Experimental Investigation on Mechanical Splices in Fiber Reinforced Concrete Beams

Jeevarekha R[1], Vanathi R[2]

[1]*PG Student, Department of Civil Engineering, The kavery College of Engineering, Mecheri, TN*
[2]*Asst Professor, Depatment of Civil Engineering, The kavery College of Engineering, Mecheri, Tamil Nadu, India*

---***---

Abstract – *Lap splicing has become the traditional and conventional method of connecting two steel reinforcing bars. The overlap load transfer mechanism takes advantages of the bond between the steel and concrete to transfer the load. The load in one bar is transferred to the concrete and then from the concrete to the ongoing bar. Lap splices are not considered reliable under cyclic loading and they are not effective for larger spans and have many hidden coasts. As a result engineers started use of mechanical splices which lead to huge cost savings. Also mechanical splices have various benefits such as reduces congestion and are more reliable than lap splices because they do not depend on concrete for load transfer. Seismic or other natural events are other advantages of mechanical splices. Mechanical splices (couplers) do not overlap, less rebar is used, reduce material costs. In this project attempt has been made to study the strength parameters of concrete by inducing fibers in concrete. Basalt fiber is an inorganic material from volcanic rock and is comparatively new in the industry. The grade of concrete is* M_{25}*. The fibers were added at percentage of 0 to 1.5 with an increment of 0.5%. This paper provides result data of the compressive strength, split tensile strength and flexural strength test for 7days and 28 days to find optimum dosage of basalt fiber in concrete.*

Key Words: Mechanical threaded coupler, Basalt fiber, Compressive strength, Split tensile strength, Strength parameters.

1. INTRODUCTION

General: Steel reinforcement bar is also known as rebar and reinforcement steel. It is versatile constructional material which is widely used in the construction industry for making of reinforced concrete. Reinforcement concrete(RC) is a composite material made up of concrete and some form of reinforcement, most commonly steel rods, wires or mesh of steel rods and steel wires. The steel reinforcement bars normally consist of such shape and size that they may easily bent and placed in concrete so as to form a monolithic structure. In the reinforced concrete structures, some reinforcing bars must be spliced. The length of bars required may be longer than the stock length of steel.

1.1 Reinforcement In Concrete Works

Concrete is good in compression but week in tension. Various members in structure are always subjected to tensile forces, bending forces etc. To take these factors and to transfer the safely to other members, the structural members are always reinforced with steel reinforcement bars.

- Mild steel bars
- Cold twisted deformed bars (C.T.D)
- High yield strength deformed bars (H.Y.S.D)
- Thermo mechanical threaded steel bars(TMT)

In building construction C.T.D/HYSD/TMT bars are used as primary reinforcement i.e. main steel and mild steel bars are used as secondary reinforcement such as ties, stirrups and distribution steel. Generally mild steel of 6mm diameter is used as secondary reinforcement and deformed bars of diameter 8,10,12,16,20,25,32&40mm used as main reinforcement.

1.2 Reinforcement Splicing

Splicing of reinforcement bars are carried out by following methods:

1. Lap splice
2. Mechanical splice
3. Welded splice

Lap splicing of reinforcement bar more than 36mm in diameter should be avoided. In case such bars have to be lapped then they should be welded. When welding of cold bars is allowed, the special instructions applicable to these bars should be followed. Where the lapping of reinforcement bars have to be done in unusual circumstances such as splicing in areas of large moments or more than 50% of the bars have to be spliced, additional closely spaced spirals should be provided around the lapped bars and the length of lap should be staggered.

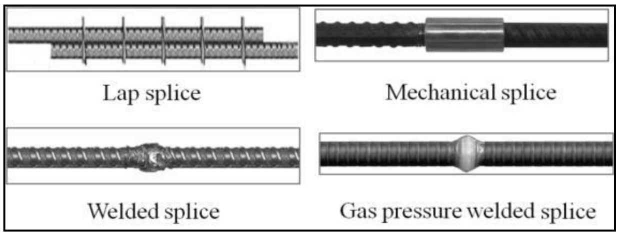

Fig-1: Splice of reinforcing bars

1.3 Basalt Fiber

Many fibers are used in the construction industry such as glass, polypropylene, carbon; fiber etc., one of the new fiber called basalt rock fiber is added to this list. Basalt rock is a volcanic rock and can be divided into small particles then formed into continues or chopped fibers. Basalt fiber has a higher working temperature and has a good resistance to chemical attack, impact load and fire with less poisonous fumes. Some of the potential applications of these basalt composites are plastic polymer reinforcement, soil strengthening, bridges and highways, industrial floors, heat and sound insulation for residential and industrial buildings, bullet proof vests and retrofitting and rehabilitation of structures.

Fig -2: Basalt Fiber

Table -1: Properties of Basalt Fibers

Characteristics	Basalt Fiber
Density(g/cc)	2.7
Length(mm)	6-10
Tensile strength (Mpa)	3000-3500
Elastic Modulus (Gpa)	79.3-93
Specific Gravity	2.65-2.8
Elongation at break%	3.1-6
Temperature of application,C^0	1450

2. OBJECTIVES

The main objective of this experimental work is to investigate the strength and behavior of normal and coupled bars with basalt fiber reinforced concrete compressive strength, tensile strength, flexural strength of concrete using basalt fiber. The tensile load test was carried out in UTM and the reports are studied to calculate the economic and cost comparison of the same.

3. EXPERIMENTAL PROGRAMME

3.1 Materials

In order to know the physical properties of the materials, various tests specified by the Indian Standards were conducted and their suitability for use was checked. The detail of the investigation is presented below.

A. Cement

The cement used should confirm to IS specifications. There are several types of cements are available commercially in the market of which Portland cement is the most well-known & available everywhere. OPC 53 grade was used for this study. The physical properties of the cement tested according to standard procedure conform to the requirement of IS 12269: 1989. Cement used for casting was OPC in Ultratech cement company.

Table -2: Physical Properties of Cement

SI.NO	Properties	values
1	Specific Gravity	3.15
2	Standard Consistency	33%
3	Initial Setting time in min	45
4	Final Setting time in min	470

B. Fine aggregate

Locally available river sand passing through 4.75mm sieve conforming to the recommendation of IS383-1970 is used. Natural river sand has been used as fine aggregate and it is collected from two various locations like Salem. The particle size distribution for fine aggregate is listed, Weight of aggregate taken = 3000 grams.

Table -3: Properties Of Fine Aggregate

SI.NO	Properties	values
1	Specific Gravity	2.60
2	Fineness modulus	5.10
3	Water absorption	1%
4	Zone	III

C. Coarse aggregate

Coarse aggregates to be used for production of concrete must be strong, impermeable, durable & capable of producing a sufficient workable mix with minimum water cement ratio to achieve proper strength. Locally available coarse aggregate retaining on 4.75mm sieve is used.

Table -4: Properties Of Coarse Aggregate

SI NO	Properties	Values
1	Specific Gravity	2.80
2	Fineness modulus	3.21
3	Water absorption	0.5%

D. Reinforcement

Thermo mechanical threaded reinforced steel bars (TMT) is used for longitudinal main reinforcement with 16mm diameter. For shear reinforcement 6 mm diameter two legged stirrups were used with a spacing of 100 mm c/c. thread is formed at end of the reinforcement with 20mm length for each bar. The properties of reinforcement are tabulated.

Table -5: Properties of Reinforcement

SI NO	Properties	Description
1	Yield Strength	415 N/mm^2
2	Grade	Fe 415
3	Type	TMT
4	Carbon Content	0.55 to 1.5%
5	Thermal resistance	Up to 600^0 C
6	Min % of elongation failure	14.5%

E. Reinforcement bar couplers

Lapped joints are not always an appropriate means of connecting reinforcing bars. The use of laps can be time consuming in terms of design and installation and can lead to greater congestion with in the concrete because of the increased amount of rebar used. Available to suit bar sizes 12mm to 50mm, the couplers are installed quickly and easily on site without the need for specially trained person or specialized, expensive machinery. The length of reinforcement bar coupler is 70mm used to connect two main longitudinal bars. The external diameter of coupler is 25mm are used.

Fig -3: Bar Coupler

Threaded coupler is designed to meet the requirements of BS 8110 and to achieve failure loads in excess of 115% of the characteristic strength of grade 500 rebar. A nominal allowance of +25mm should be allowed per threaded bar end. The couplers are generally torque onto the reinforcing bar in the bar threading shop, the internal threads protected by plastic end caps. The threaded ends of the continuation bar are protected by plastic thread protectors.

F. Basalt Fiber in Concrete

The basalt fibers typically have a filament diameter of between 10 and 20μm which is far enough above the respiratory limit of 5μm to make basalt fiber a suitable replacement for asbestos. They also have a high elastic modulus, resulting in excellent specific strength three times that of steel. Thin fibers are usually used for textile applications mainly for production of woven fabric. Thicker fiber is used in filament winding, for example production of CNG cylinders or pipes. The thickest fiber is used for pultrusion, geogrid, UD, multiaxial fabric production and in form of chopped strand for concrete reinforcement. One of the most prospective applications for continuous basalt fiber and most modern trend at the moment is production of basalt rebar that more substitutes traditional steel rebar on construction market.

Table -6: Chemical composition of Basalt Rock

Chemical Composition	%
SiO2	52.8
Al_2O_3	17.5
Fe_2O_3	10.3
MgO	4.63
CaO	8.59
Na_2O	3.34
K_2O	1.46
TiO_2	1.38
P_2O_5	0.28
MnO	0.16
Cr_2O_3	0.06

G. Applications of Basalt fiber

- Heat production
- Friction materials
- Windmill blades
- Lamp posts
- Ship hulls
- Car bodies
- Sports equipment
- Rebar
- CNG Cylinders and pipes
- Chopped strand for concrete reinforcement

3.2. Mix proportion

Based on the various physical properties of materials, the mix design is framed as per Bureau of Indian Standard (BIS) IS 10262-2009 for M_{25} grade of concrete.

Based on IS Method

Target Strength = 25Mpa
Max nominal Size of aggregate = 20 mm
Specific Gravity of cement = 3.15
Specific Gravity of fine aggregate = 2.60
Specific Gravity of Coarse aggregate = 2.80
Water cement Ratio = 0.45

Table -7: Design Mix Proportion

Water	Cement	Fine aggregate	Coarse aggregate
197litre	438kg/m³	742.35kg/m³	1059.74kg/m³
0.45	1	1.7	2.41

4. EXPERIMENTAL RESULTS

4.1 Compressive strength test

The compressive strength of concrete is one of the most important properties of concrete. In this test 150x150x150mm concrete cubes were cast, by using 25 MPa concrete. The mixing was done by cubes were de-moulded and placed under water and cured. Then the cubes were tested for their crushing strength at 7 and 28 days.

Table -8: Proportion of concrete with BF %

SI NO	Description	Proportion for M_{25} Concrete	BF %
1	Sample 1	1:1.7:2.4	0
2	Sample 2	1:1.7:2.4	0.5
3	Sample 3	1:1.7:2.4	1
4	Sample 4	1:1.7:2.4	1.5

Table -9: Average Compressive Strength

SI NO	Description	Average Compressive Strength(N/mm²)	
		7 days	28 days
1	Sample 1	20.66	24.98
2	Sample 2	22.42	28.68
3	Sample 3	23.68	33.80
4	Sample 4	23.41	32.92

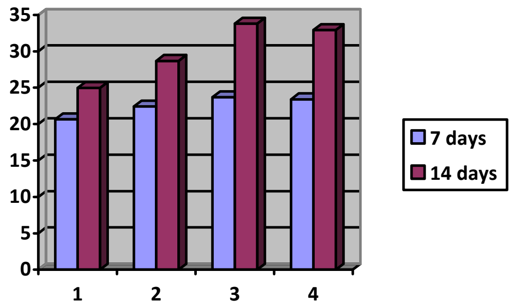

Chart -1: Average Compressive Strength

4.2 Split Tensile strength test

The test is carried out in a cylindrical specimen of 150mm diameter and 300mm length. The cylindrical specimen is placed horizontally between the loading surface of a compression testing machine and the load is applied until failure of cylinder, along the vertical diameter. The split tensile strength is given by the formula 2P / (πdl) and the stress value is in N/mm2. Where P – The ultimate load at which the cylinder fails. d, l – The diameter and length of the cylinder.

Table -10: Average Split Tensile Strength

SI NO	Description	Average Split Tensile Strength(N/mm²)	
		7 days	28 days
1	Sample 1	3.20	3.84
2	Sample 2	3.35	4.04
3	Sample 3	3.51	4.32
4	Sample 4	3.67	4.45

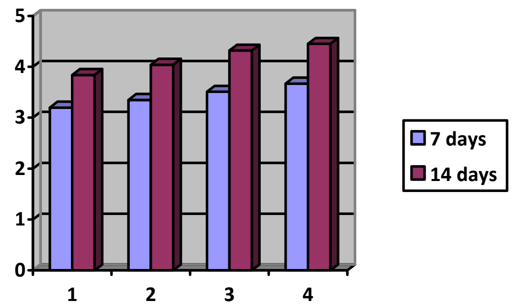

Chart -2: Average Split Tensile Strength

4.3 Tensile Test On Steel

Fig -4: Failure of steel bar

Observation:

Diameter of rod (M.S) d = 16mm
Gauge Length (L4) = 300mm
Gauge Length of Extensometer = 330mm
Least Count of Extensometer = 0.01mm
Ultimate Load = 83.5KN
Area = $(\pi/4) \times d^2$
= $201.06 mm^2$

Calculation:

Ultimate Stress = Ultimate load/Area
= (83.5 x 1000)/(201.06)
= $415.29 N/mm^2$

4.4 Flexural Strength Test

For determining the flexural strength and deflection of each specimen of size 1200mm x 150mm x 150mm was supported on the two channels. The single point load was applied at the centre of span. The deflection of the beam under the load was recorded up to first crack. All the beams were loaded up to failure.

Fig -5: Steel with Bar Coupler

Fig -6: Experimental setup for testing of RC beam

Table -11: Testing of RC beam (Bar Coupler)

Testing Days	First Crack		Ultimate Load(KN)	Max Deflection (mm)	Flexural strength of beam(N/mm^2)
	Load (KN)	Deflection (mm)			
7 days	22.2	4.8	138.5	20.6	49.24
28days	42.1	13.1	185	15.5	65.77

Table -12: Testing of RC beam with BF% (Bar Coupler)

Testing Days	First Crack		Ultimate Load(KN)	Max Deflection (mm)	Flexural strength of beam(N/mm^2)
	Load (KN)	Deflection (mm)			
7 days	24.2	6.8	142.5	22.6	51.73
28days	45.1	15.1	192	17.5	68.26

5. CONCLUSIONS

1. This project examines the results of experiments on mechanical splices in FRC with low volume fraction of fibers, significant for many practical applications.
2. Addition of basalt fiber in concrete increased strength compared to normal concrete.
3. Nearly there is 5-6Mpa increment in Compressive strength and around 1-2Mpa increment in Split tensile Strength of concrete in basalt fiber.
4. Increase in the percentage of fiber content increased the strength parameters up to 1%, after 1% of basalt fiber there is a decrease in strength is noted.
5. The compressive strength value for 28 days with 1%- $33.68N/mm^2$ and decreased in 1.5%BF- $32.92N/mm^2$.
6. The split tensile strength value for 28 days with 1% BF $4.32N/mm^2$ and for 1.5% is $4.2 N/mm^2$.
7. The flexural strength value with bar coupler as ultimate load as 138.5KN for 7 days and it as a flexural strength value is $49.24 N/mm^2$.
8. The flexural strength value for 28 days testing as ultimate load is 185KN and strength value is $65.77N/mm^2$.
9. The flexural strength value for 7 days with 1.5%BF value with ultimate load 142.5KN and $51.73N/mm^2$strength.
10. The flexural strength value for 28 days testing with load as 192KN and flexural strength value is $68.26N/mm^2$.

REFERENCES

[1] Vidmantas Jokubaitis, Linas Juknevicius (2016) "Analysed the influence of reinforcement couplers on the cracking of reinforced concrete members".
[2] Seunghun kim(2016) "Lap splices in tension between headed reinforcing bars and hooked reinforcing bars of reinforced concrete beam" vol 13 Issue 3
[3] Soumyachandran P, Linjesh Sebastian(2018) "study on alignment of lapped bars in tension region in fiber reinforced concrete beams".
[4] Hyndavi (2015) "Investigation on Flexural Strength of Reinforced concrete beam with Coupled Rebars"vol-2 Issue 06.
[5] Swami P.S, Javheri S.B(2016) "Use of Mechanical splices for reinforcing steel".
[6] Nishith O.Sardhara,(2018) "Investigate and compare various properties of basalt fiber reinforced concrete with partial replacement of cement with Rice husk ash".
[7] Mr.Piyush Jain(2017) "Flexural of basalt fiber fabric sheet strengthened reinforced concrete (RC) beams".
[8] Paulraj.S(2017) "Experimental studies on strength and scc characteristics of basalt fiber reinforced concrete"vol - 4, 2017.
[9] Mustapa Abdulhadi(2014) A comparative study of basalt and polypropylene fibers reinforced concrete on compressive and tensile behaviour-
[10] Nirmal Patel(2017) "Evaluation of mechanical properties of concrete by using basalt fiber with silica fume".
[11] IS 383 – 1970, "Indian Standard Specification For Coarse and Fine Aggregates From Natural Sources For Concrete".
[12] IS 456-2000, "Indian Standard Code Of Practice For Plain and Reinforced Concrete (fourth revision). Bureau of Indian Standards, New Delhi.
[13] IS 10262 – 2009, "Indian Standard Recommended Guidelines for Concrete Mix Design".
[14] M.S.Shetty, "Concrete Technology", S.Chand and company limited,2000