STUDY ON THE PERFORMANCE OF HIGH STRENGTH CONCRETE USING BASALT FIBER WITH METAKAOLIN

M. Amala, Assistant Professor, Department of Civil Engineering, Easwari Engineering College, Bharathi Salai, Ramapuram, Chennai , Tamil Nadu, India.

Dr. A. N. Swaminathen, Associate Professor, Adi Shankara Institute of Engineering and Technology, Kalady, Kerala.

Dr. M. Siva, Assistant professor, Department of Civil Engineering, Easwari Engineering College, Chennai, Tamil Nadu. India.

Dr.S.Meenakshi Sudarvizhi, Professor & Head, Department of Civil Engineering Pandian Saraswathi Yadav Engineering College, Arasanoor, Tamil nadu, India.

R.Saleema Begum, Assistant professor, Department of Civil Engineering, Ellenki College Of Engineering and Technology, Patelguda, Telangana, India.

Dr.K.Mohan das, Professor, Department of Civil Engineering, CMR College of Engineering & Technology, Kandlakoya village, Medchal Road, Telangana, India.

Abstract - Exploring new materials for construction field leads us to utilizing new material. For several decades, concrete has been a versatile material due to casting in any shape and provides good workability. This study presents the effect of incorporating Basalt fiber metakaolin and fly ash on the high strength concrete. For this project, the mix design is carried out for M60 grade. The basalt fiber used in the present study has a diameter of 13 µm and a length of 12 mm. This investigation was carried out to show that metakaolin has the potential to produce high strength concretes. Construction has been the most important human activity since early ages. The main aim is to study strength characteristics and flexural behavior of metakaolin with basalt fiber. In this study, basalt fiber with metakaolin concrete is produced with fly ash, silica fumes, super plasticizer and water is used as a binder. The specimen of size 100x100x100mm cubes 100x200mm cylinders and 100x 100 x 500mm beam were cast and the specimens of metakaolin base concrete are cured at ambient temperature for 7days, 14 days and 28 days. The cured specimens were then tested for compressive strength, split tensile strength and flexural strength respectively.

Keywords: Basalt fiber, metakaolin, Compressive Strength, Split Tensile Strength, Flexural Strength

1. Introduction

The construction sector is expanding quickly in many countries. Fibers and pozzolanic materials reduce the cost of concrete while enhancing its mechanical and chemical qualities [1]. The presence of basalt fibre in concrete modifies the behaviour of failure from delicate failure mode to flexible failure mode when it is compressed, tilted, and affected. Cement is substituted for the superior pozzolanic substance metakaolin in order to increase the durability of concrete. The basalt fibre utilised in this investigation has a 13 µm diameter and a 12 mm length. The use of high strength concrete (HSC) has grown significantly during the past few years. However, the danger to the environment posed by the manufacture of concrete has encouraged efforts to develop eco-friendly materials for construction. In India, dry process technology, which is good to the environment, is used in 93% of cement production [2]. Research has been done in the cement industry to collect the most recent materials and to upgrade the technology. The CO_2 varies depending upon methods and type of mix design. In India 93% of the cement industry uses dry process technology which is environment friendly[3] . In cement industry, research has been carried out in collection of latest material and up gradation of technology. The cement industry is not suitable for sustainable industry since it causes high pollution to the environment. So, there is necessity for alternate material for cement in the concrete which should be eco-friendly, should satisfy mechanical properties and durability characteristics. This new material should be more superior, preferable compared to conventional concrete based on cement. It is found that metakaolin, fly ash and basalt fiber are best source material to get satisfactory high strength concrete. This research investigation studies the results of an experimental work on strength characteristics of concrete produced with the blending of Basalt fiber and metakaolin.

2. Experimental Program*:*

2.1 Materials Used:

The Class F fly ash, according to ASTM C618-99 [13], obtained from Ennore power plant, basalt fiber from fiber zone and metakaolin obtained from Chennai were used for this investigation. The chemical properties of basalt fiber and fly ash and metakaolin were studied and the results are shown in Table 1. The coarse aggregate of downgraded size 20mm and a specific gravity of 2.71 was used. M- sand, which is locally available, confirming to Zone II as per IS 383[14] with a specific gravity of 2.62 was used for this study. Silica fume is utilized in small amounts compared to other pozzolanic materials is obtained from locally available Astra chemicals.

2.1.1 Cement

In this project, Zuari Cement is being used throughout the project 53 grade Ordinary Portland Cement is used. The cement confirms to IS 12269:1987. OPC 53 grade was chosen to get the maximum strength advantage out of cement.

2.1.2 Silica fumes

silica fume is utilised to create the pozzolanic effect in concrete. It is 150 times smaller than a cement particle and has a diameter of about 0.15mm. Silica fume is a next generation construction material. It reacts promptly with calcium hydroxide, which is delivered during cement hydration.

2.1.3 Finer gravel

Natural sand that was retained on a 75-micron size after passing through a 4.75mm IS sieve is the typical fine aggregate used (0.075mm) Fine aggregate is referred to as IS Sieve. Natural river sand is typically used as fine aggregate. In this project, common river sand that conforms to zone II is used.

2.1.4 Fly Ash

Fly ash is a pozzolanic material, which means that when it comes into contact with water, it reacts to make cement. Fly ash creates a substance that resembles Portland cement when combined with lime and water. In this project, fly ash of class F is utilized.

2.1.5 Basalt fiber

Basalt fibre has no adverse effects on human health and hasn't caused any negative interactions with water or the atmosphere. It has a great fire, is inexpensive, and is more readily available than any other material, which significantly lowers the cost of basalt fibre. It is entirely synthetic. Basalt fibre ranges in thickness from 6 to 13 microns. Since basalt fibre substitutes asbestos in all uses, fewer health issues will arise.

2.1.6 Metakaolin

Metakaolin, a pozzolanic material produced from chosen kaolin following refining and calcinations under particular circumstances, is a dehydroxylated version of the clay mineral kaolinite. It is a very effective
pozzolana that, through a pozzolanic reaction, quickly produces calcium silicate hydrates and calcium alumina silicate hydrates from the excess calcium hydroxide left over after OPC hydration. A useful additive for cement and/or concrete applications is metakaolin. Metakaolin often replaces 8–20% of the weight of opc.

2.1.6 Superplasticizer

Superplasticizer effectively makes concrete easier to work with while reducing water use. Significant improvements in overall quality are achieved by significantly reducing the water requirement in a concrete mix to increase durability by decreasing concrete permeability while expanding sand of the highest quality.

2.1.7 Water

Water used for mixing and curing must be pure and free of impurities such salts, acids, and oils.

Table 1. Chemical characteristics of materials

Materials	Fly Ash	Metakaolin	Basalt Fiber
Chemical Composition in %			
SiO_2	56.80	51.2	60.51
Al_2O_3	23.40	40.18	9.02
CaO	5.40	2.0	5.62
Fe_2O_3	5.20	1.23	9.1
MgO	0.91	0.12	2.41
SO_3	0.10	0.00	0.00
Na_2O	-	0.00	2.74
K_2O	-	0.53	1.61
LOI	1.10	0.00	0.00

Table 2. Mix Designation

Mix Designation	Binder Composition in %				
	Coarse And fine Aggregate	Fly ash	Silica fumes	MK	Basalt fiber
CC	100	5	5	0	0

B 1	100	5	5	5	0.5
B 2	100	5	5	10	0.5
B 3	100	5	5	5	1
B4	100	5	5	10	1.5

2.2 Concrete mix design

The objective of proportioning concrete is to arrive mix ratio at the most economical and practical combinations in different ingredients to produce concrete that will satisfy the performance requirements under specified conditions of use. This chapter describes the mix design for M60 grade concrete using IS10262: 2019.

2.2.1 Specimen Details

The variables taken for the preparation of high strength concrete. Cement is partially replaced by metakaolin by 0 to 15%, silica fumes of 5%, fly ash 15% and addition of basalt fiber of varying proportion is been added. Super plasticizing admixture based on selected based brown solution-sulfonated naphthalene polymers that immediately disperses in water. A detail of mix designation is given in Table 2. The ratio of water and superplasticizer is 0.3 and 0.8 is used. The properties of total of four concrete mixes have been studied and compared with conventional concrete.

2.2.2 Sample Preparation for Physical Testing

To prepare specimens First, dry materials such as fly ash, silica fumes, basalt fiber, metakaolin, coarse aggregates and fine aggregates, taken after weighing, were dry mixed for about 3 minutes. Later, the solution of superplasticizer of 0.8 ratio and water 0.3 is added. The samples were then cast in to the moulds. The mould size used are 100 x 100 x 100 mm, 100 x 200 mm and 100 x 100 x 500 mm. The mixed concrete is placed in three layers. The cubes, cylinders and beams were demoulded after 24hrs. The necessary number of samples for each combination have been prepared, and the average of the three samples was used to determine the findings. The casting of samples is shown in Fig.1.

Fig.1 Casting of Specimen

Slump test is used to determine the workability of fresh concrete. The apparatus used for doing slump test is Slump Cone and Tamping rod. The slump value is found as 120 mm.

Slump cone test True Slump

Fig.2 Slump Cone Test

2.2.3 Compressive Strength

Compressive strength for cubes is conducted for determining the strength properties. The compression test was carried out on cubes according to IS:516-2004 [16]. The test set up and progress of testing is shown below in Fig. 1 b). For each combination of mix proportions, triplicate samples were prepared and tested. The average of the three values for a mix proportion is noted. The samples were tested at 7 days, 14 days, 28 days at ambient curing. The test set up and tested samples are shown in Fig.3

Maximum load causing failure was noted. The investigation is done for the four different mixes and it has been compared.

Fig. 3 Testing Setup of Compressive Test

2.2.4 Split Tensile Strength

Split tensile test was carried on the cylindrical specimens which was prepared. They are tested at 7 days, 14 days and 28 days according to IS 5816 – 1987 [17]. The test set up and progress of testing split tensile isshown in Fig.4

Fig. 4 Test setup of Split Tensile Strength Test

2.2.5 Flexural test

Flexural tests were carried on the prism specimens which was prepared. They are tested at 7 days, 14 days and 28 days according to IS 5816 – 1987 [17]. The test set up and progress of testing flexural test isshown in Fig.5

Fig.5 Test setup of Flexural Strength Test

2.2.6 Ultra Sonic Pulse Velocity Test

An electro-acoustical transducer kept in touch with one surface of the concrete member being tested generates an ultrasonic pulse of 50 to 54 kHz, and an identical transducer in contact with the surface at the other end measures the transit time, T. The pulse velocity (V=L/T) is determined using the path length L (i.e., the distance between the two probes) and time of travel T. The density and elastic characteristics of the material being examined influence the ultrasonic pulse velocity. When using aggregate with a 20mm size, the path length will have very little of an impact as long as it is greater than 100mm. The shape of the specimen will not affect pulse velocity as long as its smallest lateral dimension does not fall below the wavelength of the pulse vibrations. The pulse velocity may be slightly yet significantly influenced by the moisture content of the concrete. In general, the velocity rises as the moisture content rises, with the effect being more pronounced for lower-quality concrete. Here CC1&CC2 denotes conventional concrete and B1, B2 donates basalt incorporated RC beam.

Table 3 Concrete based on Ultrasonic PulseVelocity Test

Pulse Velocity	Concrete Quality
>4.0 km/s	Very good to excellent
3.5 km/s – 4.0 km/s	Good to very good, slight porosity may exist
3.0 km/s – 3.5 km/s	Satisfactory but loss of integrity is suspected
<3.0 km/s	Poor and loss of integrity

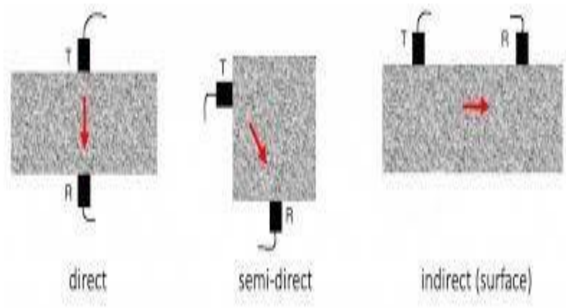


Fig6 Methods of Ultrasonic Pulse velocity test

2.2.7 Flexural test on RC Beam

The test above demonstrates the 15% metakaolin and 1% basalt fiber to Fly ash and silica fumes gives the optimum value specimen good at flexural strength. Hence, the RC beam is also tested to have better clarity and behaviour of concrete. Where 15% of Metakaolin and 1% basalt fiber replaced beams (B1 & B2) are compared with the controlled beams CC1 and CC2 in order to know the major differences and behavior changes. The static load is used to test different beam specimen types. Whereas the test takes into account deflection, crack development, the number of cracks, their spacing, and their width. The beam specifications were 1200mmx100mmx150mm, four points bending test, two numbers of a controlled specimen with 100% cement and two numbers of 10% of Metakaolin and 1% basalt fibre, 12 mm diameter rebar of Fe 415 for longitudinal reinforcement and 8 mm diameter rebar of Fe 415 grade, and curing period was 28 days at normal temperature 30-40 °C, respectively. The concrete grade was M60.

Figure 7 displays the 4 point load test configuration for the RC beam specimen. It is necessary to compare mixes of ordinary concrete with basalt fibre and metakaolin concrete. The following test will be performed on four specimens of cast beams with dimensions of 1200 mm*150 mm*100 mm.

Mix Proportions
Set 1 = 0% replacement in cement.
Set 2 = Addition of basalt fiber 1% and 10% metakaolin replacement in cement.
Fig. 6 Test setup of Flexural Strength Test of RC Beam

Figure 7 displays the 4 point load test configuration for the RC beam specimen

3. Results and Discussion

3.1 Compressive Strength

The graphs below display the results of the compressive strength test for various ambient curing time periods. All of the blends' compressive strength grew over time. With the addition of Fly ash and silica fumes (B3), the strength of basalt fiber with metakaolin concrete demonstrates a greater compressive strength of 69.3 MPa at 28 days.

Table 4 Specimen details for 7 days curing period

SampleNo.	Load(KN)	Compressive strength (MPa)	Average Compressive strength (MPa)
CC	420 454 462	42.0 45.4 46.2	44.53
B1	412 420 418	41.2 42.0 41.8	41.6
B2	390 398 387	39 39.8 38.7	39.1
B3	412 424 418	41.2 42.4 41.8	41.8
B4	391 378 381	39.1 37.8 38.1	38.3

Table 5 Specimen details for 14 days curing period.

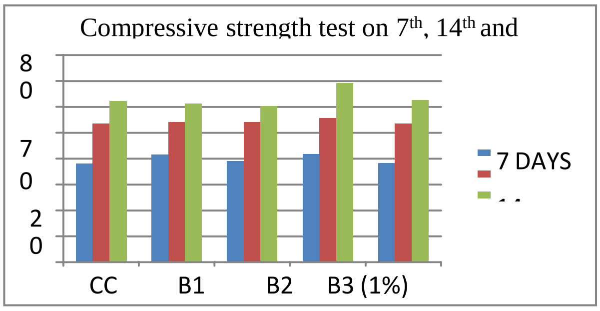
Sample No.	Load (KN)	Compressive strength (MPa)	Average Compressive strength (MPa)
CC	633 621 614	63.3 62.1 61.4	62.26
B1	611 622 609	61.1 62.2 60.9	62.4
B2	623 613 632	62.3 61.5 63.2	61.4
B3	633 642 655	63.3 64.2 65.5	69.3
B4	646 636 628	64.6 63.6 62.8	62.6

Table 6 Specimen details for 28 days curing period

Sample No.	Load (KN)	Compressive strength (MPa)	Average Compressive strength (MPa)
CC	526 516 535	52.6 51.6 53.5	53.36
B1	550 532 544	55 53.2 54.4	54.2
B2	573 549 550	52.3 54.9 55	54.06
B3	573 553 540	57.3 55.3 54	55.6
B4	536 531 550	53.6 53.1 54.3	53.6

3.2 Split Tensile Strength

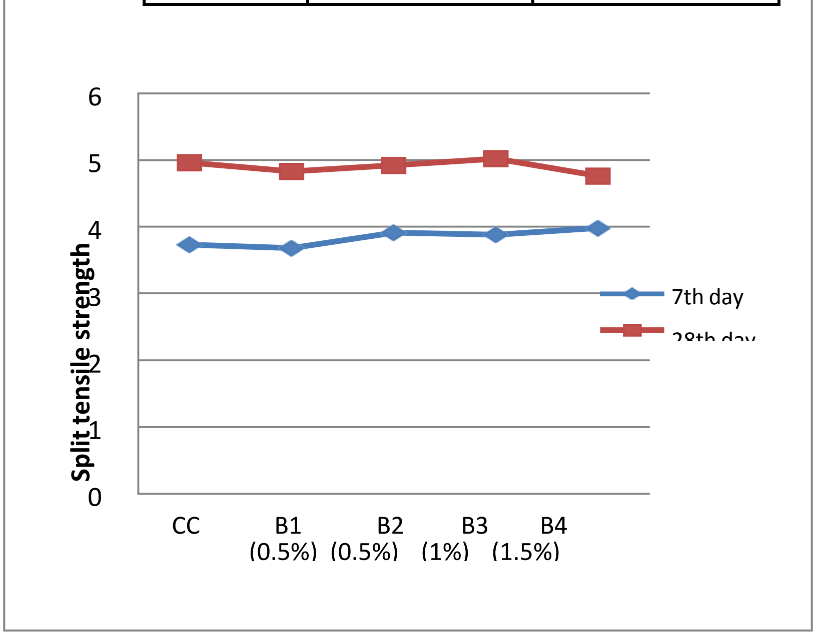
The Graph 4.2 shows the split tensile strength test results for different duration period in ambient curing (7& 28 days). The tensile strength varies from 3.8MPa from 7 days to 5.02 MPa at 28 days for 15% partial replacement of metakaolin and 1% basalt fiber (B3). The rate of increase of strength for all the mixes showed a similar trend of increase. The tensile strength of conventional concrete shows a similar strength of B4 at 28 days. This indicates that, the behaviour of mix concrete is almost similar to the conventional concrete.



Graph 1 Compressive Strength at Ambient Curing

Table 7 Split tensile test results

Sample No	Avg. Split Tensile Strength (MPa) 7th day	Avg. Split-Tensile Strength (MPa) 28th day
CC ,B1, B2 B3, B4	3.73 3.63 3.91 3.88 3.98	4.96 4.83 4.92 5.02 4.76



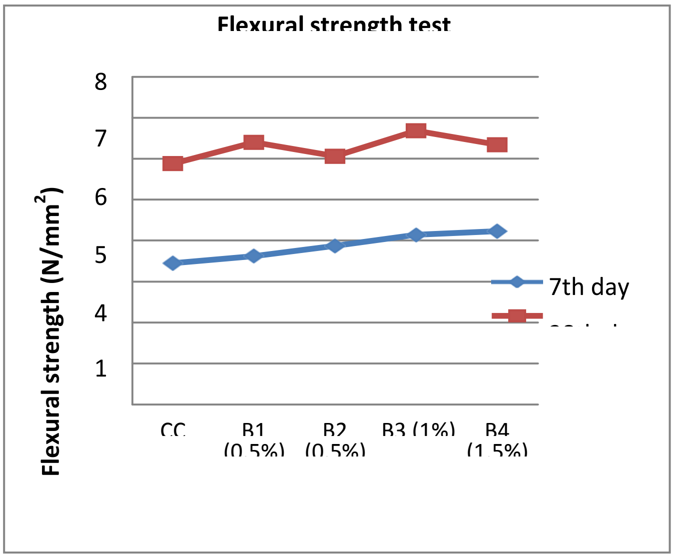
Graph 2 Split Tensile Strength

3.3 Flexural Strength

The Graph 4.3 shows the Flexural Strength of different mix proportions at various duration (7 & 28 days). The flexural strength varies from 3.45 MPa from 7 days to 6.34 MPa at 28 days for the partial replacement of 15% metakaolin with 1% basalt fiber to Fly ash and silica fumes based mix concrete showed the better results when compared to conventional concrete. The strength shows a similar trend of increase for all the mixes. The flexural strength value of the conventional concrete shows strength of 5.88 MPa at 28 days.

Table 8 Flexural strength test result

Sample No	Average Modulus of rupture =PL/bd^2 (N/mm²) 7th day	Average Modulus of rupture =PL/bd^2 (N/mm²) 28th day
CC, B1, B2, B3 B4	3.45 3.62 3.87 4.14 4.23	5.88 6.4 6.06 6.68 6.34



Graph 3 Flexural Strength

3.4 Water absorption

The results of percentage water content submerged in cubes for the water absorption test done on concrete cubes at 28 days for M60 grade concrete control mix concrete and concrete with replacement with Basalt fiber and metakaolin in several proportions.

Table 9 Water absorption test results at 7, 14 and 28 days

Concrete mixes	24Hours saturation Weight (W1) in kg	Oven dry Weight (W2) in kg	Water absorption %
7TH DAY RESULT			
CC1	2.60	2.51	3.58
B1	2.46	2.34	5.12
B2	2.52	2.41	4.56
B3	2.44	2.29	6.55
B4	2.52	2.39	5.43
14TH DAY RESULT			
C2	2.63	2.52	4.36
B1	2.41	2.29	5.24
B2	2.36	2.24	5.35
B3	2.50	2.39	4.60
B4	2.48	2.38	4.20
28TH DAY RESULT			
C3	2.59	2.45	5.71
B1	2.51	2.40	4.58
B2	2.49	2.33	6.86
B3	2.44	2.31	5.62
B4	2.50	2.41	3.73

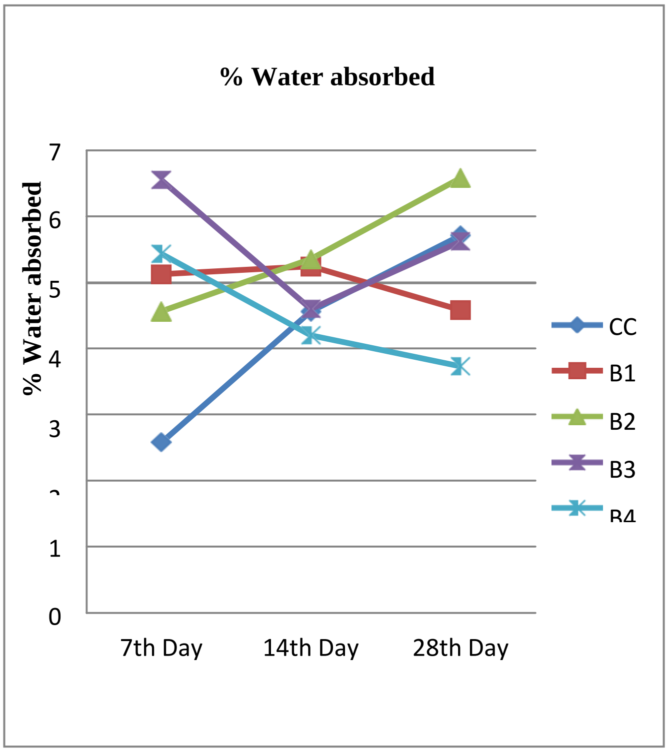
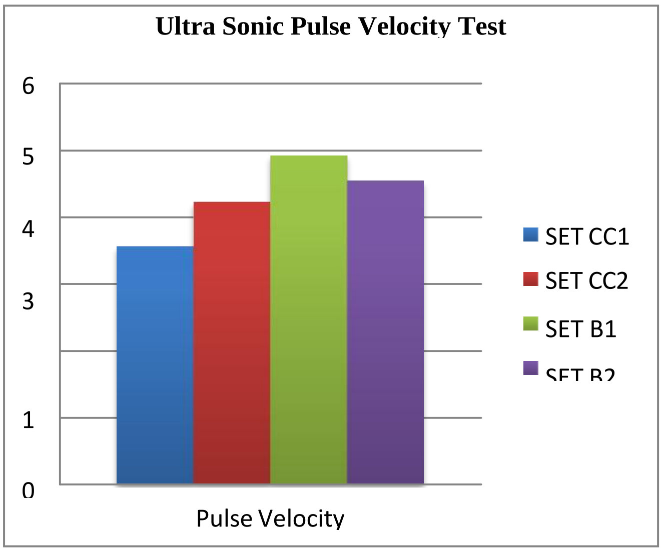


TABLE 10 ***Pulse Velocity Values***

Pulse Velocity Values	***SETCC1***	***SET CC2***	***SET B1***	***SET B2***
	3.56	4.22	4.92	4.54

3.5 Ultrasonic Pulse Velocity Test

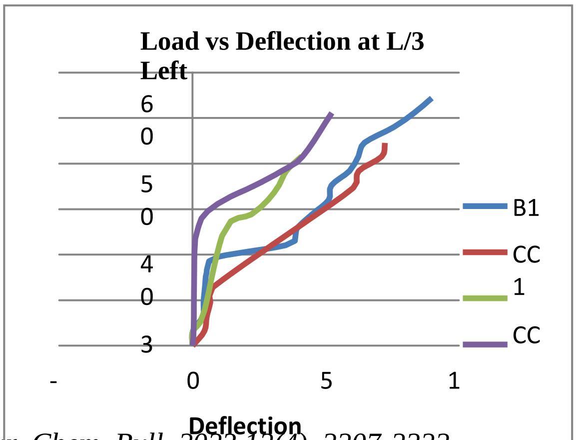
The Ultrasonic pulse velocity test results of RC Beam specimen submerged in the water test done on concrete RC beam at 28 days for M60 grade concrete control mix concrete and concrete with replacement with Basalt fiber (1%) and metakaolin (15%) in proportions. Here CC1&CC2 denotes conventional concrete and B1,B2 donates basalt incorporated RC beam.

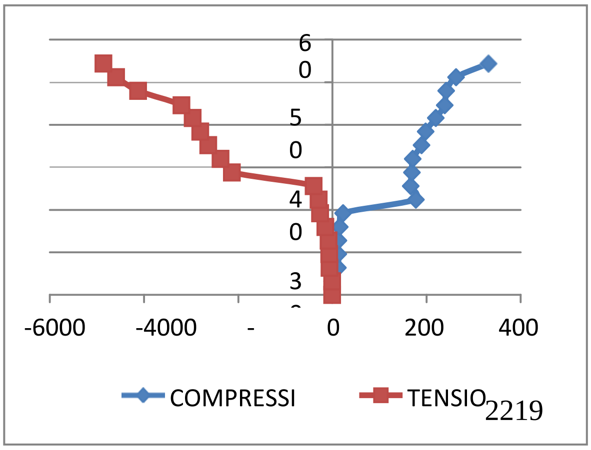


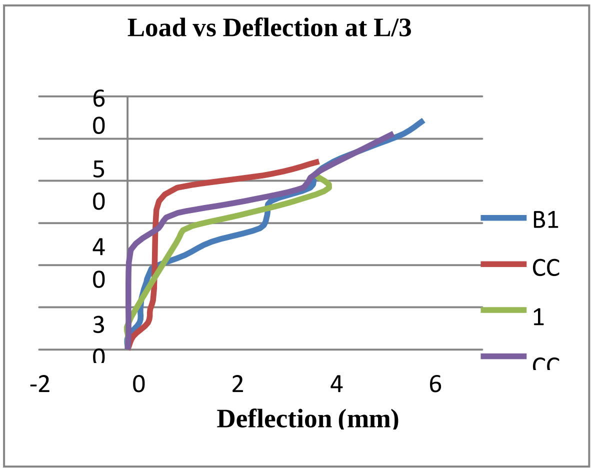
Graph 4.5 Ultrasonic Pulse velocity test result

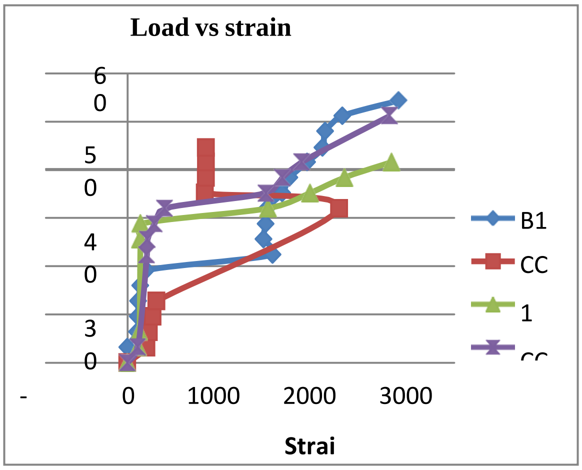
3.6 Flexural test on RC Beam

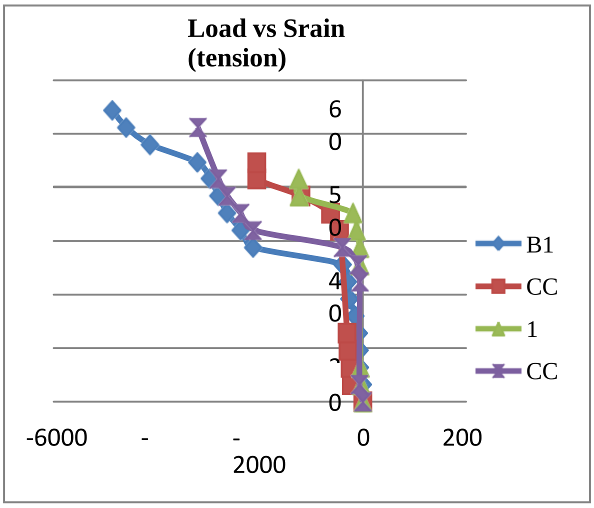
The beam specimen is tested by the static load. Where, deflection, crack propagation, the number of cracks, crack spacing, and crack width are considered under the test. The concrete grade was M60 and the beam specifications such as dimension, type of flexural test, specimen, reinforcement and curing period are 1200mmx100mmx150 mm, four points bending test, two numbers of a controlled specimen with 100% cement and two numbers of 15% of Metakaolin and 1%basalt fiber, 12 mm diameter rebar of Fe 415 for longitudinal reinforcement and 8 mm diameter rebar of Fe 415 grade and curing period was 28 days at normal temperature 30–40 °C respectively. A static load test was performed to validate the ultimate 200 strength and the flexural response of the beam. The load was applied in an ever-increasing manner until it gets failed. Fig.4.6, Fig4.7, Fig 4.8 shows the graph of concrete mixtures showing the load deflection curve of various mixes with control beam and static load for various mixes. Fig 4.9, Fig 4.10 shows.stress strain behaviour of (CC1) and (B1) basalt fiber incorporated RC beam which had showed better results.

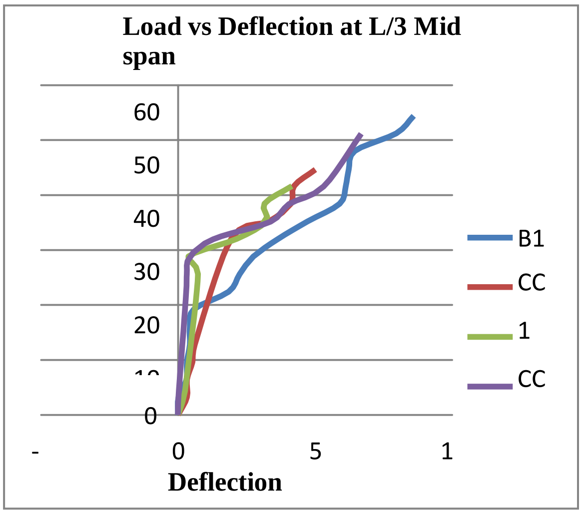












4. Conclusion

From the experimental investigation the following conclusions can be arrived.

- Slump cone test, compaction factor were measured on all the mixtures. The workability properties are decreased by the addition if fiber whereas it has increased with the addition of metakaolin when compared with control concrete.
- The compressive strength of design mix Concreteshows good results when compared to ConventionalConcrete at 28 days at ambient curing. The partial Replacement of 15% metakaolin and 1% basalt fiberto Fly ash and silica fumes gives the optimum value.
- There is an improvement in strength for the partial replacement levels of metakaolin and basalt fiber to replacement of cement.
- The Split Tensile Strength of design mix Concrete shows similar results when compared to Conventional Concrete at 28 days.
- The behaviour of Flexural Strength design mix Concrete is similar to Conventional Concrete fromthe observation of its test results.
- From above figure it describe that the 15% metakaolin and 1% basalt fiber sustains higher load than that of control beam whereas basalt fiber reinforced concrete beam carry higher load than that of control concrete.

- Basalt mix good stress train behaviour than that of mixes. More the stiffer lesser than deformation.
- The strength of the Basalt fiber increases with the ageConcrete.

Reference

1) Abdul Razak, H., & Wong, H. S. 2005.Strength estimation model for high-strength concrete incorporating metakaolin and silica fume. Cement and Concrete Research, 35(4): 688
2) Anil Kumar Nanda, Prem Pal Bansal and Maneek Kumar. 2018. Effect of nano silica and silica fumes on durability properties of HSC. International Journal of Civil Engineering and Technology (IJCIET), 9(2):115
3) Arivalagan. S. 2012. Study On the Compressive and Split Tensile Strength Properties of Basalt Fibre Concrete Members.Global Journal of Researches in Engineering Civil And Structural Engineering,12(4): 23-27
4) B.M. Sunil, Manjunatha L.S. and Subhash C. Yaragal. 2017. Durability studies on concrete with partial replacement of cement and fine aggregates by fly ash and tailing material. Advances in Concrete Construction,5(6): 671-683[5]
5) Badogiannis, E., Kakali, G., & Tsivilis, S. 2005. Metakaolin as supplementary cementitious material.Journal of Thermal Analysis and Calorimetry, 81(2): 457
6) Barbhuiya, S., Chow, P., & Memon, S. 2015. Microstructure, hydration and Nano mechanical properties of concrete containing metakaolin. Construction and Building Materials, 95: 696
7) Bhaskara Teja Chavali, Perla Karunakar.2005. Effect of varying quantities of Mk and fa on strength characteristics of concrete. International Journal for Technological Research In Engineering, 4(2): 282-288[8]
8) Bi, Q., & Wang, H. 2011. Bond Strength of BFRP Bars to Basalt Fiber Reinforced High-Strength Concrete.Advances in FRPComposites in Civil Engineering, 576
9) Dr.K.Srinivasu, M.L.N.Krishna Sai, Venkata Sairam Kumar. N .2007. A Review on Use of Mk in Cement Mortar and Concrete. International Journal of Innovative Research in Science, Engineering and Technology, 3(7).[10]
10) Er. Amritpal .2015. Durabilty Properties of Concrete with Partial Replacement of Cement with Mk and Marble Dust. International Journal of Engineering Research & Technology (IJERT), 4(07).
11) Fahima Irine I .A.2014. Strength Aspects of Basalt Fiber Reinforced Concrete. International Journal of Innovative Research in Advanced Engineering. Mohandas, K & Elangovan, G 2016, 'Retrofitting of reinforced concrete beam using different resin bonded GFRP laminates' International Journal of Advanced Engineering Technology, E-ISSN0976-3945, vol. 7 no. 2,
12) Mohandas, K & Elangovan, G 2015, 'Influence of polymeric resins on the enhancement ofstrengthening of reinforced concrete beam with phenolic resin bonded FRP'S', International Journal of Applied Engineering Research, ISSN0973-4562 vol. 10, no. 5,
13) Dr.K.Mohan das, Dr.N.Sundar, S Harishankar, A Raj Kumar, SPM Kannan & Dr.K.Ramesh "An experimental study on strength characteristics of replacement of fine aggregate with stone dust and coarse aggregate with demolished concrete waste" YMER.Volume-21;Issue-2,Pages 683-700.
14) Mohandas K, ElangovanG.2016 "Influence of polymeric resins on the enhancement of strengthening of RC beam using CFRP laminates" Asian journal of information Technology, Medwell publications, Article ID 25565

15) Baskar K, Elangovan G,Mohandas K.2017"flexural behaviuor of fibre reinforced concrete beams with different aspect ratios" FIBRES & TEXTILES in Eastern Europe, Institute of Biopolymers and chemical fibres, Poland .Issue2018,pp 59-66
16) Divaker.S,Dr.K.Arunachalam.Mohandas.K.2017 "Selfcompacting concrete with copper slag as partial substitute for sand " Journal of Computational and Theoretical Nanoscience,Americen scientific publishers. Volume 15, Number 3, March 2018, pp. 977-981(5)
17) T Ananth, Mr Prasoon PP, Mr C Vijayakumar, K Mohan Das,Partial Replacement Of cement With Sugar Cane Bagasse Ash And Hybrid Fibers,Dogo Rangsang Research Journal UGC Care Group I Journal ISSN : 2347-7180 Vol-12 Issue-08 No. 04 August 2022.
18) Rameshwari S, Mr.P.Thangamuthu, P.Karthik, A.Sathiyamoorthy, V.Yogeshwaran, PG Student, Dr.K.Mohan Das, P "AN EXPERIMENTAL STUDY ON SLICA FUME CONCRETE WITH ADDITION OF FIBRES", Dogo Rangsang Research Journal UGC Care Group I Journal ISSN : 2347-7180, Vol-12 Issue-11 No. 03 November 2022.