International Journal of Research in Advent Technology, Vol.6, No.12, December 2018
E-ISSN: 2321-9637
Available online at www.ijrat.org

Effect of Fiber Reinforcement on Blended Concrete Mixes

Saaransh Gupta[1], Aditya Jadhav[2], Shailesh Garkal[3], Rushikesh Meher[4], Mithun Sawant[5]
Department of Civil Engineering[1,2,3,4,5], Dr. D.Y. Patil Institute Of Engineering, Management & Research, Akurdi, Pune, India.[1,2,3,4,5]
Email: saaranshg98@gmail.com[1], adijadhav8777@gmail.com[2], shaileshgarkal1997@gmail.com[3], rushikesh.meher.1997@gmail.com[4], mithun.903@gmail.com[5]

Abstract- The study of various research and references gave us an idea of making use of recycled aggregate concrete (RCA) with reinforcement Basalt and Steel Fibers. The use of recycled aggregate concrete (RCA) was introduced in early 1980's. The idea was to check the feasibility of recycled aggregate concrete (RCA) and fine aggregate in concrete and maintaining its strength by adding admixtures along with recycled aggregate in concrete. Further studies concluded that using of Basalt and Steel Fiber as reinforcement gave good strength as compared to conventional concrete. This led us to an idea of making concrete with use of recycled aggregate concrete (RCA) and reinforcing it with Basalt and Steel Fiber to increase its strength and constructing an ecofriendly concrete. In this paper we are trying to put light on various concrete mix proportion and their relevant studies.

Index Terms- Basalt Fiber, Recycled Coarse Aggregate, Fiber Reinforced Concrete, Steel Fiber

1. INTRODUCTION

Concrete is usually made of cement, sand and coarse aggregates. The cost of extraction and disposal of coarse aggregates is very high. The coarse aggregates can be obtained from the demolished structures and can be reused after treating them, thus reducing the cost of the coarse aggregates and reducing the pollution. The use of RCA in non-important construction works can be done and the NCA can be saved for much more important works. Also, one of the drawbacks of concrete as a brittle material is its low tensile strength, and strain capacity. Therefore, the use of steel reinforcement is done in order to make the concrete suitable to be used as a construction material. Fibers, are generally short, discontinuous, and randomly distributed during the preparation of concrete mix, in order to prepare structure known as fiber reinforced concrete (FRC). Generally, the fibers used are made of steel, glass, and polymer or derived from natural materials. Fibers help in delaying the first cracking and thus increases the cracking resistance. This is due to the closely spaced fibers. The steel fibers and steel reinforcement are two different things and the purpose of using them is different too. The steel fibers and steel reinforcement can be used together in a same concrete.

2. MATERIALS USED

Out of all the fibers available, the use of following two fibers will be done:

2.1. *Steel Fiber (SF)*

Initially, the the steel fibers were used to prevent plastic and drying shrinkage in concrete. After some research, it was found that steel fiber can be used in concrete in order to increase the properties of the concrete.Steel strips are converted into small pieces of steel fibers by applying a large amount of pressure. These fibers are produced by two type of failure of steel strips: (a) Brittle Failure, (b) Shear Failure

Brittle fracture is obtained when the plastic deformation is minimum and at a low-energy impact level in order to produce a straight steel fiber having a uniform cross section.The shear fracture is obtained at higher energy impact levels as compared to brittle fracture, in order to obtain steel fibers that has irregular shape and are highly irregular in cross section.

2.1.1. Types of Steel Fiber

Straight, Hooked, Deformed, Flattened, Crimped.

2.2. *Basalt Fiber (BF)*

Basalt fiber is obtained by melting basalt rocks at high temperature. Basalt rock fibers does not react with air or water. They are highly non-combustible. But they are harmful if reacted with other chemicals as they can harm the human body and the environment. Basalt fiber has good hardness and thermal properties.

It originates from volcanic magma and volcanoes, a very hot fluid or semi fluid material under the earth's crust, solidified in the open air. Basalt is gray dark in

color. The basalt rock is treated by using small nozzles which help in producing continuous filaments of basalt fiber. The basalt fibers are used as it is and no other additives are used in their production, thus not increasing the cost. Basalt Fiber is made up of very fine fibers of basalt. It has almost similar properties to glass fiber but are more cheaper than carbon fibers. It is used for the following: fire proof textile in the aerospace and automotive industries and can also be used to produce products such as camera tripods.

2.2.1. *Properties of Basalt Fiber*

- Tensile Strength: 2.8-3.1 GPa
- Elastic Modulus: 85-87 GPa
- Elongation at Break: 3.15%
- Density: 2.67 g/cm^3

3. LITERATURE REVIEW

Tam, C.T., Ong, K.C.G., Akbarnezhad, A. and Zhang, M.H. [1] In 1980's, the use of recycled aggregates had just come into picture, before the establishment of British European Standards (BSEN 12620,2002) for recycled aggregates in its use in concrete (BS 8500-2, 2006). The idea was to check the feasibility of both, recycled coarse and fine aggregates, in a new concrete having same or higher strength, by adding the admixtures along with recycled aggregates in new concrete. The paper involves the study of RCA in brief and also shows the properties of RCA. The paper shows both the studies, of 1980's and the recent studies.

Prabhat Kumar, Abhishek Kumar, Mohd. Afaque Khan[2] Akanksha Tiwari studied that water absorbtion of RCA is higher than the natural aggregates. Also, a good tensile strength is observed when replaced upto 25-30%. Prof. Chetna M Vyas and Prof. (Dr.) Darshana R Bhatt studied the replacement of RCA with natural coarse aggregates by 0% - 40%, gives enough compressive strength to the concrete as per the required standards.

Prasad Karunakaran.R, Jegidha.K.[3] The study of paper states the effect on strength of concrete for M30 grade, by varying percentage of fibers in concrete. Fiber content varied by 0.25%, 0.50%, 0.75%, 1%, 1.5%, 2% by volume of cement. To check the compressive strength values, concrete blocks of size 150mm X 150mm X 150mm were casted, whereas to check the flexural strength, beams of size 500mm X 100mm X 100mm were casted. Before crushing, the specimens were cured for a period of 3, 7 and 28 days. A significant improvement in strength of steel reinforced concrete of varying fiber percentage having a curing period of 3, 7 and 28 days was found. The optimum fiber content of 1% was found while studying the compressive strength of cube, whereas for flexural strength, it was found to be 0.75%. Also, increase in strength of concrete was observed with increase in fiber content up to the optimum value. To measure the workability of concrete, slump cone test was adopted, which showed the reduction of workability with addition of fiber.

Jason Duic, Sara Kenno, Sreekanta Das[4] The study of paper states the evaluation of performance of concrete beams with BFRP rebar. Full scale test, on eight large scale concrete beam specimens reinforce with either BFRP rebars or steel rebars were undertaken. Mechanical and durability tests on basalt fibers were done by Sim et al. (2005) and were compared with glass and carbon fibers. The study revealed that in increased weathering and temperature conditions, basalt fiber should perform better then the glass and carbon fibers. A ultimate strength of about twice that of conventional reinforcing steel bar was observed in BFRP rebars. Good strength retention in increased weathering condition of heat and alkalinity was found in BFRP rebars in a study conducted by Serbescu et al. (2015). Excellent bond durability among BFRP rebars was observed and also higher bond strength than GFRP was observed.

John Branston, Sreekanta Das, Sara Y. Kenno, Craig Taylor[5] The study of the paper reveals the research done by Li & Xu that Basalt Fiber can significantly increase the energy absorption capacity of geo polymer concrete under impact loading by using a split- Hopkinson pressure bar system. However, the performance of BFRC under impact in general is not well effective. As non- comparable results are obtained from different test method, practical references are obtained from simple test results for which future comparisons can be made. BFRC being a relatively new composite has this particularly used and further development can be expected to enhance its material properties for concrete reinforcing applications. Comparison of pre and post- cracking mechanical behavior of concrete reinforced with chopped basalt fiber, basalt minibars (MB) and commonly used hooked and steel fibers is the main purpose of experimental work presented in this paper. The comparative performance is evaluated by flexural and drop weight impacting. Filament Dispersion and Bundle Dispersion are two types of chopped Basalt Fibers available. Bundle dispersion fibers are selected in this study.

Zeynep Algin, Mustafa Ozen[6] The study of paper says about the increased widespread utilization of basalt fibers as a concrete reinforcement material due to availability of excess of raw material and its low production cost. Due to this study to check the affect of basalt fiber, the mechanical properties of concrete has gained a full demand. An investigations by many researchers was done in this and showed the results that making use of basalt fiber up to approximately 0.3 to 0.5% by volume provides beneficial results. Jun and Ye investigated the effect of basalt fiber utilization of flexural strength on concrete using fiber having length

of 30 mm and using fiber amount of 0.1 to 0.35%. The conclusion stated that the flexural strength of the concrete increases with rising amount of fiber addition and maximum value of flexural value obtained in this case is 0.3% of basalt fiber utilization.

Fabrizio Sarasini, Jacopo Tirillo, Maria Carolina Seghini[7] The variation in mechanical behavior of the basalt fiber was observed by following the treatments at different temperatures (200°C – 600°C), and heating for a period of 1 hour. The aim is to study the effect of different temperature or heating conditions on the properties of single basalt fiber having two different sizes, one optimized for thermoset resins (epoxy) and the other one optimized for thermoplastics (polypropylene). This paper shows a systematic study of the effect of atmosphere and temperature on the properties of basalt fiber. The possible factors for the strength loss of basalt fiber with the increasing temperature are discussed taking into account thermogravimetric analysis, X-ray diffraction analysis and density measurements.

Vasudev R, Dr. B G Vishnuram[8] This research is based on expanding the existing knowledge on the applications of SFRC. It increases the durability of the concrete as the addition of fibers toughens the joints and makes the structure more durable. It is observed that the construction of one ton of cement releases one ton of Carbon Dioxide. In this paper, the comparison between the ordinary reinforced beam and the steel fiber reinforced concrete is done by preparing cubes and cylinders of both the types of concrete and then performing the tests on the same. Thus, increasing the knowledge about the properties, advantages and disadvantages of the steel fiber reinforced concrete.

Han Ayliea, Antoniusb and Aldyan W. Okiyartac[9] Hadi and Paultre et al, showed the positive aspects of fibers in the use of concrete structure and confirmed the addition of steel fibers, up to a specific amount, increases the properties and improves the bond between the mortar and the aggregates and enhancing the energy absorption and toughness characteristics. Antonious et al, concluded that, even in high temperatures, the steel fiber concrete maintains its ductility. The steel fibers does not undergo any corrosion like the steel reinforcing bars.

A.P. Singh & Dhirendra Singhal[10] The effect of fibers added in a concrete mix depends upon few factors, such as fiber content, fiber length, aspect ratio (the ratio of length to the diameter), fiber volume fraction and the age of curing. M20 grade of concrete was taken and cubes were casted, having a design mix concrete containing 1.0%, 2.0% and 4.0% weight fractions of crimped fibers. These were tested after 7, 14, 28 and 60 days of curing to determine the permeability. The addition of short and discrete fibers enhances the engineering properties of the fibers like compressive, flexural, tensile and shear strengths along with the toughness and ductility of the fibers. SFRC can be used in bridge deck overlays, highways and artificial pavements and in earthquake resistant structures.

4. METHODOLOGY

The methodology includes the comparison among various research papers having information about Recycled Coarse Aggregate, Steel Fiber and Basalt Fiber. The basis of comparison is to study the properties of a structure by either replacing NCA by RCA or addition of Basalt Fiber or Steel Fiber individually and that too in different proportions as per the research papers. The various tests performed on each specimen are: compression test, flexural test, split tensile test, etc.

4.1. Recycled Coarse Aggregate

Table 1. Review papers on RCA

Tam, C.T., Ong, K.C.G., Akbarnezhad, A. and Zhang, M.H.[1]	**Prabhat Kumar, Abhishek Kumar, Mohd. Afaque Khan**[2]
The concrete blocks are produced with RCA before and after oven drying them and are replaced by NCA in a percentage of 20%, 40%, 60%, 80% and 100%. The test for compressive strength, flexural strength and modulus of elasticity is done.	The compressive strength of the cubes is studied at different percentage of RCA replaced by NCA.

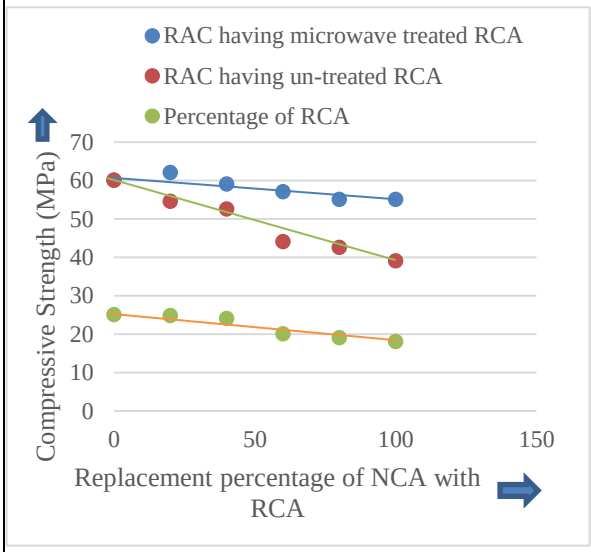

Fig.1.Effect of replacement of NCA by various percentage of RCA on compressive strength (MPa) after 28 days.

4.2. Basalt Fiber

Table 2. Review papers on Basalt Fiber

John Branston, Sreekanta Das, Sara Y. Kenno, Craig Taylor[5]

Using five cylinders having 100mm diameter and 200mm height, the compressive strength was evaluated according to ASTM C39. The flexural test was done according to the guidelines of ASTM C1609. The value of Impact resistance was also observed. The tests were performed after 28 days.

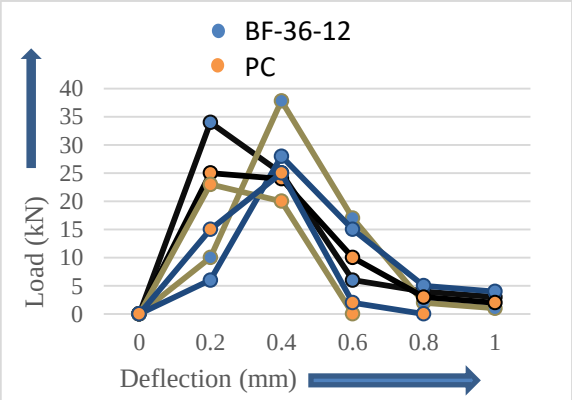

Fig.2.Flexural Test Results for BF- 36

Jason Duic, Sara Kenno, Sreekanta Das[4]

The ultimate load carrying capacity, stress, strain and modulus of elasticity of basalt fiber has been observed in this research paper. The stress strain (a) until rupture and (b) until 2% strain is observed.

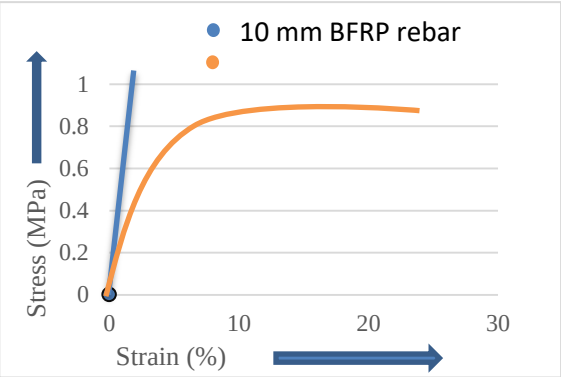

Fig.3.(a) Until Rupture

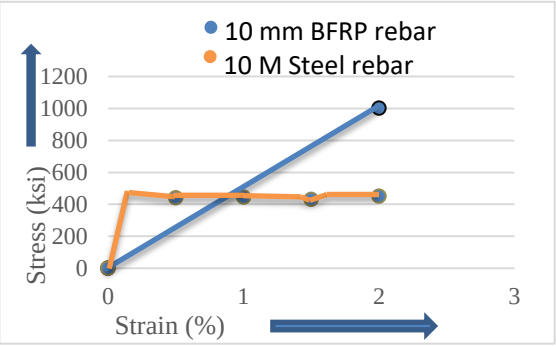

Fig.3.(b) Until 2% strain

Zeynep Algin, Mustafa Ozen[6]

The use of basalt fibers having length of 3, 6, 12 and 24mm are incorporated in a SCC in a percentage of 0.1, 0.3, 0.5% of concrete volume. The tests for compressive strength, flexural strength, split tensile strength, water penetration and rapid chloride permeability are performed.

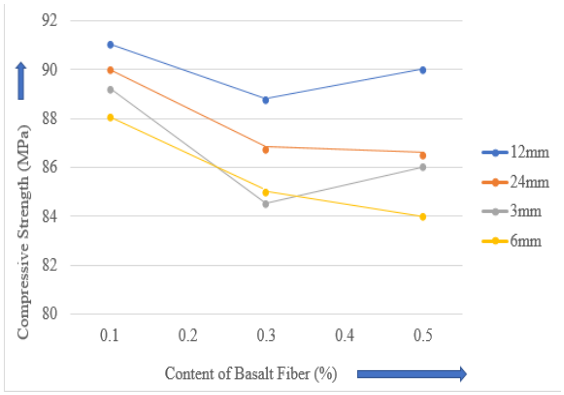

Fig.4.Compressive strength after 28 Days w.r.t different lengths of Basalt Fiber at different %.

Fabrizio Sarasini, Jacopo Tirillo, Maria Carolina Seghini[7]

The mechanical behaviour of basalt fiber and its properties at different temperatures is observed. The tensile strength of basalt fiber is observed at different temperatures. The comparison between BCF 13 and BCF 13-PP is observed.

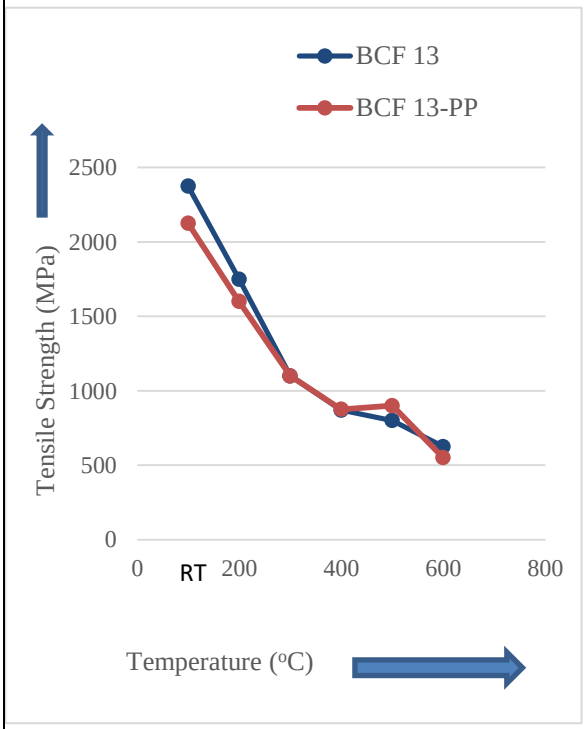

Fig.5.Tensile Strength w.r.t. varying temperature

4.3. Steel Fiber

Table 3. Review papers on Steel Fiber

Prasad Karunakaran. R, Jegidha.K.J[3]

The test for compressive strength and split tensile strength is done for 7, 14 and 28 days and the flexural test is done after 28 days. For each test, 3 number of cubes, cylinder and beam are casted for compressive, split tensile and flexural strength respectively. M25 grade of concrete is used with steel fibers of 0.5% by volume of concrete is used.

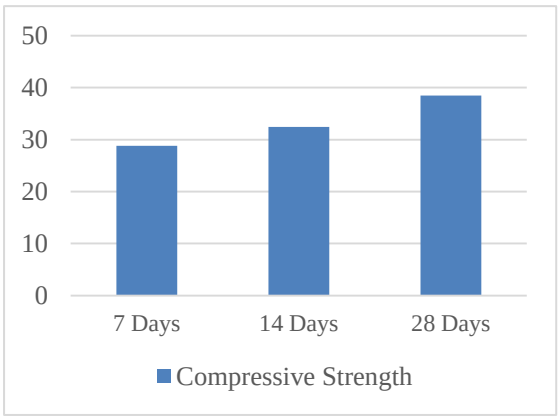

Fig.6.Compressive Strength Graph for 0.5% steel fiber for M25 concrete mix

Han Aylie, Antonius and Aldyan W. Okiyarta[9]

The cylinders of size 150 mm X 300 mm are casted for conventional concrete and as well as steel fiber concrete. The copressive strength is tested. The stirrups are provided in all the specimens with a normal stirrup configuration. BN is taken as conventional concrete and BF_1, BF_2, etc. are the different arrangements of stirrups when 0.5% steel fiber is added. The ultimate moment and cracking moment capacity is observed.

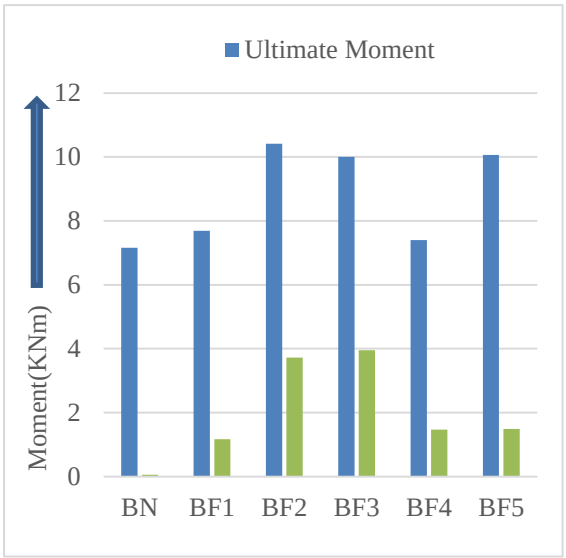

Fig.7.Ultimate and Cracking moment capacity

Vasudev R, Dr. B G Vishnuram[8]

The M20 concrete mix is used with steel fiber in different percentage. The range of steel fiber is 0, 0.25, 0.5, 0.75 & 1%. The compressive strength for different fiber content is observed for 7 and 28 days.

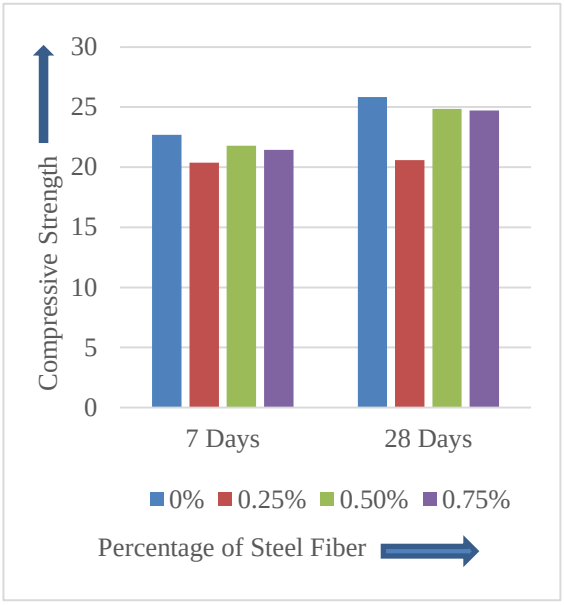

Fig.8.Compressive Strength of M20 grade of concrete cubes

A.P. Singh & Dhirendra Singhal[10]

The water permeability of samples is tested after 7, 14, 28 and 60 days. The samples are casted with addition of 1%, 2% and 4% of crimped steel fibers having aspect ratios 65, 85 and 105.

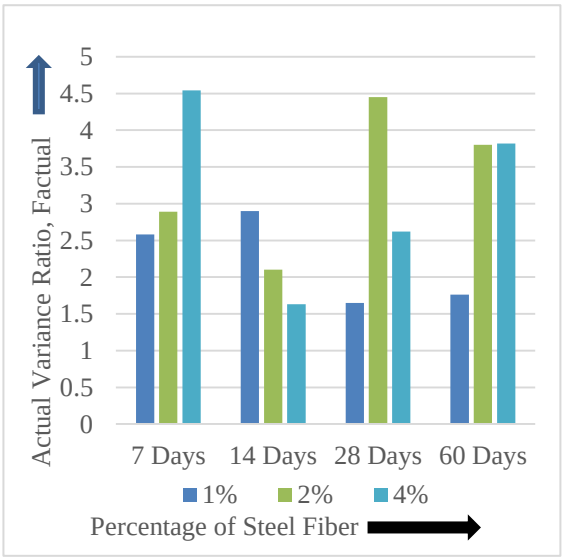

Fig.9.Variance Ratio values for permeability with varying fiber content

5. CONCLUSION

RCA

Recycled aggregates and natural aggregates can be used together. The optimum usage of RCA is found to be 40%. If the optimum value is exceeded, it may affect the and reduce the properties of the structure. The complete removal of mortar from the aggregates is done by acid treatment technique, that takes only 24 hours to remove the mortar. The RCA can be used after treatment and can act as an alternative for the natural coarse aggregates, so that, the natural coarse aggregates can be saved for much more important works.

Basalt Fiber

The use of basalt fiber helps in delaying the first crack and thus increases the crack resisting strength of the concrete. The use of basalt fiber more than 12 kg/m^3 can cause the balling of fibers which may led to the mixing problems. When 12 mm & 24 mm length of BF of 0.1% fiber content is used, then it gives the highest compressive strength. When the addition of BF of 24 mm length is 0.5%, then it gives the highest flexural and split tensile strength. The optimum value of basalt fiber should have 0.49% fiber content and length of fiber should be 21.12 mm.

Steel Fiber

The use of steel fiber increases the compressive strength, tensile properties of concrete and the flexural strength of the concrete. Increase in the steel fiber content increases the strength of the concrete. The steel fiber also helps in increasing the resistance to cracks. As the addition of steel fibers increases, the decrease in the permeability of concrete is observed. The optimum value of steel fiber is found to be 1% for best compressive strength and 0.75% for best flexural strength for a concrete grade of M30.

REFERENCES

[1] Tam, C.T., Ong, K.C.G., Akbarnezhad, A. and Zhang, M.H., “Research on Recycled Concrete Aggregates at NUS”, Electronic Journal of Structural Engineering, Vol. 13(1), 2013, pp 22-30.

[2] Prabhat Kumar, Abhishek Kumar, Mohd. Afaque Khan, “A Review Paper on Experimental Study for Recycled Concrete”, International Research Journal of Engineering and Technology (IRJET), Vol. 3, Issue 3, Mar 2016, pp 1617-1619.

[3] Prasad Karunakaran.R, Jegidha.K.J. “Experimental Study on Behaviour of Steel Fiber Reinforced Concrete”, International Journal of Engineering Science and Computing IJESC, Vol. 7, Issue No. 3, March 2017, pp 5594-5599.

[4] Jason Duic, Sara Kenno, Sreekanta Das, “Performance of Concrete Beams Reinforced with Basalt Fiber Composite Rebar”, Construction and Building Materials C&BM, Vol. 176, 2018, pp 470-481.

[5] John Branston, Sreekanta Das, Sara Y. Kenno, Craig Taylor, “Mechanical Behaviour of Basalt Fiber Reinforced Concrete”, Construction and Building Materials C&BM, Vol. 124, 2016, pp 878-886.

[6] Zeynep Algin, Mustafa Ozen, “The Properties of Chopped Basalt Fiber Reinforced Self Compacting Concrete”, Construction and Building Materials C&BM, Vol. 186, 2016, pp 678-685.

[7] Fabrizio Sarasini, Jacopo Tirillo, Maria Carolina Seghini, “Influence of Thermal Conditioning on Tensile Behaviour of Single Basalt Fibers”, Composites Part B, ELSEVIER, Vol. 132 Part-B, 2018, pp 77-86.

[8] Vasudev R, Dr. B G Vishnuram, “Studies on Steel Fiber Reinforced Concrete – A Sustainable Approach”, International Journal of Scientific and Engineering Research IJSER, Vol. 4, Issue 5, May 2013, pp 1941-1944.

[9] Han Aylie, Antonius and Aldyan W. Okiyarta, “Experimental Study of Steel Fiber Reinforced Concrete Beams with Confinement”, Procedia Engineering, ELSEVIER, vol. 125, 2015, pp 1030-1035.

[10] A.P. Singh & Dhirendra Singhal, “Permeability of Steel Fiber Reinforced Concrete Influence of Fiber Parameters”, Procedia Engineering, ELSEVIER, vol. 14, 2011, pp 2823-2829.