Indian J.Sci.Res. 20(2): 56-60, 2018

ISSN: 0976-2876 (Print)
ISSN: 2250-0138(Online)

AN EXPERIMENTAL STUDY ON PARTIAL REPLACEMENT OF CEMENT BY BASALT FIBER IN A CONCRETE

R. ANITHA[a1] AND P. DEEPAN[b]

[ab]Department of Civil Engineering, Mahendra Engineering College, Namakkal, Tamil Nadu, India

ABSTRACT

This project deals with the art of knowledge of basalt fiber, it is relatively new material. Basalt fiber is a high performance non-metallic fiber made from basalt rock melted at high temperature. Basalt fiber reinforced concrete offers more Characteristics such as light weight, good fire resistance and strength. In future it is very beneficial for construction industry. Many applications of basalt fiber are residential, industrial, highway and bridges etc. In this study trial test for concrete with basalt fiber and without basalt fiber are conducted to show the difference in flexural strength.M-30 grade concrete was used and tests were conducted for various proportions of basalt fiber (i.e. 0.5%, 1.0%, and 1.5%) with locally available material. In this project flexural strength is determined and the strength is increases gradually.

KEYWORDS: Basalt Fiber, Basalt Rock, Aggregate, Cement

Concrete is a composite material composed of coarse aggregate bonded together with a fluid cement that hardens over time. Most concretes used are lime -based concretes such as Portland cement concrete or concretes made with other hydraulic cement. However, asphalt concrete, which is frequently used for roadsurface, is also a type of concrete, where the cement material is bitumen, and polymer concretes are sometimes used where the cementing material is a polymer.

Concrete is a compound material made from sand, gravel and cement. The cement is a mixture of various minerals which when mixed with water, hydrate and rapidly become hard binding the sand and gravel into a solid mass. The oldest known surviving concrete is to be found in the former Yugoslavia and was thought to have been laid in 5,600 BC using red lime as the cement. Reinforced concrete changes with varying concretes, fiber materials, geometries, distribution, orientation, and densities.

BASALT FIBER

Basalt is an igneous rock, which means it began in a molten state. For many years, basalt has been used in casting processes to make tiles and slabs for architectural applications. Additionally, cast basalt liners for steel tubing exhibit very high abrasion resistance in industrial applications. In crushed form, basalt also finds use as an aggregate in concrete. More recently, continuous fibers extruded from naturally fire resistant basalt have been investigated as are placement for asbestos fibers, in almost all its applications. In the last decade, basalt has emerged as a contender in the fiber reinforcement of composites. Basalt is a type of igneous rock formed by the rapid cooling of lava at the surface of a planet. It is the most common rock in the Earth's crust. Basalt rock characteristics vary from the source of lava, cooling rate, and historical exposure to the elements. High quality fibers are made from basalt deposits with uniform chemical makeup. The production of basalt and glass fibers is similar. Crushed basalt rock is the only raw material required for manufacturing the fiber. It is a continuous fiber produced through igneous basalt rock melt at about 2,700° F (1,500° C).Though the temperature required to produce fibers from basalt is higher than glass . It was observed that the use of continuous basalt fibers improved the tensile strength of concrete more than E glass fibers and gave a greater failure strain than the carbon fibers. The use of continuous basalt fiber in concrete was investigated. The results obtained in the research have shown an improvement in the thermal and mechanical properties of concrete. Some researchers have studied the effect of using short basalt fiber on the mechanical properties of concrete.

Figure 1: Basalt fiber

[1]Corresponding Author

Basalt fibers are manufactured in a single-stage process by melting naturally occurring pure basalt rock. Basalt is a natural, hard, dense, dark brown to black volcanic igneous rock. It is the most common type in the earth's crust (the outer 10 to 50 km). Its origins are at a depth of hundreds of kilometers beneath the earth surface and it reaches the surface as molten magma. Basalt density ranges between 2700 to 2800 kg/m3. The basic characteristics of basalt materials are high-temperature resistance, high corrosion resistance, resistance to acids and alkalis, high strength and thermal stability. Basalt can be formed into continuous fibers with the same technology utilized for E-Glass and AR-Glass fibers, but the production-process requires less energy and the raw materials are widely diffused all around the world. This justifies the lower cost of basalt fibers compared to glass fibers. Moreover, basalt fibers are environmentally safe, non-toxic, non-corrosive, non-magnetic, possess high thermal stability, have good heat and sound insulation properties, durability and vibration resistance.

Basalt has a fine-grained mineral texture due to the molten rock cooling too quickly for large mineral crystals to grow, although it is often porphyritic, containing the larger crystals formed prior to the extrusion that brought the lava to the surface, embedded in a finer-grained matrix.

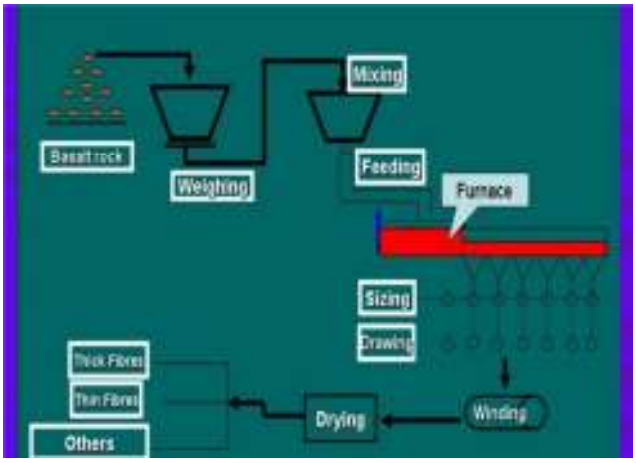

Figure 2: Manufacturing of basalt fiber

PROPERTIES OF BASALT FIBER

Physical Properties

Color: It is available in golden brown in color.

Diameter: It is available in different diameter like 5.8 micron.

Length: Available in 6mm, 8mm, 12mm etc.

Density: Density of basalt fiber is 2.75 g/cm^3

Coefficient of friction: The coefficient of friction may be between 0.42 to 0.50.

Chemical Properties

- Basalts are more stable in strong alkalis.
- Weight loss in boiling water, Alkali and acid is also significantly lower.
- Possess resistance to UV- Light & biologic and fungal contamination.
- Are compatible with phenolic resins.
- Absorption of humidity comes to less.

Thermal Properties

- With a thermal range of –260 ◦C to 982 ◦C and melt point of 1450◦C as well as low thermal conductivity 0.031 – 0.038w/mk, the basalt fibers are ideal for fire protection and insulation applications.
- Basalt fibers are most cost effective than the other high-temper Materials including E-glass, silica, ceramics, stainless steel and carboby preventing rapid overheating and improving brake life.
- Offer three times the thermal efficiency of asbestos with no Mental and heat hazards.
- Basalt fiber is the best solution for asbestos replacement.
- Basalt fiber is non- combustible and explosion proof.
- After exposition less than 400 ◦C the basalt fibers loss on their initial strength, while the E-glass loss more 50%.

Mechanical Properties

- The specific tenacity (rupture stress to density ratio) of basalt fibers exceeds that of steel, many times.
- Basalt fibers are non-capillary and non-hygroscopic, giving good moisture resistance.
- Basalt has shot content generally less than 3%.

Applications of Basalt Fiber

Construction

- Reinforcement of bridges and tunnels.

- Internal waste pipes.
- Repair of cracks and local damage to buildings and bridges.

Petro Chemical Industries

- Chemical and wear proof covering of tanks.
- Pipelines and oil pipelines.
- Nonflammable coverings and composite materials.

MATERIALS AND METHODS

Natural basalt fiber, it is a new coming material to the construction industry. Basalt is a nonmetallic, high performance material made from naturally available igneous rock. Under high temperature basalt fiber and other products formed from igneous rock. Basalt fiber incorporated concrete has more beneficial characteristics like higher strength, good temperature resistance and light weight. In forthcoming days it is very essential for construction domain. This fiber is useful in many civil engineering applications include construction of Commercial, industrial building, pavements (flexible & rigid) and highway bridges. This article deals about the strength characteristics of basalt incorporated concrete with conventional concrete to reveal the compressive strength of cubes & Flexural strength of beams. This research article provides more positive features about the basalt as a construction material in the booming infrastructure industry. (GokilaG 2017)

Compressive, flexural, and split tensile strength of basalt fiber reinforced concrete. Concrete had a good future and is unlikely to get replaced by any other material on account of its ease to produce, infinite variability ,uniformity ,durability and economy with using of basalt fiber in high strength of concrete. Basalt fiber offers more characteristics such as light weight, good fire resistance and strength. The main aim of this investigation is to study the effect of different proportion of basalt fiber in the mix. In this study trial test for concrete with basalt fiber and without basalt fiber are conducted to show the difference in compressive strength and flexural strength by using cubes, cylinders and concrete beams of grade M25.This paper provides data of fiber reinforced concrete containing fibers of 12mm length of various percentage by weight of cement. (K.Sathes Kumar, etal 2017)

TEST ON MATERIALS

Tests on Cement

Table 1: Properties of cement

Sl. No.	Name of Test	Value
1	Consistency	37 %
2	Initial setting time	31 minutes
3	Final setting time	480 minutes
4	Fineness modulus	1.74
5	Specific gravity	3.15

Tests on Fine Aggregate

Table 2: Properties of fine aggregate

Sl. No.	Name of Test	Value
1	Specific gravity	2.6
2	Fineness modulus	2.75
3	Water absorption	2.5 %
4	Bulk density	1650 Kg/m^3

Tests on Coarse Aggregate

Table 3: Properties of coarse aggregate

Sl. No.	Name of Test	Value
1	Specific gravity	2.8
2	Fineness modulus	3.15
3	Water absorption	1.0 %
4	Bulk density	1650 Kg/m^3

Water

Portable tap water available in laboratory with pH value of 7.0 ± 1 and confirming to the requirement of IS: 456-2000 was used for mixing concrete and curing the specimens as well. Combining water with a cementations material forms a cement paste by the process of hydration. The cement paste glues the aggregate together, fills voids within it, and makes it flow more freely.

A lower water to concrete ratio yields a stronger, more durable concrete, while more water gives a free flowing concrete with a higher slump. Impure water used to make concrete can cause problems when setting or in causing premature failure of the structure.

Hydration involves many different reactions, often occurring at the same time. As the reactions proceed, the products of the cement hydration process gradually bond

together the individual sand and gravel particles and other components of the concrete, to form a solid mass.

Basalt Fiber

It is chopped fibers from monofilament fibers. Monofilament fibers are made by extrusion process from basalt.

Table 4: Properties of basalt fiber

Sl. No.	Name of Test	Value
1	Base Materials	Basalt Rocks
2	Fiber Type	Basalt chopped fiber strands
3	Length	18 mm
4	Diameter	13 µm
5	Density	2.6 g/cm^3

Calcium Silicate Hydrate

Calcium silicate hydrate is the main product of the hydration of Portland cement and is primarily responsible for the strength in cement based materials.

Calcium silicate hydrate (CSH) is critical to cement paste strength and durability, many ambiguities remain regarding its atomic structure. This knowledge is vital for optimizing CSH-based concretes with the aim of reducing the CO2 associated with its production. Despite extensive study, CSH in cements has continued to escape detailed and direct atomic structure analysis for two main reasons: difficulty in separating it from other phases and its broad diffraction signal. The manufacture of every ton of Portland clinker emits approximately 0.8 tons of CO2 into the atmosphere, comprising 5%–7% of the total human made CO2 emission. CSH is the main binding phase in a Portland cement matrix; therefore, there is strong motivation to optimize the strength and durability of CSH so that less cement is used. Despite the vast amount of literature available on cementitious materials, many questions and ambiguities on the understanding of the atomic scale structure of this cement remain.

TEST RESULTS AND DISCUSSION

Table 5: 0% plain concrete flexural Strength

Type	Ultimate load kN	Flexural Strength N/mm^2	Average Flexural Strength N/mm^2
1	15	2.51	2.47
2	16	2.81	
3	14	2.10	

Table 6: 0.5% Basalt concrete flexural Strength

Type	Ultimate load kN	Flexural Strength N/mm^2	Average Flexural Strength N/mm^2
1	23	4.52	4.45
2	25	4.89	
3	21	3.96	

Table 7: 1% Basalt concrete flexural Strength

Type	Ultimate load kN	Flexural Strength N/mm^2	Average Flexural Strength N/mm^2
1	27	5.15	5.32
2	29	5.93	
3	26	4.90	

Table 8: 1.5% Basalt concrete flexural Strength

Type	Ultimate load kN	Flexural Strength N/mm^2	Average Flexural Strength N/mm^2
1	32	6.14	6.27
2	33	6.85	
3	30	5.83	

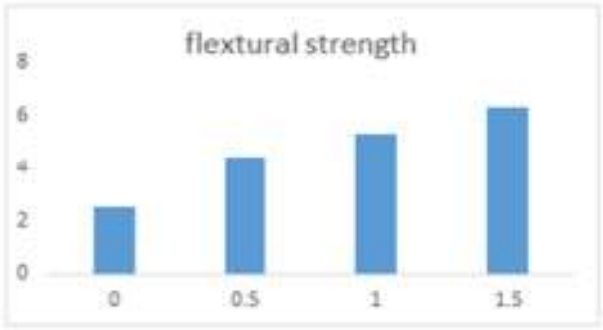

Figure 3: 28 days of basalt concrete flexuralStrength

CONCLUSION

Based on the above investigation, it have been found that

- By the optimum percentage of cement replaced by basalt fiber in M30 grade, the target mean flexural strength of the cylinders have been studied.
- It has been noted that the strength increase as % replacement of basalt increases.
- Hence it may be possible to replace the cement till 1.5% by basalt to achieve the good strength.
- As the percentage of basalt in a concrete exceeds about 1.5%, the split tensile mean Decreases gradually.
- Hence, a good result has been obtained through internal curing until the replacement of cement by basalt till 1.5%.

REFERENCES

Nihat Kabay, 2014. "Abrasion resistance and fracture energy of concretes with basalt fiber", Construction and Building Materials, **50**: 95–101.

Marijonas Sinica, Georgij A. Sezeman, Donatas Mikulskis, Modestas Kligysa and Vytautas C. Esnauskas, 2014. "Impact of complex additive consisting of continuous basalt fibers and SiO2 microdust on strength and heat resistance properties of autoclaved aerated concrete", Construction and Building Materials, **50**: 718–726.

Gore Ketan R., "The performance of basalt fiber in high strength concrete", Journal of Information, Knowledge and Research in Civil Engineering, ISSN: 0975 – 6744| NOV 12 TO OCT 13, **2**(2).

Singh K., 2012. "A Short Review on Basalt Fiber", International Journal of Textile Science, **1**(4):19-28.

Tumadhir M., 2013. "Thermal and Mechanical Properties of Basalt Fiber Reinforced Concrete", World Academy of Science, Engineering and Technology, **7**:04-26.

Milind V. Mohod, 2012. "Performance of Steel Fiber Reinforced Concrete**",** International Journal of Engineering and Science, ISSN: 2278-4721, **1**(12):01-04.

Nataraja M.C., "Fiber Reinforced Concrete- Behaviour Properties and Application".