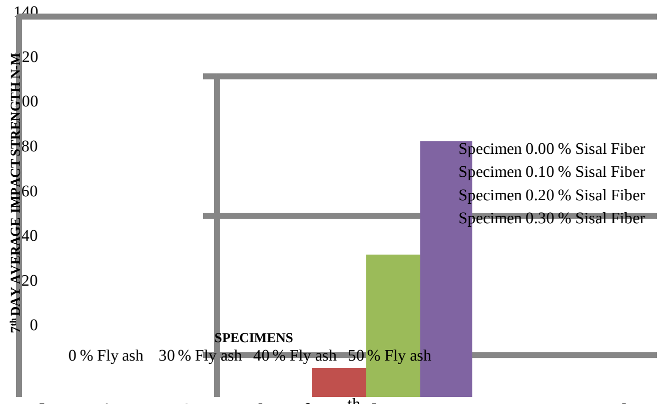
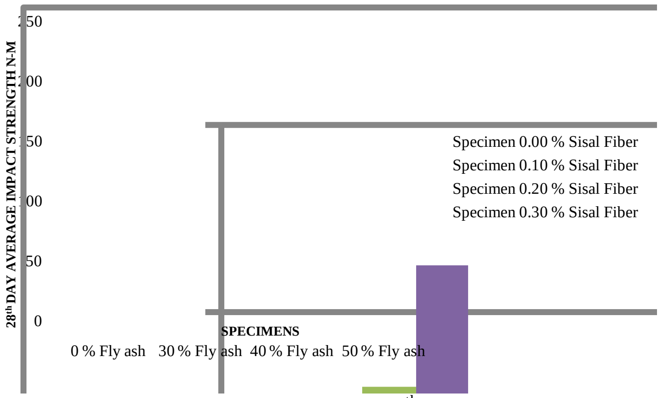


Bar chart Figure 5.9: Bar chart for 7th day average impact strength



Bar chart Figure 5.10: Bar chart for 28th day average impact strength

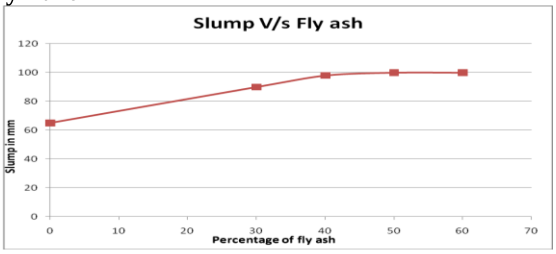
EFFECTS OF FLY ASH ON AS PER IS: 10262-2009

Workability

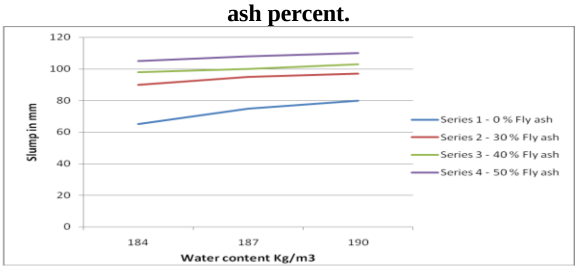
To analyze the behavior of concrete in fresh state, four control concrete mixes of series A1, B1, C1 and D1 with water cementious material ratio (W/C) of 0.52, 0.51, 0.50 and 0.49 were used for water content of 191.36 kg/m^3, 187.68 kg/m^3, 184.00 kg/m^3 and 180.32 kg/m^3 each respectively. For each series three slumps to be taken and three specimens tested for compressive strength, Graph 5.11, and Graph 5.12 shows the behavior of workability in terms of slump, for W/C ratio of 0.52, 0.51, 0.50 and 0.49 respectively.

Effects of Fly Ash on Properties of Concrete as Per IS: 10262-2009: Workability

To analyze the behavior of concrete in fresh state, four control concrete mixes of series A1, B1, C1 and D1 with water cementious material ratio (W/C) of 0.52, 0.51, 0.50 and 0.49 were used for water content of 191.36 kg/m3, 187.68 kg/m3, 184.00 kg/m3 and 180.32 kg/m3 each respectively. For each series three slumps to be taken and three specimens tested for compressive strength, Graph 5.11, and Graph 5.12 shows the behavior of workability in terms of slump, for W/C ratio of 0.52, 0.51, 0.50 and 0.49 respectively.



Graph 5.11: Behavior of workability in terms of slump v/s fly ash percent.



Graph 5.12: Behavior of workability in terms of slump v/s water content.

It is observed that from the Graph 5.11, the slump increases due to increase in fly ash percentage. So, addition of fly ash increases the workability. It goes on increasing with increase in percentage of fly ash from 0% to 50%. Also from Graph 5.12 for each W/C ratio of 0.52, 0.51, 0.50 and 0.49 and for respective fly ash content 0%, 30%, 40%, and 50%. All for that the separate graph drawn, which shows the decrease in W/C ratio, Workability goes on increasing with increase in percentage of fly ash from 0% to 50%. The 0% fly ash graph line at the bottom i.e. less slump as compared to the fly ash content graph line. This trend is consistent for W/C ratio of 0.52, 0.51, 0.50 and 0.49. For W/C ratio of 0.52, mixes without fly ash is very low workable as per IS 456-2000. Hence a higher dosage of super plasticizer (SP) is required to achieve desired workability.

VI. COST ANALYSIS

Cost analysis of concrete

Now, we determine the actual cost the concrete used for the casting wall panel in Table no. 5.

Table 5: Comperision of Cost Analysis for M20 grade Concrete with various percentages of Fly ash and Sisal fiber

Sr. No.	Series	Specimen	Composition			Cost per Cu.m of Conc. Rs.	Eco.Costof ConC. Rs.
			Cement %	Fly ash %	Sisal fibre %		
1	A Colour less	A1	0	0	0.00	4347.00	4347.00
2		A2	0	0	0.10	4469.00	
3		A3	0	0	0.20	4591.00	
4		A4	0	0	0.30	4712.00	
5	B Blue colour	B1	70	30	0.00	3775.00	3775.00
6		B2	70	30	0.10	3897.00	
7		B3	70	30	0.20	4018.00	
8		B4	70	30	0.30	4140.00	
9	C Red colour	C1	60	40	0.00	3569.00	3569.00
10		C2	60	40	0.10	3691.00	
11		C3	60	40	0.20	3813.00	
12		C4	60	40	0.30	3935.00	
13	D	D1	50	50	0.00	3364.00	3364.00

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14	Yello	D2	50	50	0.10	3486.00	
15	w	D3	50	50	0.20	3607.00	
16	colour	D4	50	50	0.30	3729.00	

Emphasis is laid on making the most economical use of available materials so as to produce concrete of the required attributes at the minimum cost.

From above Table 5, cost analysis comparison with strength of concrete, the increases in fly ash will decreases the all strength of concrete at 7th day and 28th day but after later age the increases in the strength of concrete due to pozzolonic reaction of fly ash. Also cost analysis compression of all series shows that the series D is most economical as compared to the other series, but the increases in sisal fiber percentage from 0.00% to 0.30% increases the cost of concrete by nearly about 7% cost of control section. So using 0.30 % sisal fiber increases the cost by nearly about 7%, but actual incorporating sisal fiber improves the properties of concrete i.e. splitting strength, flexural strength and tremendously increases in impact strength. Only compression strength and bond stress strength to be increased up to 0.20% of incorporating sisal fiber and then decreases with further addition of sisal fiber. So we considering maximum compression strength and bond stress the Series D-3 are most economical composition of 50% fly ash incorporating with 0.20% sisal fiber having economical cost per Cu.M. of concrete is Rs. 3607.00. So this investigation concluded that the Series D is most economical as compared to the series A, B, C and D in cost.

Finalize the series of concrete on basis of Cost and Strength

From the result of testing concluded that the increase in fly ash reduces the strength and cost but increasing in incorporating sisal fiber increases strength and cost of concrete as compares to the control section i.e. 0% fly ash and 0.0% Sisal fiber. The increase in cost of concrete due to sisal fiber as compared to the decrease in cost of concrete due to fly ash is minor, so increase in cost of concrete due to sisal fiber is neglected. So this investigation concluded that the Series D is most economical as compared to the series A, B, C and D in cost as well as in strength. There for constructing wall panel, the concrete is choose as per strength requirement of the fly ash concrete incorporating with sisal fiber 0.0%, 0.10%, 0.20% and 0.30% of from series D having 50% fly ash content. From series D the sub series D4 is most economical as compared to D1, D2 and D3 in cost as well as in strength but they used in where compressive strength and bond stress strength is not important, otherwise subseries D3 is most economical in cost as well as in strength.

VII. CONCLUSIONS

A. Discussion and Conclusion

From the results obtained in this investigation, it becomes evident that fly ash cement based matrix incorporating with sisal fiber can bring new trend in composite materials. The salient conclusions from the study are summarized below;

1. For all W/C ratio considered and percentage replacement of fly ash by ordinary portland cement, its strength increases tremendously from 7th day to 28th day.

2. Improvement in the compression strength of composite with addition of sisal fiber continuous till up to 0.20% sisal fiber content and decreases with further increase of sisal fiber content beyond 0.20%.

3. Improvement in the Splitting strength of composite with addition of sisal fiber continuous till up to 0.30% sisal fiber content.

4. Improvement in the Pullout (bond stress) strength of composite with addition of sisal fiber continuous till up to 0.20% sisal fiber content and decreases with further increase of sisal fiber content beyond 0.20.

5. Improvement in the Flexural strength of composite with addition of sisal fiber continuous till up to 0.30% sisal fiber content.

6. Tremendously improvement in the Impact strength of composite with addition of sisal fiber continuous till up to 0.30% sisal fiber content.

7. The study on high volume fly ash incorporating with sisal fiber reinforced pre-cast wall panel concrete shows that the increases in percentage of fly ash up to 50% decreases strength, but this incorporating with sisal fiber up to 0.30% increases in strength of concrete. Except that compression and pullout (Bond stress) strength increases up to 0.20% of fiber.

8. Also investigate that the increases in the percentage of strength of each series concrete are increases with using fly ash and sisal fiber combination as compared to control section.

9. Cost of concretes of all series shown in Tables 6.5, in this cost compression table series D are lower than the cost of respective series.

10. There for constructing wall panel, the concrete is choose as per strength requirement of the fly ash concrete incorporating with sisal fiber 0.0%, 0.10%, 0.20% and 0.30% of from series D having 50% fly ash content. From series D the sub-series D4 is most economical as compared to D1, D2 and D3 in cost as well as in strength but they used in where compressive strength and Bond stress strength is not important, otherwise sub-series D3 is most economical in cost as well as in strength.

11. Use of Sisal fibers significantly enhanced the 28th day impact strength (1 to 3 times) of fly ash concrete with the increase in percentage of fibres. With the increase in age, improvement in impact strength of fly ash concrete with age due to the pozzolonic reaction of fly ash.

12. To achieve desired workability, water content for W/C ratio of 0.52, 0.51, 0.50 and 0.49 can be selected with the help of Graph 5.11 and Graph 5.12 respectively.

13. By knowing water content and W/C ratio, cementitious material content can be calculated.

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