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AN EFFECT OF BASALT AND STEEL FIBRE ON THE MECHANICAL PROPERTIES OF CONCRETE

S. Venkada Priya[1], S. Aishwarya[2], M. Surya[3], S. Vijaya Ragavan[4], D. Saravana Kumar[5], R. Muniyasamy[6]

[1]Assistant Professor, Department of Civil Engineering, Velammal College of Engineering and Technology, Madurai, Tamil Nadu, India
[2]PG Scholar of Structural Engineering, Vickram College of Engineering, Madurai, Tamil Nadu, India
[3,4,5,6] UG Student, Department of Civil Engineering, Velammal College of Engineering and Technology, Madurai, Tamil Nadu, India

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Abstract:

This experimental investigation on fibre reinforced concrete by reducing the volume of cement with adding fibre(basalt fibre, steel fibre).This experiment presents the effect of fibre on various properties of concrete such as compressive strength, split tensile strength and flexural strength with various contents of fibre (0%, 0.25%, 0.5%, 0.75%, 1%).The result of this investigation indicates comparative study between basalt fibre and steel fibre by adding fibre increases the compressive strength, split tensile strength, flexural strength and also find optimum percentage value of fibre in concrete.

Key words: basalt fibre*, steel fibre, M30 concrete, addition of fibre, maximum strength, decreasing cement content, optimum percentage value of fibre*.

1. INTRODUCTION

Construction industry needs faster development of strength in concrete. High early strength concretes are more prone to cracking than moderate or low strength concrete. Fibres suitable for reinforcing concrete have been produced from steel, glass and synthetic fibres. When concrete cracks, the randomly oriented fibre start functioning, arrest crack formation and propagation and thus improves strength and durability.

In recent days, the various fibres develop and used in the construction, industrial and highway engineering. The steel is mainly used in that various application. In that list new one fibre is added, called, basalt fibres. Basalt fibre is a high performance nonmetallic fibre material made from basalt rock melted in high temperature. Basalt fibre originates from volcanic magma and volcanoes, a very hot fluid and semi fluid material under the earth crust. Basalt fibre has good hardness and thermal properties. Basalt fibre have been successfully used for foundation such as slabs on ground concrete. By industrial production of basalt fibres on the basis new technology their cost is equal and even less then the cost of glass fibre.

From a modern perspective, research into steel fibre reinforced concrete (SFRC) was pioneered by Romualdi and Batson (1963) in the early 1960s where it was demonstrated that tensile strength and cracy resistance of concrete can be improved by providing suitable arranged, closed spaced, wire reinforcement. Today, steel fibres are used as main and secondary concrete reinforcement in an increasing number of applications. well-known and well established application are, for example, heavy pavements, slab tracks, slab on grade, short Crete linings and precast applications. More recent SFRC applications can be seen in the domain of structural raft foundation, liquid tight slabs and piled supported slabs, and even bridges and suspended structures. The most important properly when designing of a SFRC structural element is its post-cracking, or residual tensile strength. Steel fibres are active as soon as micro-cracks are formed in the concrete. The fibres are able to bridge the crack, transmit stress across the crack and, in the process, provided some resistance to the widening and fracture process of the crack.

2. MATERIALS

2.1 CEMENT

Perhaps the earliest known occurrence of cement is from twelve million years ago. A deposit of cement was formed after an occurrence of oil shale located adjacent to a bed of limestone burned duo to natural causes. Theses ancient deposit were investigated in the 1960s and 1970s.

In the most general sense of the word, a cement is a binder, a substance that sets and hardens independently, and can bind other materials together. Cement used in construction is characterized as hydraulic or non-hydraulic. Hydraulic cements (e.g., Portland cement) harden because of hydration, chemical reaction that occur independently of the mixture's water content; they can harden even underwater or when constantly exposed to wet weather.

2.2 FINE AGGREGATE

Fine aggregate is natural sand which has been washed and sieved to remove particles larger than 5mm and coarse aggregate is gravel which has been crushed, washed and sieved so that the particles vary from 5 up to 50mm in size. In construction works sand is mainly used as inert material in mortar and concrete. Sand can be obtained artificially by crushing stones also. In constructing dams and bridges, artificial sand is very commonly used. Silica of sand contributes to formation of silicates resulting into hardened mass. It prevents shrinkage of cementing material. It adds the density of mortars.

2.3 COARSE AGGREGATE:

Concrete in made of many components, but is mostly made up of materials known as coarse aggregate. Coerce aggregate have a wide variety of construction application because they resemble standard rock particles, as opposed to fine aggregate, which more closely resembles sand. coarse aggregate are an integral part of many construction applications, sometimes used on their own, such as asphalt or concrete mixtures.

Coarse aggregate are generally categorized as rock larger than standard no. 4 sieve (3/16 inches) and less than 2 inches. Coarse aggregate is minded from rock quarries or dredged from river beds, therefore the size, shape, hardness, texture and many other properties can vary greatly based on location. Even materials coming from the same quarry or pit and type of stone can vary greatly. Most generally, coarse aggregate can be characterized as either smooth or rounded (such as river gravel) or angular (such as crushed stone). Because of this variability, test methods exist to characterize the most relevant characteristics, since exact identification would be impossible. Several key characteristics that are frequently used to describe the behaviour of coarse aggregate include relative density (or specific gravity), bulk density, and absorption.

2.4 WATER

Concrete mixture water is very sensitive and important raw materials used to provide the workability of concrete and to ensure cement hydration. The reason for being sensitive and important is the fact that the amount of water can affect all properties of fresh and hardened concrete. Concrete mixture water should be as clean as possible and there should contain as much substances such as chloride, sulphate, acid, sugar, organic materials, industrial waste, oil, clay and slit which may harmful. Cement requires up to 25%of its weight for hydration. Water used more than this amount is only aimed at increasing its workability. This, by time, leaves the body of the concrete, leaving hollowness in its place. The greater the amount of mixture water, the greater the hollows, and this not only affects the strength, but also affects the durability of the concrete negatively.

2.5 BASALT FIBRE

Basalt is a natural, hard, dense, dark brown to black volcanic igneous rock originating at a depth of hundreds of kilometers beneath the earth. Basalt fibre is a material made from extremely fine of basalt, which is composed of the minerals plagioclase, pyroxene, and olivine.

Fig-1: Basalt fibre

It is similar to fibre glass, having better physic mechanical properties than fibre glass, but being significantly cheaper than carbon fibre. The taken basalt fibre having the length 12mm, density of 2650kg/m^3 and tensile strength is 4150 to 4800 Mpa.

2.6 NEED FOR BASALT FIBRE:

Nowadays, among all basalt fibres, an inert mineral fibre is gaining more importance due to its exceptional properties, which include resistance to corrosion and low thermal conductivity. It also improves tensile strength, flexural strength and toughness of concrete.

2.7 STEEL FIBRE

Steel fibre is a metal reinforcement. Steel fibre for reinforcing concrete is defined as short, discrete lengths of steel fibres with an aspect ratio (ratio of length to diameter) from about 20 to 100, with different cross-section, and that are sufficiently small to be randomly dispersed in an unhardened concrete mixture using the usual mixing procedure. A certain amount of steel fibre in concrete can cause qualitative changes in concrete's physical property, greatly increasing resistance to creaking, impact, fatigue, and bending, tenacity, durability and other properties. The taken steel fibre having the cross section straight, hook ended, deformed, diameter 0.3 to 0.7mm, length 25 to 30mm, aspect ratio 55, density 7900kg/m^3, youngs modulus $2.1x10^5$n/mm^2, specific gravity 7.90 and tensile strength 500 to 2000n/mm^2.

Fig-2: Steel fibre

2.8 NEED FOR STEEL FIBRE:

Steel fibres are added to the concrete to improve the structural properties, particularly tensile and flexural strength. The extend of improvement in the mechanical properties achieved with SFRC over those of plain concrete depends on several factors, such as shape, size, volume, percentage and distribution of fibres. Plain, straight and round fibres were found to develop weak bond and hence flexural strength of SFRC was found to increase with aspect ratio. Even though higher ratios of fibres gave increased flexural strength, workability of green SFRC was found to be adversely affected with increasing aspect ratios.

3. MIX DESIGN FOR M30 GRADE CONCRETE

Table-1: MATERIALS REQUIRED AS PER IS METHOD OF DESIGN

Materials	water	cement	Fine aggregate	Coarse aggregate
Quantity/m^3	185.4	487.89	520.65	1325.22
Proportion	0.38	1	1.1	2.71

Gread of concrete-M30
The properties of materials used are

- Specific gravity of cement =3.15
- Specific gravity of fine aggregate =2.66
- Specific gravity of coarse aggregate =2.81

3.1 EXPERIMENTAL PROGRAMME

The following tests were made after 28 days curing:

- Workability test
- Compressive strength test
- Split tensile strength test,

3.1.1 Workability test

3.1.1.1 Slump cone test

The concrete slump test is an empirical test that measures workability of fresh concrete. The test measures consistency of concrete in that specific batch. It is performed to check consistency of freshly made concrete. Consistency refers to the case with test is popular due to the simplicity of apparatus used and simple procedure. Unfortunately, the simplicity of the test often allows a wide variability in the manner in which the test is performed. The slump test is used to ensure uniformly for different batches of concrete under field conditions, and to ascertain the effects of plasticizers on their introduction. Metal mould, in the shape of the frustum of a cone, open at both ends, and provided with the handle, top internal diameter 100mm, and bottom internal diameter 200mm with a height of 300mm.

Fig- 3: Slump test

The slumped concrete takes various shapes, and according to the profile of slumped concrete, the slump is termed as the true slump, shear slump or collapse slump is achieved, a fresh sample should be taken and the test repeated. A collapse slump is an indicated of too wet a mix or that it is a high workability mix, for which the slump test is not appropriate. Very dry mixes having 10 -40mm are used for foundation with light reinforcement, medium workability mixes, 50 – 90 mm for normal reinforcement concrete placed with vibration , high workability concrete > 100mm.

3.1.2 Compressive strength test

This test method covers the deformation of cube compressive strength concrete specimen. The specimen is prepared by pouring freshly mixed concrete into lubricated cube moulds. Consolidation is done extremely over vibrating table for 1-2 minutes. After vibration and finishing, the moulds are kept at normal atmosphere conditions for 231/2 ± ½ hours after which demoulding is done. The specimen are then cured in water tank.

Fig -4: Compressive Strength Testing Arrangement

The test is conducted at surface dry condition. The specimen is tested at the age for 28 days of curing under the compression testing machine.

$$\text{Compressive strength} = \frac{\text{Maximum load at failure}}{\text{Loaded surface area}} \times 1000$$

The tests were carried out on a set of triplicate specimen and the average compressive strength values were taken.

3.1.3 Split tensile strength test

Splitting tensile strength test was conducted on concrete cylinders to determine the tensile nature of carbon black concrete. The wet specimen was taken from water after 28 days of curing. The surface of specimen was wiped out. The weight and dimensions of the specimen was noted. The cylinder specimen was placed on compression testing machine. The load was applied. The test consist of applying a compressive line load along the opposite generators of a concrete cylinder placed with its axis horizontal between the compressive plates. Due to the compression loading a fairly uniform tensile stress is developed over nearly 2/3 of the loaded diameter as obtained from an elastic analysis.

Split tensile strength $= 2P / (\Pi dl)$

Fig -5: Split Tensile Strength Testing Arrangement

4. RESULT AND DISCUSSION

Table 1: COMPRESSIVE STRENGTH AT 7 DAYS

Si.no	Concrete mix	Basalt fibre	Steel fibre
1.	0%	22.90	22.90
2.	0.25%	23.40	27.86
3.	0.5%	25.62	28.25
4.	0.75%	27.87	28.95
5.	1%	28.89	29.40

Table 2:COMPRESSIVE STRENGTH AT 14 DAYS

Si.no	Concrete mix	Basalt fibre	Steel fibre
1.	0%	26.90	26.73
2.	0.25%	27.65	28.80
3.	0.5%	29.20	30.23
4.	0.75%	32.50	31.21
5.	1%	33.22	32.35

Table3: COMPRESSIVE STRENGTH AT 28 DAYS

Si.no	Concrete mix	Basalt fibre	Steel fibre
1.	0%	32.40	32.40
2.	0.25%	35.50	33.23
3.	0.5%	38.40	34.20
4.	0.75%	40.20	34.85
5.	1%	39.40	35.30

Table 4: SPLIT TENSILE STRENGTH AT 7DAYS

Si.no	Concrete mix	Basalt fibre	Steel fibre
1.	0%	2.22	2.22
2.	0.25%	2.30	2.32
3.	0.5%	2.64	2.45
4.	0.75%	2.87	2.52
5.	1%	3.02	2.86

Table 5: SPLIT TENSILE STRENGTH AT 14 DAYS

Si.no	Concrete mix	Basalt fibre	Steel fibre
1.	0%	2.35	2.35
2.	0.25%	2.62	2.43
3.	0.5%	2.90	2.76
4.	0.75%	3.14	2.87
5.	1%	3.65	3.02

Table 6: SPLIT TENSILE STRENGTH AT 28 DAYS

Si.no	Concrete mix	Basalt fibre	Steel fibre
1.	0%	2.95	2.95

2.	0.25%	3.03	3.07
3.	0.5%	3.33	3.15
4.	0.75%	3.64	3.30
5.	1%	3.94	3.40

5. CONCLUSIONS

Based on the experimental investigation, the following findings are observed.

- The optimum value of fibre content of steel fibre reinforced concrete was found to be 1% for compressive strength. But for basalt fibre reinforced concrete the optimum percentage is 0.75%.
- The rate of increase of split tensile strength in basalt fibre concrete is 34% which is only 15% in steel fibre concrete.
- Basalt base composites can replace steel and known reinforced plastics (1kg of basalt reinforces equals 9.6kg of steel).
- Whatever corrosion problem exists, basalt fibre reinforced concrete has potential to replace steel in reinforced concrete.
- Basalt fibres are cheaper and have durability under extreme condition.

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BIOGRAPHIES

S.VENKADA PRIYA M.E.,
Assistant Professor,
Department of Civil Engineering,
Velammal College of Engineering and Technology,
Madurai,
Tamil Nadu.

S.AISHWARYA.M.E.,
PG Scholar of Structural Engineering,
Department of Civil Engineering,
Vickram College of Engineering,
Madurai,
Tamil Nadu.

K.ABINAS M.SURYA
IVth Civil Engineering,
Department of Civil Engineering,
Velammal College of Engineering and Technology,
Madurai,
Tamil Nadu.

S.VIJAYARAGAVAN
IVth Civil Engineering,
Department of Civil Engineering,
Velammal College of Engineering and Technology,
Madurai,
Tamil Nadu.

D.SARAVANA KUMAR
IVth Civil Engineering,
Department of Civil Engineering,
Velammal College of Engineering and Technology,
Madurai,
Tamil Nadu.

R.MUNIYASAMY
IVth Civil Engineering,
Department of Civil Engineering,
Velammal College of Engineering and Technology,
Madurai,
Tamil Nadu.