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Evaluation of Mechanical Properties of Basalt Fiber Reinforced Lightweight Concrete

P Bharath[1], R Shanthi Vengadeshwari[2]

[1]Student, Dept. of Civil Engineering, Dayananda Sagar College of Engineering, Bengaluru-560078
[2]Associate Professor, Dept, of Civil Engineering, Dayananda Sagar College of Engineering, Bengaluru-560078

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Abstract - *Lightweight aggregate concrete has a lot of brilliant properties such as light weight, high strength, heat preservation, heat insulation, fire proof, antifreeze, earthquake, and is unaffected to chemical corrosion. But light aggregate concrete is easy to generate craze, bigger brittleness. We are supposed to boost toughness of lightweight aggregate concrete and find the key technologies of high performance lightweight aggregate concrete. This can be attained by adding fibers (basalt fibers) to light weight aggregate concrete. The influence of basalt fiber on the strength of lightweight aggregate concrete was systematically studied. The experimental results show that the basalt fiber lightweight aggregate concrete has a flexural strength increased by 62%, the compressive strength is improved by 10% and the toughness is increased by 36% compared with that of the non-fiber.*

Key Words: Lightweight aggregate concrete; fibre lightweight Concrete; Basalt Fibre; fibre Reinforcement;

1. INTRODUCTION

1.1 Lightweight Aggregate and fibres

Lightweight aggregate concrete with light, heat insulation, heat insulation, fire and seismic and many other advantages, has become the amount of ordinary concrete after the new building materials. But high-strength lightweight aggregate concrete is still a prominent flaw, that is, the material brittle, that is, its tensile, bending, impact resistance and toughness and other poor performance. Therefore, how to enhance the toughness of lightweight aggregate concrete is the key to the development of high performance lightweight aggregate concrete. As the fiber has a good toughening, cracking, anti-wear properties, the chopped fiber used in mortar and concrete, the fiber through the bridge cracks can improve the cement matrix toughness, tensile strength, and bending strength, so that the inherent brittleness problem of cement concrete products has been greatly improved.

1.2 Basalt Fibre

Basalt fiber is parallel to carbon fiber and fiberglass, but basalt has better mechanical properties than fiberglass and is lower in cost than carbon fiber. It is used as a fireproof textile in the aerospace and automotive industries and can also be used as a composite to produce a wide range of products.

2. TESTS ON MATERIALS

Table -1: Comparison between regular coarse aggregate and cinder.

Property	Coarse Aggregate	Cinder
Specific gravity	2.75	2.05
Fineness modulus	4.6	2.82
Water absorption (%)	0.5	1.3
Maximum nominal size	20mm	20mm

Table -2: Tests on coarse aggregate

Sl.No	PROPERTIES	VALUES
1	TYPE	CRUSHED
2	WATER ABSORPTION	ABOUT 0.1%
3	FINENESS MODULUS	7.35
4	IMPACT VALUE	26.28%
5	SPECFIC GRAVITY	2.58
6	ANGULARITY NUMBER	3
7	AGGREGATE CRUSHING VALUE	25.07%

Table -3: Sieve Analysis of Coarse Aggregate

IS SIEVE SIZE (mm)	80	40	20	10	4.75	2.36	1.18	0.6	0.3	0.15
WEIGHT RETAINED (kg)	0	0	1.94	2.956	0.062	0.042	0	0	0	0
CUMULATIVE WEIGHT RETAINED (kg)	0	0	1.94	4.896	5	5	5	5	5	5
CUMILATIVE % WEIGHT RETAINED	0	0	38.8	97.92	99.16	100	100	100	100	100
CUMULATIVE % WEIGHT PASSING	100	100	61.2	2.08	0.84	0	0	0	0	0

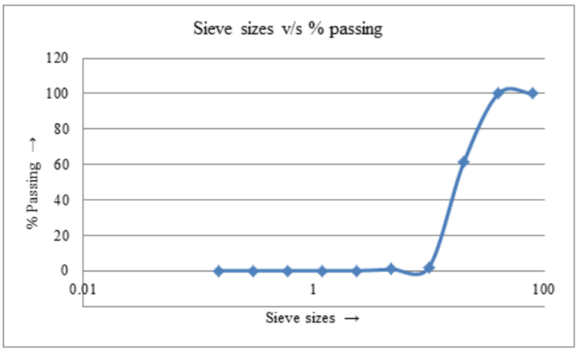

Chart -1: Sieve Analysis of Coarse Aggregate

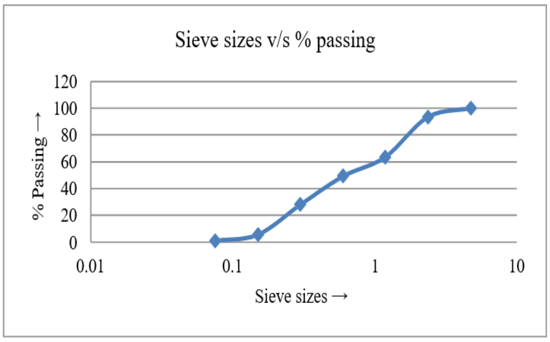

Chart -2: Sieve Analysis of Fine Aggregate

Table -4: Test on fine aggregate

Sl no	PROPERTIES	VALUES OBSORVED
1	SPECIFIC GRAVITY	2.53
2	WATER ABSORPTION	20.12%
3	FINENESS MODULUS	4.59

Table -6: Test on cement

Sl. No	Test on cement	Results
1	Specific gravity test	3.12
2	Normal consistency	32%
3	Fineness	4%
4	Initial setting time test	45minutes
5	Final setting time test	330minutes

Table -5: Sieve Analysis of Fine Aggregate

IS SIEVE SIZE	4.75mm	2.36mm	1.18mm	600micron	300micron	150micron	75micron	Pan
WEIGHT RETAINED (kg)	0	0.066	0.3	0.142	0.212	0.226	0.046	0.008
CUMULATIVE WEIGHT RETAINED (kg)	0	0.066	0.366	0.508	0.72	0.946	0.992	1
CUMILATIVE % RETAINED	0	6.6	36.6	50.8	72	94.6	99.2	100
% PASSING	100	93.4	63.4	49.2	28	5.4	0.8	0

Table -7: Mix preposition

Sl. No	Ingredients	Mix proportion
1	Cement	438 kg/m^3
2	Water	197 liters
3	Fine aggregate	620.63 kg
4	Coarse aggregate	1077.63 kg
5	W/C ratio	0.45
6	Cinder (70%)	754 kg (of CA replaced by volume)
7	LECA (30%)	323 kg (of CA replaced by volume)

3. RESULTS AND DISCUSSION

3.1 Compressive Strength Test

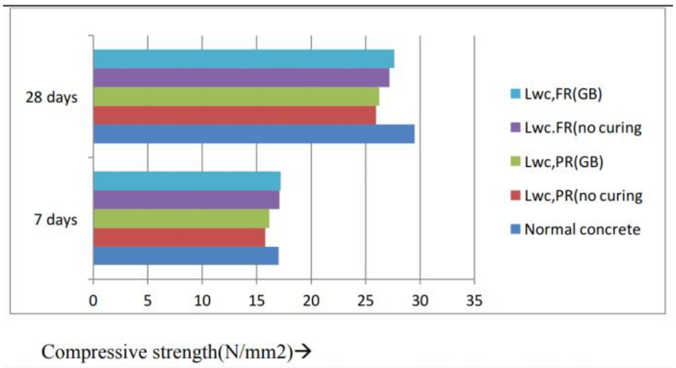

Chart-3: Compressive Strength of Concrete at 7 And 28 Days

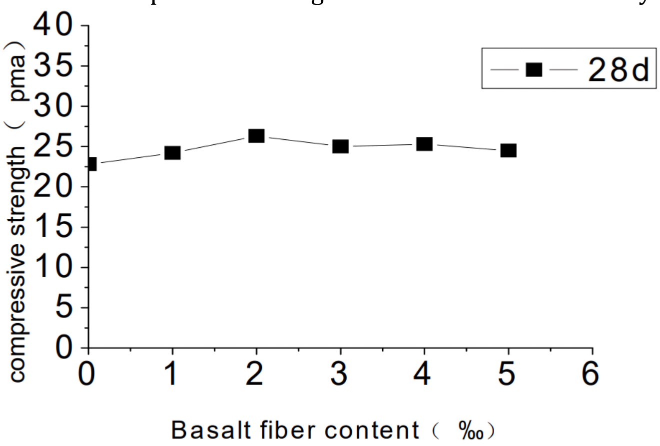

***Chart-4**: Basalt fiber on compressive strength of cinder light weight aggregate concrete*

Effect of light weight aggregate on compressive strength

As shown in Chart -3 strength of light weight aggregate concrete partial (30%) and full (100%) replacement after 7- and 28-days strength. The compressive strength was 26.25 and 27.65 N/mm³ for 30% and 100% replacement respectively. Thus, the compression strength has increased partially with increase in replacement. The strength of normal concrete 17.12 and 29.5 after 7 and 28 days, and for partial and full replacement the strength have decreased. This phenomenon may be because lightweight aggregate increases the air content, which decreases the strength.

Effect of fiber content on compressive strength

Chart -3 lists the strengths of all the specimens, which were measured after 7 and 28 days. The influence of the fibers on the compressive strength was marginal, as shown in Chart -4. The compressive strengths were 27.65-29.5 N/mm³ except for the specimens with basalt fibers. The addition of basalt fibers may have had a negative influence on the development of the compressive strength, which was only 24.65 N/mm³. Thus, the compressive strength of the lightweight concrete decreased by 11% with 3% basalt fibers. This phenomenon may be because basalt fibers increase the air content, which decreases the strength.

Comparison of light weight aggregate concrete with and without fiber on compression strength

Chart -3 shows the strength of normal concrete and lightweight aggregate at 30% and 100% replacement. Strength gradually decreases with decrease on % of replacement with light weight aggregate and also and marginal less compared to normal concrete, this may be because of strength of lightweight aggregate is low than conventional aggregate.

3.2 Split Tensile Strength Test

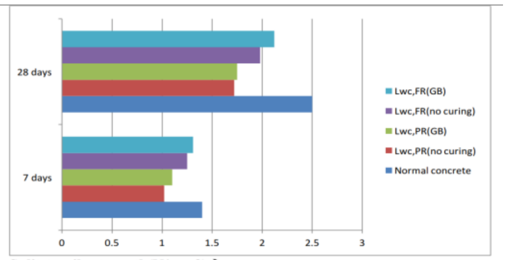

Chart -5: Split-Tensile Strength of Concrete At 7 And 28 Days

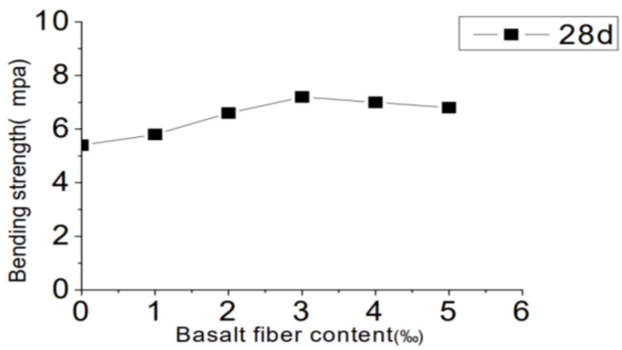

***Chart -6**: Basalt fiber's influence on the toughness of lightweight aggregate concrete*

Effect of lightweight aggregate in split tensile strength

Chart -5 that the lightweight aggregate concrete itself sustained less tension loads than conventional aggregates. The decrease in split tensile strength of lightweight aggregate concrete at 30%, and 100% replacement, is in the order of 21, and 3%, respectively, when compared to the conventional concrete. At 100% replacement the reduction is marginal, light weight aggregate is poor in tensile strength compared to conventional aggregate.

Effect of fiber content in split tensile strength

Split tensile strength tested on normal concrete was higher than that of lightweight aggregate concrete, but addition of fibers to lightweight aggregate concrete, the split tensile strength was increased by 32% and 30% compared to normal concrete and lightweight aggregate concrete respectively. As it was expected, basalt fibers enhanced splitting tensile strength of lightweight concrete proportionally to their content (Chart -6).

Comparison between lightweight aggregate concrete with and without fibers on tensile strength

Incorporation of basalt fibers into lightweight aggregate concrete caused considerable increase of split tensile strength by 32% but lightweight aggregate concrete without fibers had a decrease by 3%. Because of higher brittleness of lightweight concrete, the increment of its tensile splitting strength resulting from basalt fiber incorporation, appears to be more pronounced than for normal weight concrete (Chart -6).

3.2 Flexural Strength Test

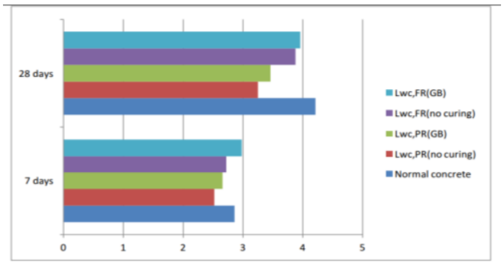

Chart-7: Flexural Strength of Concrete At 7 And 28 Days

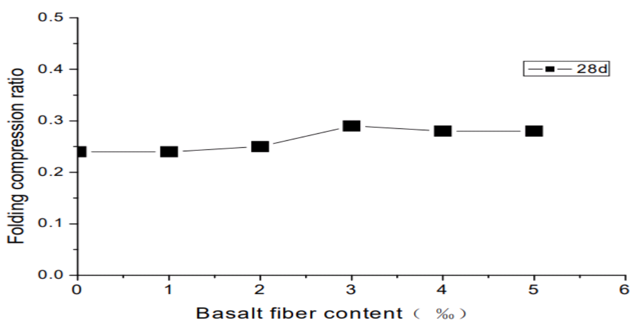

Chart-8: Basalt fiber on flexural strength of light weight aggregate concrete

Basalt fiber dosage is 3‰, the flexural strength in a best point. Because of its high specific surface area of the basalt fiber, rough surface, high friction coefficient, it increased the mixing flow relative friction, block light aggregate buoyancy, the uniformity and workability of concrete; On the other hand, the basalt fiber has good hydrophilicity. After the basalt fiber mixed with mixture, then dispersed into thin flocculent silks, packaging the flocculent fiber requires a lot of cement mortar, which makes the mixture flow performance reduced. Basalt fiber dispersed evenly in the lightweight aggregate concrete, to form a mesh structure, the energy which is transmitted from the base body is damaged when the matrix is destroyed, thereby increasing the compressive strength and bending strength.

Effect of lightweight aggregate on flexural strength

Just as in the case of tensile splitting strength, flexural strength of lightweight concrete was lower than for normal weight concrete of the same compressive strength. There was no increase of strength observed after 7 and 28 days. At 30% and 100% replacement of coarse aggregate by lightweight aggregate, there was decrease by 17 and 5% respectively (Chart -7).

Effect of fiber content on concrete flexural strength

Incorporation of basalt fibers into lightweight aggregate concrete caused considerable increase of flexural strength by 82% (Chart -7). Similarly, to tensile splitting strength, the results dispersion for flexural strength was higher for reinforced concrete than for plain one. The probability of fibers location in the middle of a test beam in the right position (preferably perpendicular to the loading direction) is the factor responsible for higher results dispersion (Chart -8). Nevertheless, increasing the fiber content made this dispersion lower due to a higher probability of the fibers appearing on the route of a crack.

Comparison of lightweight aggregate concrete with and without fiber on flexural strength

In this study, three-point loading is applied in such a way that neither specimens nor the flexural testing machine has been designed to assure uniform pull applied to the concrete. In beams, the direct measurement of tensile strength depends upon the flexural strength property. The flexural strength of the concrete beam specimens is shown in Chart -8 where the increase for lightweight aggregate concrete, and fiber-reinforced lightweight aggregate concrete is 80%. Flexural strength of lightweight aggregate concrete without fibers is reduced by 5% compared to conventional concrete. To overcome these flaws addition of fibers to lightweight aggregate concrete is increased by 71% compared to normal concrete (Chart -7).

4. CONCLUSIONS

The M25 grade light weight concrete had an average compressive strength of 27.45N/mm^{2}which was almost nearer to the compressive strength of normal aggregate concrete which was 29.5N/mm². The addition of LECA aggregates in the concrete increases the hydration degree, which results in producing denser microstructure and ultimately leading to improved curing in the concrete. The improved hydration in concrete also reduces micro cracking because of the lower shrinkage tendency of concrete with lightweight aggregates (LECA and Cinder) which are used for internal curing purpose.

The main advantage of using LWAs in the concrete is to produce concrete mixes with lower weight which results in reduced dead load of structures. These aggregates also play a major role in reducing the shrinkage and subsequent cracking as these aggregates are initially presoaked in water and also these LWAs are capable of acting as an internal curing agent in the hardened concrete.

A technique of basalt fiber reinforces the cinder concrete mechanical properties to get the following conclusion, after mixed with basalt fiber, light aggregate concrete's compressive strength and bending strength increased, and flexural strength increased significantly higher than the compressive strength, greatly improving the folding ratio of light aggregate concrete, which significantly improved the toughness of lightweight aggregate concrete. With basalt fiber content gradually increases, when the basalt fiber dosage is 3 ‰, the compressive strength increased by 2%, the flexural strength increased by 33.4%, the basalt fiber content into 3‰.

REFERENCES

[1] L. Xiao, Q. Liu, and J. Li, "Basalt Fiber on Cinder Strength of Lightweight Aggregate Concrete," no. Aeece, pp. 232–236, 2016.

[2] D. Kim, M. S. Kim, G. Y. Yun, and Y. H. Lee, "Bond strength of steel deformed rebars embedded in artificial lightweight aggregate concrete," vol. 27, pp. 490–507, 2013.

[3] N. Divyah, R. Thenmozhi, M. Neelamegam, and R. Prakash, "Characterization and behavior of basalt fiber-reinforced lightweight concrete," *Struct. Concr.*, no. September 2019, pp. 1–9, 2020.

[4] S. Ipek and Z. Algın, "Combined effects of microsilica , steel fibre and artificial lightweight aggregate on the shrinkage and mechanical performance of high strength cementitious composite," vol. 262, 2020.

[5] N. Du, "Effect of steel fibers on the mechanical properties of natural lightweight aggregate concrete Og," vol. 59, pp. 3357–3363, 2005.

[6] M. Bernhardt, H. Tellesbø, H. Justnes, and K. Wiik, "Fibre reinforced lightweight aggregates," *J. Eur. Ceram. Soc.*, vol. 34, no. 5, pp. 1341–1351, 2014.

[7] K. Dana, Š. Veronika, Č. Monika, V. Eva, and Č. Robert, "Influence of Basalt Fibers and Aggregates on the Thermal Expansion of Cement-Based Composites," vol. 1054, pp. 17–21, 2014.

[8] J. Choi, G. Zi, S. Hino, K. Yamaguchi, and S. Kim, "Influence of fiber reinforcement on strength and toughness of all-lightweight concrete," *Constr. Build. Mater.*, vol. 69, pp. 381–389, 2014.

[9] E. Science, "Influence of surface modified basalt fiber on strength of cinder lightweight aggregate concrete Influence of surface modified basalt fiber on strength of cinder lightweight aggregate concrete," pp. 5–10, 2017.

[10] P. Taylor, "Journal of Civil Engineering and Management Modification of properties of structural lightweight concrete with steel fibers," no. February 2014, pp. 37–41, 2011.