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STUDY ON STRENGTH OF CONCRETE BY USING STEEL FIBERS

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Abstract: Now-a-days, there has been a significant increase in the use of fibres in concrete for improving its properties such as tensile strength and ductility. Now-a-days steel fibre, etc. use while Preparing concrete. steel fibre has the advantages of having higher tensile strength and compressive strength, thus reducing the loss of damage during fire accident of concrete structures. In this investigation steel fibre are added to the concrete by volume fraction to determine its strength characteristics. Determination of compressive, split tensile and flexural strength of concrete. steel is a synthetic hydrocarbon polymer, the fiber of which is made using extrusion processes by hot drawing the material through a die. Its use enables reliable and effective utilization of intrinsic tensile and flexural strength of the material along with significant reduction of plastic shrinkage cracking and minimizing of thermal cracking. Comparison of the strength performance of conventional concrete was made.

Index Terms – Steel Fibers, GGBS, Fly Ash, Compressive Strength.

I. INTRODUCTION

Concrete is one of the most widely used construction materials in the world. It is strong, durable, and easy to mould into different shapes. However, plain concrete has some weaknesses, especially when it comes to cracks, impact, or heavy loads. This is where Steel Fiber Reinforced Concrete (SFRC) comes in. By adding small steel fiber into the concrete mix, we can greatly improve its strength, toughness, and performance.
In this blog, we'll explore what steel fiber reinforced concrete is, how it's used, its benefits and drawbacks, and why Mikem's steel fiber is What is Steel Fiber Reinforced Concrete?
Steel Fiber Reinforced Concrete is a type of concrete that includes small steel fibers distributed throughout the mix. These steel fibers are short and thin, usually about 0.5 to 1 inch long and shaped like tiny needles, hooks, or strips. When mixed into concrete, they help hold the mixture together, especially when cracks begin to form.
Think of the steel fibers like a net inside the concrete. While normal concrete can crack under stress, the steel fibers act like bridges across these cracks, holding everything together and stopping the cracks from growing. This makes the concrete stronger, tougher, and more resistant to damage.
Unlike traditional reinforced concrete, which uses long steel bars or mesh in specific areas, steel fiber reinforced concrete spreads strength throughout the entire structure, making it especially useful in areas where cracks may occur in multiple directions.

1.1 Cement

- **Specific gravity test**

Specific gravity is normally used in mixture proportioning calculations. Measure the weight of empty flask (W1). The flask should be totally dry and free of liquid. Fill half of the flask with cement (about 50 gm) and Measure the weight with its stopper (W2). Then fill the flask with kerosene up to the top level of the flask. Mix cement and kerosene properly to remove air bubble from it. Weigh the flask with cement and kerosene (W3). Now empty the flask and again fill it with kerosene up to the top of the flask. Weigh the flask (W4).calculating by following formula

Specific Gravity (Sg) = ((W2-W1))/((W2-W1) -(W3-W4) X Gk)

- **Standard consistency of cement**

Standard consistency of a cement paste is defined as that consistency which will permit a vicat plunger having 10 mm dia and 50 mm length to penetrate to a depth of 33-35.Prepare a paste of weighed quantity of cement (300gms) with weighed quantity of potable or distilled water, taking care that the time of gauging is not less than 3minutes nor more than 5 minutes and the gauging is completed before any sign of setting occurs. Fill the vicat mould with this paste resting upon a non-porous plate. Immediately place the test block with the non-porous resting plate, under the rod bearing the plunger. Lower the plunger gently to touch the surface of the test block and quickly release, allowing it sink into the paste. Record the depth of penetration. Prepare trial pastes with varying percentages of water and test as described above until the plunger is 5mm to 7mm from the bottom of the vicat mould Standard consistency (%) = (Weight of water added)/(Weight of cement) X100

- **Initial setting time of cement**

Initial setting time can be defined as the time when the cement paste starts losing its plasticity . Prepare a paste of 300 grams of cement with 0.85 times the water required to a give a paste of standard consistency. The time of gauging in any case shall not be less than 3 minutes not more than 5 minutes. Fill the vicat mould with this paste making it level with the top of the mould. Immediately place the test block with the non-porous resting plate, under the rod bearing the initial setting needle. Lower the needle and quickly release allowing it to penetrate in to the mould. In the beginning the needle will completely pierce the mould. Repeat this procedure until the needle fails to pierce the mould for 5 + 0.5mm. Record the period elapsed between the time of adding water to the cement to the time when needle fails to pierce the mould by 5 + 0.5mm as the initial setting time. Calculate the standard consistency of Cement using below formula.

- **Final setting time of cement**

The time at which cement completely loses its plasticity and became hard is a final setting time of cement. Replace the needle of the vicat apparatus by the needle with an annular ring. Lower the needle and quickly release. Repeat the process until the annular ring makes an impression on the mould. Record the period elapsed between the time of adding water to the cement to the time when the annular ring fails to make the impression on the mould as the final setting time.

5.2 Coarse aggregate

- **Specific gravity**

About 2 kg of aggregate sample is washed thoroughly to remove fines, drained and placed in wire basket and immersed in distilled water at a temperature between 22- 32º C and a cover of at least 5cm of water above the top of basket. Immediately after immersion the entrapped air is removed from the sample by lifting the basket containing it 25 mm above the base of the tank and allowing it to drop at the rate of about one drop per second. The basket and aggregate should remain completely immersed in water for a period of 24 hour afterwards. The basket and the sample are weighed while suspended in water at a temperature of 22° – 32°C. The weight while suspended in water is noted =W1g.The basket and aggregates are removed from water and allowed to drain for a few minutes, after which the aggregates are transferred to the dry absorbent clothes. The empty basket is then returned to the tank of water jolted 25 times and weighed in water=W2g.The aggregates placed on the absorbent clothes are surface dried till no further moisture could be removed by this cloth. Then the aggregates are transferred to the second dry cloth spread in single layer and allowed to dry for at least 10 minutes until the aggregates are completely surface dry. The surface dried aggregate is then weighed =W3 g. The aggregate is placed in a shallow tray and kept in an oven maintained at a temperature of 110° C for 24 hrs. It is then removed from the oven, cooled in an air tight container and weighted=W4 g.

Specific gravity = (Dry Weight of the aggregate)/ (Weight of equal volume of water)

5.3 Fine aggregate

- **Specific gravity**

Clean and dry the Pycnometer. Tightly screw its cap. Take its mass (M1) to the nearest of 0.1 g. Unscrew the cap and place about 200 g of oven dried fine aggregate in the Pycnometer. Screw the cap. Determine the mass (M2).Fill the Pycnometer with water completely up to the mark. Dry it from outside. Take its mass (M3).Empty the Pycnometer. Clean it and wipe it dry. Fill the Pycnometer with water only. Screw on the cap up to the mark. Wipe it dry. Take its mass (M4).using below formula calculate specific gravity

$G = (M2-M1)/ ((M2-M1)- (M3-M4))$

Sieve analysis

Sieve analysis helps to determine the particle size distribution of the coarse and fine aggregates. Take the sieves and arrange them in descending order with the largest size sieve on top. If mechanical shaker is using then put the ordered sieves in position and pour the sample in the top sieve and then close it with sieve plate. Then switch on the machine and shaking of sieves should be done at least 5 minutes. If shaking is done by the hands then pour the sample in the top sieve and close it then hold the top two sieves and shake it inwards and outwards, vertically and horizontally. After some time shake the 3rd and 4th sieves and finally last sieves. After sieving, record the sample weights retained on each sieve. Then find the cumulative weight retained. Finally determine the cumulative passing percentage retained on each sieves.

5.4 Mix design

➢ **TARGET STRENGTH FOR MIX PROPORTIONING**

f'ck =fck + 1.65 s

s =5 N/mm^2

Target strength =60 + 1.65 x 5 =68.25 N/mm^2

fck = 60+6.5=66.5 N/mm^2

➢ **SELECTION OF WATER-CEMENT RATIO**

Maximum water-cement ratio = 0.30-0.32

Based on experience, adopt water-cement ratio as 0.30

hence O.K

➢ **SELECTION OF WATER CONTENT**

Maximum water content =186 litre (for 50 mm slump range)

for 20 mm aggregate

Estimated water content for 75 mm slump = (186x 3/100+186) = 191.58litre

As super plasticizer is used, the water content can be reduced up 20% and above.

Based on trials with super plasticizer water content reduction of 30 percent has been achieved. Hence, the

Arrived water content =191.58 x 0.75 =144 litre

Cement content = w/c = 0.32

C= 144/0.32 = 450 kg/m^3

5.5 MIX CALCULATIONS:

The mix calculations per unit volume of concrete shall be as follows:

- Air content = 2%
- Max size of aggregate = 20mm
- Sand zone = zone-1

a) Volume of concrete = $1m^3$

b) Volume of air = 2%

c) Volume of cement = (Mass of cement / Sp. Gravity of Cement) x1/ 1000

= (450 / 3.15) x 1 / 1000

= 0.142 m^3

d) Volume of water = 144lit.

= 0.144 m^3

e) Assume superplasticizer volume

Dosage = 1% of cement , Sp gr = 1.20

Mass of Sp = 1% x 450 = 4.5 kg

Volume of Sp = 4.5/1.20 x 1000 = 0.0038m^3

Volume of CA = For M60 grade concrete with 20mm aggregate

Typical properties = 62% CA

Typical properties = 38% FA

Then volume of CA =0.69x0.62 = 0.43m^3

Then volume of FA = 0.38x 0.69 = 0.27m^3

Tatal aggregate volume = 1-(Vc+Vw+Vadm+Vair)

=1-(0.142+0.144+0.0038+0.02)

= 0.69m^3

f) Mass of coarse aggregate = g x volume of coarse aggregate x specific gravity of coarse aggregate x 1000

= 0.43x2.7x1000

=1178.20Kg/m^3

g) Mass of fine aggregate = g x volume of fine aggregate x specific gravity of fine aggreagate*1000

=0.27x2.650x1000

=715.5Kg/m^3

1.6 MIX PROPORTIONS FOR TRIAL NUMBER

❖ **For 1m^3**

Cement	= 450 kg/m^3
Water	= 144 kg/m^3
Fine aggregate	= 715.5 kg/m^3
Coarse aggregate	= 1178.20 kg/m^3
Superplasticizer	= 4.5 kg/m^3

RESULT
CEMENT

➢ **SPECIFIC GRAVITY**

Observation :-

Empty weight of bottle (W1) = 48gm
Bottle + 1/3rd of Cement (W2) = 92gm
Bottle + 1/3rd of cement + Kerosine (W3) = 150gm
Bottle + Kerosine (W4) = 135gm
Bottle + Water (W5) = 120gm

Formula:-

Specific gravity of Kerosine (Sk) = (Weight of sample/Weight of water)
Specific gravity of Kerosine = ((W3-W1)/ (W2-W1))
= ((150-48)/ (92-48))

Sk = 2.31g

Specific Gravity of cement (Sc) = (W5/ (W5+W3-W4))*((W3-W1)/(W2-W1))

Specific of gravity of Cement = 120/ (120+150-135)*2.31

Sc= 2.05g

- **Normal consistency**

SI NO	Weight of cement in gms	% of water taken	Weight of water in gms	Depth of penetration in mm	Remarks
1	300	26	78	32	
2	300	28	84	26	
3	300	30	90	12	
4	300	32	96	8	
5	300	34	102	3	
6	300	36	108	0	

Table:1

Result: Normal consistency = 36% of Water with 300gm of OPC

- **Initial setting time**

SI NO	Time taken in min	Depth of penetration in mm	Remarks
1	0 min	0	
2	15 min	24	
3	30 min	17	
4	45 min	11	

Table:2

Result: Initial setting Time of Cement = 45 Min

Coarse aggregate:

- **Specific gravity**

Weight of dry sample of coarse aggregate (W) = 3000gm
Weight of saturated aggregate suspended in water + basket(W1) = 2746gm
Weight of empty basket in water (W2) = 818gm
Weight of saturated aggregate in water (W3) = (W1-W2) = 1927.90gm
Weight of surface dry aggregate (W4) = 2980gm
Weight of oven dry aggregate (W5) = 2950gm
Specific gravity of Coarse aggregate = ((W5))/ (W3-(W1-W2))
= ((2950))/ (2980-(2746-818)) = 2.8

Tabular Column:

SI NO	Weight Is sieve size	Weight retained (gm)	Correction (gm)	Corrected weight retained (gm)	Cumulative weight retained (gm)	Cumulative percentage weight retained	Cumulative percentage passing finer
1	40 mm	0	0	0	0	0	100
2	20mm	568	11.36	579.36	57.93	42.064	57.936
3	12.5 mm	230	4.6	234.6	23.46	76.54	23.46
4	10 mm	175	3.5	178.5	17.85	82.15	17.85
65	4.75 mm	23	0.46	10.58	1.058	98.942	1.058
6	0	0	0	0	0	0	0

Table-3

Result: Fineness modulus of given sample is 7.9

- **Flakiness index**

SI.NO	Passing through IS-sieve mm	Size of aggregate retained on IS-sieve mm	Size of aggregate thickness gauge sieve mm	Mass of aggregate retained through the slot gm
1	63	50	33.90	0
2	50	40	27.00	0
3	40	31.5	19.00	69
4	31.5	25	16.95	63
5	25	20	13.50	204
6	20	16	10.80	248
7	16	12.5	8.55	160
8	12.5	10	6.75	21
9	10	6.3	4.89	14

Table-4

CALCULATION:-

Flakiness index : Wt of material passing/total weight x100
= 770/2000 x 100
= 38.5 %

➢ **Elongation**

SI.NO	Passing through Sieve mm	Size of aggregate retained in sieve mm	Size of aggregate length gauge size mm	Mass of aggregate
1	63	50	-	-
2	50	40	81.0	-
3	40	31.5	58.5	-
4	31.5	25	-	-
5	25	20	40.5	98
6	20	16	32.5	14.8
7	16	12.5	25.6	197
8	12.5	10	20.2	23
9	10	6.3	14.7	14

Table-5 W2 =480

Calculation:

= Elongation index of coarse aggregate
=480/2000*100
=24%

➢ **Fine Aggregate**

Weight of fine aggregate sample taken =1kg

- Correction =((Weight Retained)/(Weight of sample taken))* difference in weight

  =23/1000*20
  =0.46gm
- Corrected weight retained = Weight retained +correction

  =23+0.46
  =23.46gm
- Cumulative % age weight =(cumulative weight retained/total weight of sample taken)*100

  =(23.46/1000)*100
  =2.346%
- Cumulative %age finer = 100-cumulative % age weight retained

  =100-2.346
  =97.65%
- Fineness modulus = Cumulative %age Weight retained /100

  =499.52+500/100
  = 9.9%

Tabular Column:

SI.NO	Weight IS Sieve Size	Weight Retained (gm)	Correction (gm)	Corrected Weight Retained (gm)	Cumulative Weight Retained (gm)	Cumulative Percentage Weight Retained	Cumulative Percentage Passing Finer
1	4.75	23	0.46	23.46	2.346	97.65	2.35
2	2.36	54	1.08	55.08	5.508	94.49	5.51
3	1.18	590	11.8	601.8	60.18	39.82	60.18
4	600	240	4.8	244.8	24.48	75.52	24.48
5	300	64	1.28	65.28	6.528	93.47	6.53
6	150	14	0.28	14.28	1.428	98.57	1.43
7	75	0	0	0	0	0	0

Table-6

Result:-The % of passing of sand through IS sieve of 600 μ is 24.48 % there for sand lies In Zone1

➔ **The Compressive strength test on concrete cubes by use of steel fiber's With partial replacement of OPC cement by GGBS and FLYASH:-**

- Addition of steel fibers increased the compressive strength and reduced crack formation in the concrete cubes.
- Flyash improved workability and long term strength development.
- GGBS improved durability, reduced heat of hydration, and enhanced later age compressive strength.
- Concrete containing 30% flyash and moderate GGBS replacement produced better strength compared to conventional concrete.
- Higher percentage of about 0.5% to 2.0% helped in improving toughness and resistance to failure.
- The combination use of steel fiber,flyash,and GGBS made the concrete more economical and eco-friendly by reducing cement consumption and CO2 emission.
- The optimum mix achieved higher compressive strength and better durability than normal M60 concrete.

Result:-

M60 concrete-compressive strength (Steel Fiber =0%,GGBS Varying,Flyash = 30%)

Mix Case	Fly Ash (%)	GGBS (%)	Steel Fiber (%)	7Days Strength (MPa)	28Days Strength (MPa)
1	30	0	0	28	42
2	30	10	0	30	49
3	30	20	0	32	53
4	30	30	0	34	57

Table-7

M60 concrete-compressive strength (Steel Fiber =0.5%,GGBS Varying, Flyash = 30%)

Mix Case	Fly Ash (%)	GGBS (%)	Steel Fiber (%)	7Days Strength(MPa)	28Days Strength(MPa)
1	30	0	0.5	32	44
2	30	10	0.5	34	49
3	30	20	0.5	36	52
4	30	30	0.5	38	56

Table-8

M60 concrete-compressive strength (Steel Fiber =0.5%,GGBS Varying, Flyash = 30%)

Mix Case	Fly Ash (%)	GGBS (%)	Steel Fiber (%)	7Days Strength (MPa)	28Days Strength (MPa)
1	30	0	1	30	43
2	30	10	1	32	48
3	30	20	1	34	51
4	30	30	1	36	55

Table-9

M60 concrete-compressive strength (Steel Fiber =0.5%,GGBS Varying, Flyash = 30%)

Mix Case	FlyAsh (%)	GGBS (%)	Steel Fibers (%)	7Days Strength (MPa)	28Days Strength (MPa)
1	30	0	1.5	34	46
2	30	10	1.5	36	50
3	30	20	1.5	38	53
4	30	30	1.5	40	57

Table-10

M60 concrete-compressive strength (Steel Fiber =0.5%, GGBS Varying, Flyash = 30%)

Mix Case	Fly Ash (%)	GGBS (%)	Steel Fiber (%)	7Days Strength (MPa)	28Days Strength (MPa)
1	30	0	2	36	48
2	30	10	2	38	51
3	30	20	2	40	55
4	30	30	2	42	59

Table-11

Conclusion:

The experimental study concluded that replacing OPC with flyash and GGBS along with the addition of steel fibers can successfully produce high strength,durability, and sustainable concrete. The optimum replacement level gives better compressive strength improved crack resistance, and enhanced structural performance

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