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Experimental Study on Mechanical & Durability Properties of Basalt & Steel Fiber Reinforced Concrete

Vinoth J[1],Suganya R[2], Narmadha M[3]

[1]*Vinoth J, Structural Engineering & Dhirajlal Gandhi College of Technology*
[2]*Suganya R, Assistant Professor,Civil Engineering & Dhirajlal Gandhi College of Technology*
[3]*Narmadha M, Assistant Professor,Civil Engineering & Dhirajlal Gandhi College of Technology*

Abstract - concrete is the most used material in the construction field. In present days, different types of concrete and its strength are increased but the durability is not considered because of the modern and faster construction criteria and strength of the concrete will not give durability for all situations and environmental exposes. Durability plays a most important role in concrete as it gives more life to it. Addition of fiber in the concrete increases the strength and durability. Many researchers have developed strength and durability of concrete using different types of fibers with different volume fraction. In this paper, M30 Concrete Grade for both nominal mix and design mix with addition of basalt fiber and steel fiber with different volume fractions ranging from 0.3% to 1.0% volume of cement will be studied. The mechanical properties (compressive strength, split tensile strength and flexural strength) and durability properties (Acid attack test, chloride attack test, sulphate attack test, carbonation test and permeable voids test) will be obtained.

Key Words: Strength, durability, basalt fiber and steel fibers

1.INTRODUCTION

Concrete is a composite material which is made up of filler and a binder. Typical concrete is a mixture of fine aggregate, coarse aggregate, cement and water. Concrete has many properties that make it a popular construction material. For a long time concrete was considered to be a very durable material requiring a little or no maintenance. The assumption is largely true, except when it is subjected to highly aggressive environments. We build concrete structures in highly polluted urban and industrial areas, aggressive marine environments, and harmful subsoil water in coastal areas and in many other hostile conditions where other materials of construction are found to be non-durable. Since, the use of concrete in recent years, has spread to highly harsh and hostile conditions, the earlier impression that concrete is a very durable material is being threatened, particularly on account of premature failures of number of structures in the recent past.

Strength of concrete is a pivotal aspect to be considered in the Concrete mix design for attaining all favorable qualities including durability in the past. Durability parameters of concrete are to be considered in the revision of IS 456 of 2000.

2. Material Used

Cement, Fine Aggregate, Coarse Aggregate and fibres are used

2.1 Cement

Ordinary Portland (Birla super) cement was chosen so that the influence of Tuticorin thermal power plant fly ash could be studied without any other intervention. The 53 grade ordinary Portland cement was chosen because of its greater fineness which would have effective hydration and also secondary hydration

2.2 Aggregate

Usually the aggregates occupy 70% to 80% of the volume of concrete and have an important influence on its properties. They are granular materials, derived generally from natural rock and sands.

2.3 Steel Fibers

A number of steel fiber types are available as reinforcement. Round steel fiber the commonly used type are produced by cutting round wire in to short length. The typical diameter lies in the range of 0.25 to 0.75mm. Steel fibers having rectangular cross sections are produced by silting the sheets about 0.25mm thick. Fibers are made from mild steel drawn wire. Round steel fibers are produced by chopping the wire, flat sheet fibers having a typical cross section varying from 0.15 to 0.41mm in thickness and 0.25 to 0.90mm in width are produced by silting flat sheets. Deformed fiber, which are loosely bounded with water-soluble glue in the form of a bundle are also available.

2.4 Basalt

Basalt is a natural, hard, dense, dark brown to black volcanic igneous rock originating at a depth of hundreds of kilometers beneath the earth and resulting the surface as molten magma. And it's gravy, dark in color, formed from the molten lava after solidification. The production of basalt fiber consists of melt preparation, extrusion, fiber formation, application of lubricates and finally winding. Method is also known as spinning. A fiber is a material made into a long filament with density generally in the order of 300g/cm2 of 50cm. The aspect ratio of length and diameter can be ranging from thousand to infinity in continuous fibers. It is do not undergo any toxic reaction with water and do not pollute air also. The functions of the fibers are to carry the load and provide stiffness, strength, thermal stability and other structural properties in the BFRP.

2.5 Polypropylene Fiber

Polypropylene fiber also known as a thermoplastic polymer used in a wide variety of applications including packing and textile, stationary plastic parts and reusable containers of various types, laboratory equipment, loudspeakers, automotive components etc., an addition of polymers

2.6 Super plasticizers

Super plasticizers (high-range water-reducers) are low molecular weight, water-soluble polymers designed to achieve high amounts of water reduction in concrete mix in order to attain a desired slump. The use of super plasticizer in concrete is an important milestone in the advancement of concrete

technology. Super plasticizers produce a homogeneous, cohesive concrete generally without any tendency for segregation and bleeding. Super plasticizers are more powerful dispersing agents which make the mix more cohesive and cement to hydrate completely. The nature of super plasticizers, their action and their dosage requirements are discussed in this section.

ADVANTAGES

Advantages of Steel fibres

- Improve structural strength
- Reduce steel reinforcement requirements
- Improve ductility
- Reduce crack widths and control the crack widths tightly, thus improving durability
- Improve impact— and abrasion—resistance
- Improve freeze-thaw resistance.

Advantages of Steel Fibers

- It is resistant to alkalis and acids c It is thermally electrically and sound Insulated
- Its tensile strength can be greater than large-tow carbon fibre, its elongation is better than small carbon fibre.
- Basalt has a 3-dimentional molecule and when compared with single infiltrating linear polymeric fibers.
- It is cost effectiveness
- Ant aging, as well as other excellent Characteristics.
- Basalt fiber for cement and concrete is not expensive,
- It is a competitive alternative product of poly propylene fiber and poly acrylonitrile fiber.
- Basalt fiber is a typical ceramic fiber, it's easy to disperse when mixed with cement concrete and mortar.
- Therefore, basalt fiber reinforced concrete serves the functions of reinforcement, crack resistance, and can extend the life of construction in the fields of housing bridges, Highways, railways, urban elevated roads, runways, ports, subway tunnels, the coastal Protection works, plant facilities

3. Material Testing

Table 3.1-Material Testing

S.no	Cement	
	Parameters	**Test Results**
1	Specific Gravity	3.15
2	Initial Setting time	30 minutes
3	Compressive Strength	33 MPa

S.no	Fine Aggregate	
	Parameters	**Test Results**
1	Specific Gravity	2.41
2	Fineness Modulus	2.27

S.no	Coarse Aggregate	
	Parameters	**Test Results**
1	Specific Gravity	2.73
2	Type	Crushed
3	Maximum Size	20 mm

S.no	Steel Fibre	
	Parameters	**Test Results**
1	Length	35
2	Diameters	0.25 to 0.75 mm

S.no	Polypropylene Fibre	
	Parameters	**Test Results**
1	Length	30
2	Diameters	5mm

4. Mix Design

Introduction

The determination of relative quantity of materials like cement, fine aggregate, coarse aggregate and water is called the mix design of concrete. Proportion is for concrete should be selected to make the most economical use of available materials to produce concrete of required quality.

Many methods have been recommended for mix proportioning of concrete all over time world. Among those methods, INDIAN STANDARD method was selected. The design of mix used for the present work is by the method given below.

CONCRETE MIX DESIGN (GRADE M30)

Design Stipulation

1. Characteristic compressive strength = 30Mpa Required in the field at 28 days
2. Maximum size of Aggregates = 20mm
3. Degree of workability = 0.9 (Compacting Factor)
4. Degree of quality control = Good
5. Types of exposure = Mild

Data for Testing

1. Specific gravity of cement = 3.15
2. Specific gravity of coarse aggregate = 2.73
3. Specific gravity of fine aggregate = 2.41
4. Water absorption of coarse aggregate = 0.5%
5. Water absorption of fine aggregate = 1%
6. Surface moisture of coarse aggregate = 2%
7. Surface moisture of Fine aggregate = 2%

Target Mean Strength of concrete

The target mean strength for specified characteristic cube strength is 30+(1.65x0.6)=30.99 Mpa.

Selection of Water Cement Ratio

The water cement ratio required for the target mean strength of 30.99 Mpa is 0.45.

Selection of Water and Sand Content

For 20mm Maximum size aggregate, sand conforming to grading Zone III, water content per cubic meter of concrete is equal to 191.6kg and sand content as percentage of total aggregate by absolute volume is 35%

For Change in Value of water cement ratio, compaction factor and sand belonging to Zone III following adjustment is required.

Table-4.1

S.no	CHANGE IN CONDITION	PERCENT ADJUSTMENT REQUIRED	
		WATER CONTENT	SAND IN TOTAL AGGREGATE
1	For decrease in water cement ratio by (0.6-0.45) that is 0.5	0	-2.5
2	For increase in compacting factor (0.9-0.8) that is 0.10	+3	0
	TOTAL	+3	-2.5

Therefore required sand content as percentage of total aggregate by absolute volume=35-2.5=32.5%

Required water content = 186+(186x3)/100=191.6 lit/cu.m

Determination of Cement Content

Water cement ratio= 0.45

Water = 186 litre

Cement = 186/0.45=425.78 kg/m3

This cement content is adequate for 'Mild" exposure condition.

Determination of Coarse and Fine Aggregate Content

The Maximum Size of Aggregate of 20mm, the amount of entrapped air in the wet concrete is 2 percent. Taking this into account and applying equations on

$$V=\{(W+C/Se+(1/p)(fa/Sfa)\}x\ (1/1000)$$

$$CA=\{(1-P)/P)Xfax(Sca/Sfa)\}$$

Where,

V= Absolute Volume of fresh concrete, which is equal to gross volume (m3) minus the volume of entrapped air,

W= Mass of Water (Kg) per m3 of concrete

C=Mass of cement(kg) per m3 of concrete

Se= Specific gravity of cement

P= Ratio of FA to total aggregate by absolute volume

Ca, Fa= Total mass of CA and FA (kg) per m3 of concrete respectively and Sfa, Sca= Specific gravity of saturated, surface dry fine aggregate and coarse aggregates respectively.

0.98=(191.6+(425.78/3.15)+(1/0.315c(fa/2.6)}x(1/1000) Fa= 716kg/m3

0.98= {191.6+(425.78/3.15)+(1/0.315x(Ca/2.68)}x(1/1000)Fa=1575 kg/m3

The mix proportion then becomes:

WATER : CEMENT : F.A : C.A

191KG : 425.80kg : 716Kg : 1575Kg

0.45 : 1 : 1.68 : 3.69

For 50Kg of Cement, the quantity of materials are worked out,

Cement = 50 Kg

F.A = 84 Kg

C.A = 184.5 Kg

5. Experimental Tests

Table-5.1- Results of compressive Strength

MIX	Mix Ratio		
	Basalt Fibre %	Steel Fibre %	Average compressive strength at 28th day (Mpa)
M1	0	0	30.2
M2	5	5	32.5
M3	10	10	34.72
M4	15	15	35.08
M5	20	20	31.77
M6	25	25	22.68
M7	30	30	20.65

From Result, it can be seen that the compressive strength of the concrete mixes with M1,M5 are nearer to conventional compressive strength. The highest strength was obtained at 15% adding of Basalt fibre and steel fibre along with fixed percentage of polypropylene (0.35) was found 35.08 Mpa compared with conventional concrete.

Table-5.2- Results of Spilt tensile Strength

MIX	Mix Ratio		
	Basalt Fibre %	Steel Fibre %	Average spilt tensile strength at 28th day (Mpa)
M1	0	0	3.09
M2	5	5	3.2
M3	10	10	3.75
M4	15	15	3.65
M5	20	20	3.17
M6	25	25	2.1
M7	30	30	2.012

Table-5.3- Results of flexural strength of PCC

MIX	Mix Ratio		
	Basalt Fibre %	Steel Fibre %	Average flexural strength at 28th day (Mpa)
M1	0	0	8.1
M2	5	5	7.2
M3	10	10	8.5
M4	15	15	8.25
M5	20	20	7.5
M6	25	25	7.8
M7	30	30	6.1

DURABILITY TESTS

1. CHLORIDE ATTACK

A non-porous container is selected and chloride solution has been prepared by adding 3.5% sodium chloride in distilled water. This solution is stirred well so that all the sodium chloride salts get dissolved in the solution. The initial weights of the cubes are found. They are then immersed in a chloride solution. After drying the cubes, the changes in weight and also the compressive strength of concrete cubes were found.

Table-5.4- Average percentage gain in weight of chloride attack

MIX	Mix Ratio		
	Basalt Fibre %	Steel Fibre %	Average % gain in weight
M1	0	0	0.97
M2	5	5	1.63
M3	10	10	1.95
M4	15	15	1.35
M5	20	20	1.15
M6	25	25	1.05
M7	30	30	0.95

Table-5.5- Percentage loss in strength of chloride attack

MIX	Mix Ratio		Strength result (N/mm2		
	Basalt Fibre %	Steel Fibre %	Before attack	After attack	% of loss in strength
M1	0	0	30.2	28.2	6.65
M2	5	5	32.5	30.6	5.84
M3	10	10	34.72	33.15	4.52
M4	15	15	35.08	33.49	4.54
M5	20	20	31.77	29.56	6.95
M6	25	25	22.68	21.66	4.45
M7	30	30	20.65	19.45	5.81

Sulphate Attack

When concrete is exposed to environment containing aggressive chemicals, it leads to deterioration of concrete which can be assessed in terms of loss of weight of concrete, to study the acid resistance of concrete, the cubes of concrete were cured and then immersed in 3% Na_2So_4 solution up to 28 day. After 28 days of immersion, the specimens were taken out and visually observed for the deterioration of the concrete due to sulphate attack. The specimens were weighted once again and the weight is compared with the normal concrete in order to calculate the percentage of loss of weight and also the loss of strength.

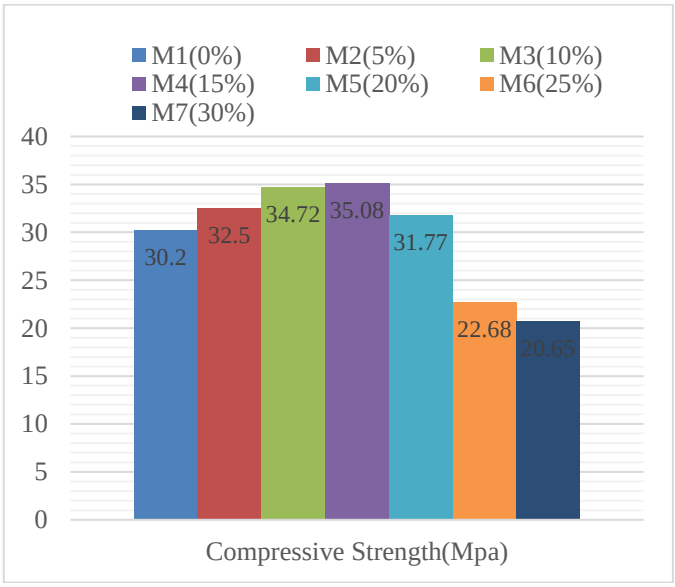
Table-5.6- Average percentage gain in weight of sulphate attack

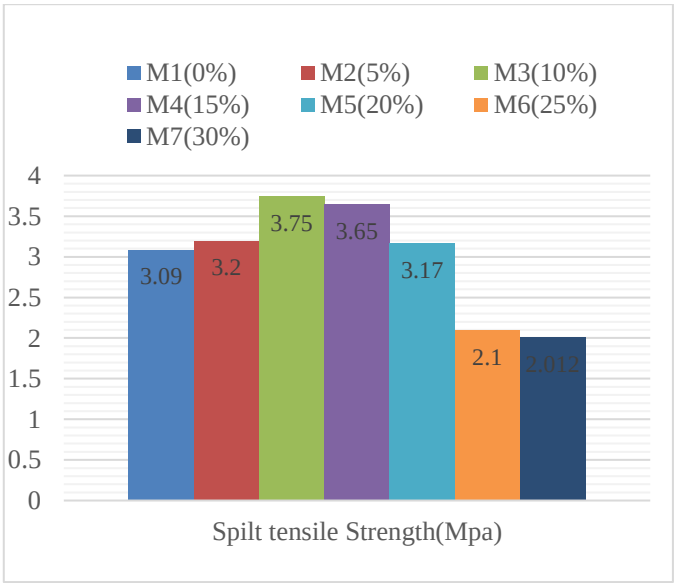
MIX	Mix Ratio		
	Basalt Fibre %	Steel Fibre %	Average % gain in weight
M1	0	0	3.85
M2	5	5	3.44
M3	10	10	3.65
M4	15	15	3.74
M5	20	20	2.85
M6	25	25	1.64
M7	30	30	1.24

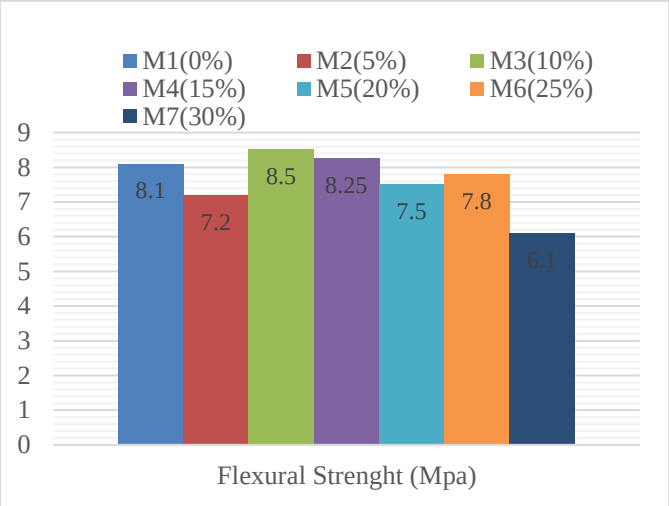
Table-5.7- Percentage loss in strength of sulphate attack

MIX	Mix Ratio		Strength result (N/mm2		
	Basalt Fibre %	Steel Fibre %	Before attack	After attack	% of loss in strength
M1	0	0	30.2	26.95	10.76
M2	5	5	32.5	26.75	17.69
M3	10	10	34.72	31.5	9.27
M4	15	15	35.08	32.02	8.63
M5	20	20	31.77	29.55	6.98
M6	25	25	22.68	19.55	13.8
M7	30	30	20.65	19.55	5.32

Charts







3. CONCLUSIONS

The experimental study has proved to better method or way in providing strong and durable concrete. From this study concluding we conclude that addition of Steel Fibre and Basalt Fibre are used without affecting the strength characteristics. In standard curing method the compressive, split tensile test and flexural strength of concrete increased with the addition of steel and basalt fibre.

The compressive strength results shows a 14.48% increase in strength for 28 days curing by the addition of steel fibre and basalt fibre on the aspect of study made compared to the normal M30 grade mix design.

The optimum Value achieve from the 25% added of steel fibre and basalt fibre.

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