Experimental Investigation on Basalt Fiber Reinforced Concrete

Djaksimuratov Karamatdin Mustapaevich
Candidate of Natural Sciences, Nukus Mining Institute

Jumabayeva Guljahon Jaqsilikovna
Intern teacher, Nukus Mining Institute "Natural and general professional sciences"

Maulenov Nurlibek Axmet o'g'li, Rametullayeva Mehriban Po'latbek qizi
Student of Nukus Mining Institute

Abstract: this thesis focus on experimental investigation on fiber reinforced concrete, works were carried out on experimental investigation of basalt fiber concrete. Properties of concrete were checked by testing cubes, cylinders and prisms. The specimens were cast usingM20 Grade concrete with locally available materials. The object of the present work is to study the effect of different proportions of fibers in the concrete and find out optimum percentage of fibers with maximum strength criteria. The specimens like cubes, split tensile strength and flexural strength. Concrete specimens with different proportions (0.25%, 0.30%, and 0.35%) of basalt fibers were cast along with control specimens. Based on the literature study, it was found that the basalt fiber concrete have better toughness and impact strengths than the control concrete. It was also found that the addition of basalt fiber in concrete changes the mode of failure from brittle mode of failure to ductile mode of failure when subjected to compression, bending and impact. Because of its high tensile property it improves tensile strength of concrete when mixed in optimum fiber ratio and has shown adequate enhancement in flexural behaviour such as Load-deflection, Moment-curvature and crack pattern.

Keywords: Basalt fiber concrete (BFC), Compressive strength, Flexural strength, Split tensile strength, Chopped basalt fibres.

INTRODUCTION

Construction is a major part of development plan of developing countries including Uzbekistan. At present, raw material reserves of basalt in Uzbekistan, in particular in the Republic of Karakalpakstan, have been partially identified. Several deposits in Karakalpakstan have been noted, such as Sheikhjeyli, Dushchebulak and Berkuttau. The amount of certain raw material reserves of Uzbekistan and Karakalpakstan is indicated. It was found that basalt rocks are the main component of the earth, with a share of 25 to 38%. Planets known to science have basalts, including the Earth's moon - the Moon. All information about basalt is related to the geological processes of volcanic eruptions. Analysis of the literature on the location of basalt rocks in the deposits of Uzbekistan showed that the main appearance of basaltic igneous rocks can be observed on the surface of the earth's crust. Such a location of basalts occurred after the eruption of an ocean volcano, with the rapid cooling of the magmas, along with many igneous rocks to form basalt. Basalts can be distinguished from other minerals by up to 5 mm in size by smelting operations. Apparently, it is difficult to distinguish them from diabases and dolerites. Analysis of the mineralogical composition of the basalt rock and comparison of the obtained results with the rock composition from different regions of the world showed that the silicate content of the basalt is high. As noted above, the presence of metal oxides is particularly noticeable, which contributes to the formation of plagioclase, pyroxene, and olivine in basalts. All the existing hypotheses of scientists about the behavior of the liquid state of the rock can be incorporated into the chemical composition of basalt. It is noted that the chemical components determine the direction and methods of basalt processing.To meet the large demand for infrastructure development, maintenance andlife enhancementofstructuresareveryimportant.Concreteisthe most widely used manmade construction material. Plain concrete possesses a very low tensile strength, limited ductility and little resistance to cracking. Conventional concrete doesn't meet many functional requirements such as impermeability, resistance to frost adequately. The presence of micro cracks at the mortar–aggregate interface is responsible for the inherent weakness of plain concrete. Because of the poor tensile strength, crack propagates with the application of load leading to brittle fracture of concrete. Micro cracks are formed in concrete during hardening stage. Natural disasters like earthquakes, cyclones, tsunami, etc destroy the high rise buildings, bridges, monumental structures, world wonders, etc. One such development has been two phase composite materials i.e. fiber reinforced concrete, in which cement based matrix, is reinforced with ordered or random distribution of fibers. Fiber in the cement under load which eventually cause failure.

BASALTFIBER

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.Itisthemostcommontypeintheearth'scrust (theouter 10 to 50km). Its origins are at a depth of hundreds of kilometers beneath the earth surface and it reaches the surface asmoltenmagma. Basalt densityranges between 2700to2800kg/m3.Thebasic characteristics of basalt materials are high-temperature resistance, high corrosion resistance, resistance to acids and alkalis, high strengthand thermal stability. Basalt can be formed into continuous fibers with the same technology utilized for E-Glass and AR-Glass fibers, but the production-processrequireslessenergyandtherawmaterials 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.

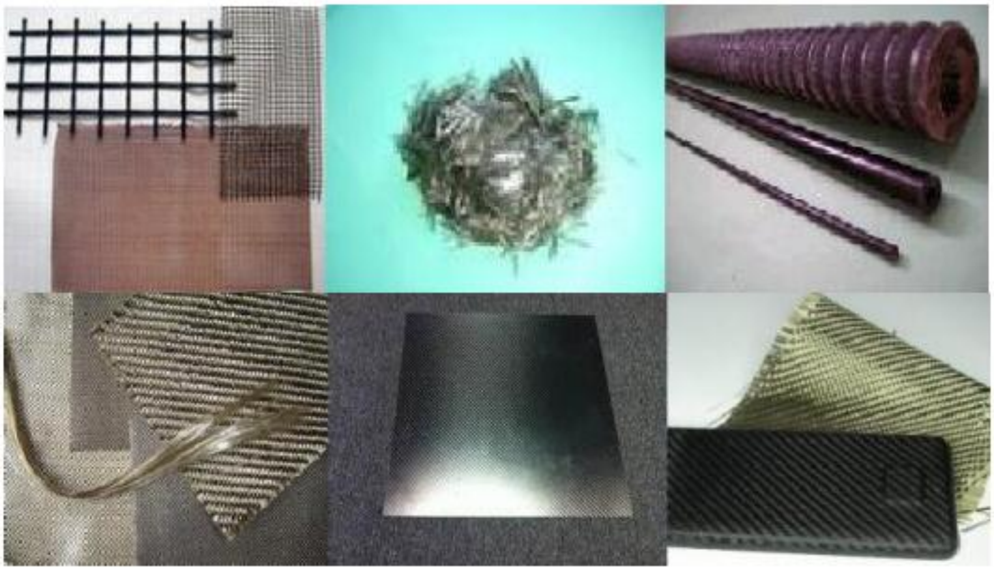

Fig. 1 Basalt fiber

Some studies have already investigated on fundamental propertiesof basaltfibersanditsappli cationas strengthening and reinforcing material. It is found that the basalt fiber presents a modulus of elasticity at least 18% higher than that of E-Glass fibers and beams strengthened with basalt fibers showed a more ductile failure than those strengthened with E-Glass fibers. Strengthened with EGlass fibers.

MIXINGPROPORTIONING

The mixture proportioning was done according to the Indian Standard Recommendation method IS 10262-2009. The ordinary Portland cement (opc) of Grade 43 is used. Cement, fine aggregate, coarse aggregate & basalt fiberwere properly mixed together in accordance with IS code in the ratio 1:1.52:2.78 by weight before water was added and was properly mixed together to achieve homogenous material. Water absorption capacity and moisture content were taken into consideration and appropriately subtracted from the water/cement ratio used for mixing. Basalt fibers with different percentages 0.25%, 0.30%, 0.35% are being replaced for the total volume of concrete. Cubes, cylinders and prism moulds were used for casting; compaction of concrete in three layers with 25 strokes of 16mm rod was carried out for each layer. The concrete was left inthe mould and allowed to set for 24 hours before the moulds were de-mouldedand then they wereplacedin the curingtankuntil The day oftesting(28days).The mix proportion obtainedisas shown below.

Table: Mix proportion

Water	Cement	Fine aggregate	Coarse aggregate
192 lit	427 kg/m³	648 kg/m³	1179 kg/m³
0.45	1	1.52	2.78

BASIC CHARACTERISTICS OF BASALTMATERIALS

The use of Basalt fibers has captured the interest of structural engineering community due to its favorable properties such as;

1. High temperature resistance
2. High corrosion resistance
3. Resistance to acids and alkalis.
4. High strength & thermal stability.
5. Environmentally safe.
6. Having good heat and sound insulation properties.
7. Durability and vibration resistance.
8. Non-toxic, Non-corrosive &Non-magnetic.
9. Possess high resistance against low and high temperature & have high thermal stability.

PROPERTIES OF USEDMATERIALS

- Chopped Basalt fiber with aspect ratio50.
- Cement: Ordinary Portland cement of 43 grade having specific gravity of3.14

- Fine aggregate: Natural river sand conforming to IS-383, Zone-II having specific gravity2.60
- Coarse aggregate: Crushed granite angular aggregate of size 20mm confirming to IS-383 having specific gravity 2.78.
- Water: Ordinary potable water conforming to IS456

STRENGTHPROPERTIES

The program was conducted for understanding the effectiveness of adding basalt fibers in concrete, the testing was carried out on 12 concrete cubes (150mm x 150mm x 150mm) for compressive strength, 12 concrete cylinders (150mm x 300mm) for Elasticity modulus and 12 concrete prisms (100mm x 100mm x 500mm) for flexural strength. Casting was made in M20 Gradeand the specimen's weremade to cure for 28 days in potable water.

COMPRESSION STRENGTHTEST

The Compressive strength is the capacity of a material or structureto with standcompressiveload with out failure.It can be measured by plotting applied force against deformation noted from the universal testing machine. Some materials fracture at their compressive strength limit, others deform irreversibly, so a given amount of deformation may be considered as the limit for compressive load. Compressive streng this the keyvaluefor design of concrete structures. Compressive strengthof the concreteisobtained bytesting the cubes of size 150mmx150mmx150mm at 28th day. The Concretecubes designed for M20grade were castandcuredfor 28 days. After 28 days of continuous curing the specimens were taken out and they were exposed to atmosphere for few hours. Surface water and grit shall be wiped off and any projecting fins are removed. In the case of cubes, the specimen is placed in the machine in such a manner that the load is applied to opposite sides of the cubes. A spherically seated block is brought to bear on theSpecimen; the movable portion is rotated gently by handso that uniform seating may be obtained. The load isappliedWithout shock and increased continuously untiltheresistance of the specimen to the increasing load breaks down andnoGreater load can besustained. The compressive test on hardened control&B a s a l t concrete were performed on a 2000kN capacityhydraulic testing machine in accordance to the relevant Indianstandards. A typical setup is shown in fig 2. Three concrete cubes were tested for every compressive strength test.

Fig: 2 Compressive strength test set up

FLEXURALSTRENGTHTEST

Concrete as we know is relatively strong in compression and weak in tension. In reinforced Concrete members, little dependence is placed on the tensile strength of concretes incesteel reinforcing bars are provided to resist alltensile forces. The Flexural streng thof the concreteisob tained by testing the Prismspecimensof size100mmx100mmx500mmat28thday. The concrete Prism specimens designed forM20 gradewere cast and cured for 28 days. After 28 days of continuous curing the specimens were taken out andt hey were exposed toatmosphere for few hours. The bearing Surface softhe supporting and loading rollersarewipedclean, and anyloosesand or other material removed from the surface of the specimen where they are to make contact with the rollers. The specimen is then placed in the machine in such a manner that the load is applied to the uppermost surface as cast in the mould, along two lines spaced 13.3 cm apart. The axis of the specimen is carefully aligned with the axis of the loading device. No packing is used between the bearing surfaces of the specimen and the rollers. The load is applied without shock and increasing continuously at a rate such that the extreme fiber stress increases approximately 0.7 kg/sq cm/minthatis,atarateof loading of 180kg/min.Theloadis being increased until the specimen fails, and the maximum load applied to the specimen during the test is recorded. The appearanceofthefracturedfacesofconcreteandanyunusual features in the type of failure is noted. A typical setup is shown in fig 3. The flexural strengthof the specimen is expressed as the modulus of ruptureFb

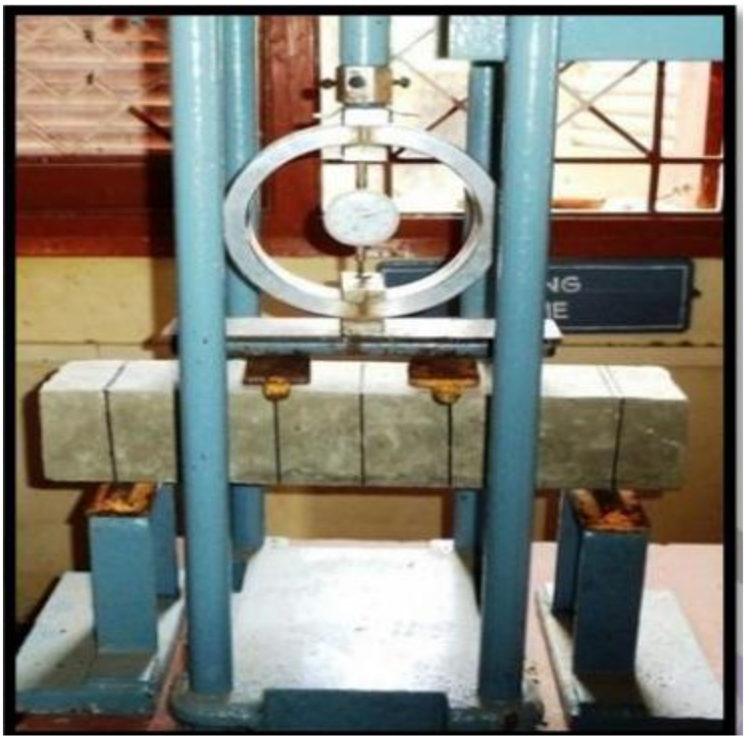

Fig: 3 Flexural strength test set up

MODULUS OF ELASTICITY INCONCRETE

Modulus of Elasticity is the measure of the ratio of stressto the corresponding strain. The modulus of elasticity can be determined by testing the cylinder specimens of size 150mmx300mm by meansofuniaxial compression. The concrete cylinders designed for M20 grade were cast and cured for 28 days. After 28 days of continuous curing the Specimens were taken out and they were exposed to atmosphere for few hours. Surface water and grit shall be Wipedoffandany projectingfins are removed.Thespecimen is thenplacedin the machine insuchamanner that theaxisof the specimen is carefully aligned with the axis of the loading device. The stress and corresponding strain values can be obtained by subjecting the cylinder specimen to uniaxial compression through an universal testing machine as shown in the fig below, and measuring the deformation by meansof dial gauges fixed between certain gauge length. Dial gauge reading divided by gauge length will give the strain and load applied divided by area of cross-section will give stress. The E value can be finally predicted by drawing initial, secant & chord modulus on the stress-strain graph plotted for tested values.

Fig: 4 Test on Concrete Cylinders for E for concrete

ADVANTAGES OF BASALTFIBRES

1. Basalt fiber materials does not undergo any toxic reaction with water and air, also do not have any side effects on humanhealth.
2. Basalt fibers have major qualities like acid resistance, alkali resistance. It is thermally, electrically and sound insulated.
3. Basalt base composites can replace steel (1 kg of basalt rein forces equals 9.8kgofsteel) aslight weight concrete can be get from basalt fiber.
4. Basalt has several excellent properties like high Elasticity modulus and excellen the at resistance. These fibers Havesignificantcap ability ofheat & acoustic damping and are out standing vibration isolators.
5. The basalt fiber has low density as 2.8 g/cc to 2.9 g/cc, which is much lower than other metals and closer to carbon and glass fibers, though cheaper than carbon fiber and high strength than glass fiber. Hence basalt is suitable as low weight cheaper tough compositematerial.
6. They possessamodulus of Elasticityatleast18%higher than that of E-Glass fibers.

CONCLUSION

The following conclusions were derived from this experimental work:

1. Generally the workability of the concrete is greatly affected by the addition of fibers with the concrete and also imparts the use of super plasticizers to improve the work ability but the addition of Basaltfibers with the concrete shows the same workability as the normal concrete and there is no need for any kind of super plasticizers to improve the Work

ability.Soinwork ability point of viewaddition of basalt fiber is not a defectiveone.

2. As we know, concrete is strong in compression. The addition of basaltfiber with normal concrete further improves The compressive strength of concrete. The experimental results shows that the compressive strength of Basalt fiber concrete is 38.43 N/mm2 which is 23% higher than control concrete 31.34 N/mm2
3. Concrete is very weakintension,to over come this defect weareaddinghightensile fiber material(i.e.Basaltfiber)into The concrete. It is not edfrom the experimental results that the Basalt fiber concrete exhibits higher tensile strength than the normal concrete. The tensile strength of basalt fiberconcrete 7.76N/mm2is found to be 55% higher than the tensile strength of normal concrete 5.26 N/mm.

REFERENCES

1. A5-030 Budget Research and Development Report. Navoi, NGGI. "Exploration of natural resources in order to develop technology for obtaining refractory and composite materials from local raw materials." 2006. -70s.
2. Dodis G.M. and Kudinova IV.. Melted structure from basalt rocks. KGNU bulletin. Kyrgyzstan.-2007.-S 2-14.
3. Qurbonov A.A. Specific properties of Kyzylkum basalts. Ed. "Fan" of the Academy of Sciences of Uzbekistan, 2009, 160 p.
4. Qurbonov A.A. Structural study of basalts of Uzbekistan. RMZ - materials and geo environment. - Slavenia, 2012, 59 vols. - № 1. - s. 55-70.
5. Singaravadivelan, P.Chinnadurai,,.KL.Muthuramu and .P.Vincent(2013) “ Flexural Behaviour of Basalt Chopped Strands Fiber
6. TumadhirMerawiBorhan, Colin G. Bailey (2013) “Structural behaviourof basalt fibre reinforced glass concrete slabs” - Materials and Structures.
7. Tumadhir M., Borhan (2013) “Thermal and Mechanical Properties of Basalt Fibre Reinforced Concrete” - Engineering and Technology vol762013