Flexure Study on Bagasse Ash Concrete with Bagasse Fibre

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Abstract

In the construction industry, Concrete is the most powerful designing material due to its strength and durable properties. The utilization of cementitious materials concretes exhausted normal assets as well as builds the poisonous material in the climate. To reduce the environmental impact, in the form of reducing the cement content and agricultural waste utilization of bagasse ash and bagasse fibre. The study investigates the flexure behaviour of bagasse ash and bagasse fiber on the reinforced concrete beams. The beams were prepared with and without bagasse fiber (replacing of 5%, 10%, 15% and 20% of cement), in addition to that of bagasse ash the bagasse fiber was added (0.5%, 1%, 1.5% and 2%).The test set-up for all the beams were identical. Beams were tested under monotonic testing up to failure. From the test results reveals that the 10% of bagasse ash with 1% of bagasse fibre provides a substitution on the concrete based on the flexure behaviour.

Keywords: *Bagasse Ash, Bagasse Fiber, Fibre, Flexural behaviour*

1. Introduction

The most usually utilized cement is the ordinary Portland Cement (OPC). One of the principle constituents of cement will be concrete which is hurting the climate at a quick rate.Concrete is a fine dark fine substance which is made by consuming a combination of dirt and lime, and sets hard when it is blended in with water. The assembling of concrete includes a few cycles like pulverizing, processing and proportioning of lime, silica, alumina, iron and gypsum. Concrete is a cover material which is a substance that helps in restricting various materials together [1]. This property makes it a brilliant constituent of cement. Creation of Cement produces high measure of CO_2. Concrete is the third biggest maker of man-made CO_2 on the planet after vehicle area and energy age area [2]. It is assessed that about 0.97 huge loads of carbon dioxide is delivered to the climate for the creation of 1 ton of the concrete. Carbon dioxide is one of the classifications of ozone harming substance and is generally answerable for unnatural weather changes [3].

This defilement of the concrete collecting plants has a terrible characteristic effect, ecological structure, and human prosperity which could cause outrageous issues noticeable all around, and butcher a couple of life classes and oppositely sway on the course of action of unwinding. A couple examines suggest a positive prosperity association between unions of nitrogen dioxide at the environment which caused harm cases and coronary disease [4].

This prompts us to examine the different choices to concrete to make the solid climate benevolent. The utilization of waste materials or by items from the assembling ventures can be utilized as a fractional substitution of concrete in cement without diminishing the ideal strength of the concrete. Sugarcane is one of the pozzolonic materials delivered by consuming the sugarcane waste. Sugarcane is one of the significant harvests filled in more than 110 nations and itsall out creation is more than 1500 million tons overall [5]. In India just, sugarcane creation is more than 300 million tons each year which causes around 10 million tons of sugarcane bagasse debris as a non-usable waste materials [6]. Subsequent to removing of all conservative sugar from sugarcane, around 40–45% stringy build-up is gotten in similar industry as fuel in boilers for heat age giving up 8–10% debris as waste, known as sugarcane bagasse debris (SCBA) [7]. The SCBA includes high measures of un-consumed matter, silicon, aluminium and calcium oxides. Yet, the cinders which are gotten straightforwardly from the factory are non-responsive on the grounds that these are singed under uncontrolled conditions and at exceptionally high temperatures.In this manner, the debris turns into a modern waste and stances removal issues. In this way, properties of eventual outcome are completely reflected with different preparing boundaries and their fixings [8]. It is critical to contemplate the utilization of SCBA as a halfway substitution of concrete in cement in light of the fact that the CO_2 emission is more on the concrete because of environment impact.

Concrete containing pressure driven concrete, water, total, and broken discrete filaments is known as fiber strengthened cement. The significant part of filaments is to recuperate the breaks that get create in the solid and increment the malleability of solid components, enhancement for post breaking conduct of cement. It increments more protection from sway load, controls plastic shrinkage and drying shrinkage and brings down the porousness of concrete and along these reduce the water bleeding. The fiber builds the concrete toughness property. The bagasse fibers are delicate to corrosion than the steel fiber. The utilization of bagasse fiber improves the crack capacity on the concrete, subsequently improving its strength Al-Jabri et al. [9].

The sugarcane bagasse ash and bagasse fiber was used as composites in constructions as a cement replacement solution to reduce the environmental hazards. The research on the bagasse ash and bagasse fiber was conducted over a last few decade to utilize the sugarcane waste in all over the world. From the sugarcane waste the sugarcane bagasse ash is obtained from the burning of sugarcane. As the early study clearly shows that the sugarcane bagasse ash contains high silica SiO_2 as the principal synthetic segments in non-translucent structure and is consequently suit capable for use as a pozzolan[10].

A few scholarly researchers from better places around the globe have done trials in using the sugarcane bagasse ash as replacement materials in cement, generally supplanting concrete. The greater part of the researchers used (0%, 5%, 15%, and 25%) of sugarcane bagasse ash as a supplementary cementitious material and study the impact of sugarcane bagasse ash on the Compression, split, flexure strength at different ages of time[11], they found that utilizing sugarcane bagasse ash as a supplementary cementitious material improved the synthetic and actual qualities of the concrete blend just as expanding the Compression, split, flexure strength at different ages of time. What's more, contingent upon the proportion that was used, the 10% had the best improving outcome for various purposes. Some examination has been led on the debris that was gotten straightforwardly from the produces to research the pozzolanic responses and suitability as bindery supplanting the concrete to some degree [12]. The fibre performance in flexural strength of concrete for various mixes was evaluated to demonstrate the Bagasse Ash Concrete with Bagasse.

2. Materials and Methods

Seventeen types of concrete were studied: One without bagasse ash and bagasse fiber and other types with bagasse ash and bagasse fiber. Ordinary Portland cement with the grade 53 was used. Fine aggregate used was with a fineness modulus of 2.7 and unit mass equal to 2.8 and specific density of 2.45kg/m^3. Coarse aggregate used was crushed stone aggregate with a specific density of 2.65kg/m^3. Bagasse ash was used as a replacement of cement. Properties of bagasse ash were shown in Table 1. Bagasse fiber was used with the aspect ratio of 50 and 70.

Table 1: Properties of Bagasse Ash

Components	Mass %	Components	Mass %
Physical Properties		Chemical Properties	
Density (g/cm^3)	2.52	Silica (SiO_2)	66.89
Surface area (cm^2/gm)	5140	Alumina (Al_2O_3)	29.18
Particle size (μm)	28.9	Ferric Oxide (Fe_2O_3)	29.18
Colour	Reddish Grey	Calcium Oxide (CaO)	1.92
		Magnesium Oxide (MgO)	0.83
		Sulphur Tri Oxide (SO_3)	0.56
		Loss of Ignition	0.72
		Chloride	-

Concrete grade used in the study was M30 with and without bagasse ash and bagasse fiber. The variables considered in the study was bagasse ash replaced with the cement in the percentage of 5, 10, 15 and 20, addition to that bagasse fiber was added in the volume fraction percentage of 0.5, 1.0, 1.5 and 2.0. The beam was casted with the size of 150 x 250 x 2000mm [13]. The steel reinforcement used for the study were made with Fe500 grade, 2 nos of 12mm diameter bar as used as a longitudinal reinforcement with 2 legged 8mm diameter bar was used as a stirrup of 100mmc/c.Table 2 lists the combination of casted beams for testing with the variables.

Table 2 Beam Designations with variables

S.No	Specimen Designation	Bagasse Ash	Bagasse Fiber
1	CC	-	-
2	B5F0.5	5	0.5
3	B5F1.0		1.0
4	B5F1.5		1.5
5	B5F2.0		2.0
6	B10F0.5	10	0.5
7	B10F1.0		1.0
8	B10F1.5		1.5
9	B10F2.0		2.0

10	B15F0.5	15	0.5
11	B15F1.0		1.0
12	B15F1.5		1.5
13	B15F2.0		2.0
14	B20F0.5	20	0.5
15	B20F1.0		1.0
16	B20F1.5		1.5
17	B20F2.0		2.0

3. Experimental set up

In order to study a flexure behaviour of a simply supported beam with a two-point loading. A study was conducted for all the beams. The beam was placed in the loading frame with the bearing of 100mm. with the help of 25t capacity hydraulic jack the beam was tested [14]. The deflection was measured during the loading at the centre and loading points with the help of deflectometer. The setup was proposed to find the flexure behaviour of reinforced concrete beams with and without bagasse ash and bagasse fiber. Longitudinal steel ratio adopted for the beam specimens was 2 bars of 12 mm diameter. 2-legged 8 mm diameter shear stirrups were provided at 100 mm c/c in order to avoid any shear failure and ensure flexural action of beams up to failure [15]. All the beams were tested in the loading frame under static loading and readings were recorded manually. On the loading frame the beams were supported with one end hinge and another end roller. On both ends 100mm bearing was provided with a span of 1800mm. At the bottom of the specimen loading points and mid points the deflection was measured during testing. The readings were taken upto the ultimate load level. Figure 1 shows the tested beams test set-up.

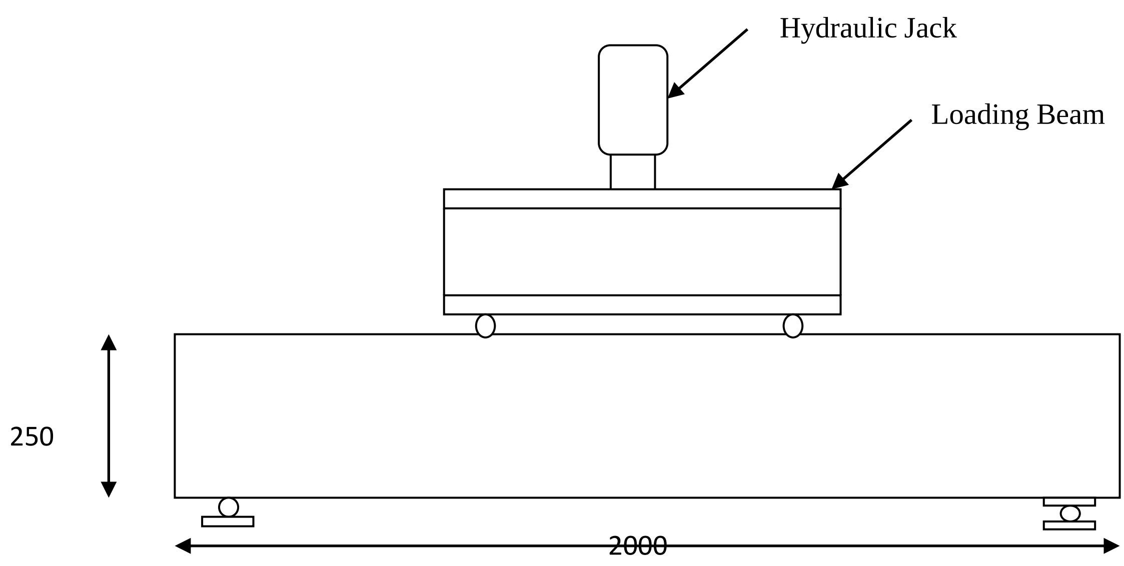

Figure 1: Test Set-up of Tested Beam

4. Results and Discussion

Table 2 Test Results of the Tested Beams

S.No	Beam Designation	Yield Load in kN	Yield Deflection in mm	Ultimate Load in kN	Ultimate Deflection in mm
1	Center to Center (CC)	24.5	5.55	31.10	6.81
2	B5F0.5	25.5	5.45	32.30	7.18
3	B5F1.0	27.5	4.75	36.00	7.55
4	B5F1.5	29.5	5.5	34.10	7.35
5	B5F2.0	26.5	5.35	31.50	6.95
6	B10F0.5	30.5	5.45	35.50	7.25
7	B10F1.0	33.5	4.65	39.50	7.75
8	B10F1.5	28.5	4.95	37.00	7.65
9	B10F2.0	27.5	5.05	36.50	7.55
10	B15F0.5	30	5.1	36.00	7.05
11	B15F1.0	31.5	5.05	37.50	7.25
12	B15F1.5	30.5	5.3	36.50	7.15
13	B15F2.0	28.5	5.4	34.50	7.05
14	B20F0.5	26.5	5.15	31.70	6.95
15	B20F1.0	27.5	5	32.60	7.05
16	B20F1.5	26.5	5.3	30.80	6.95
17	B20F2.0	25.5	5.65	28.40	6.45

Table 2 shows the test results of the tested beams and Figure 3. shows the load vs deflection of the tested beams. For specimen CC, which is a conventional reinforced concrete beam were observed the ultimate load of 31.10kN in the pure bending region. The steel reinforcement of the beam was yield at a load of 24.5kN and the deflection at the yield load was 5.55mm. The deflection of the beam at the ultimate load was 6.81mm.

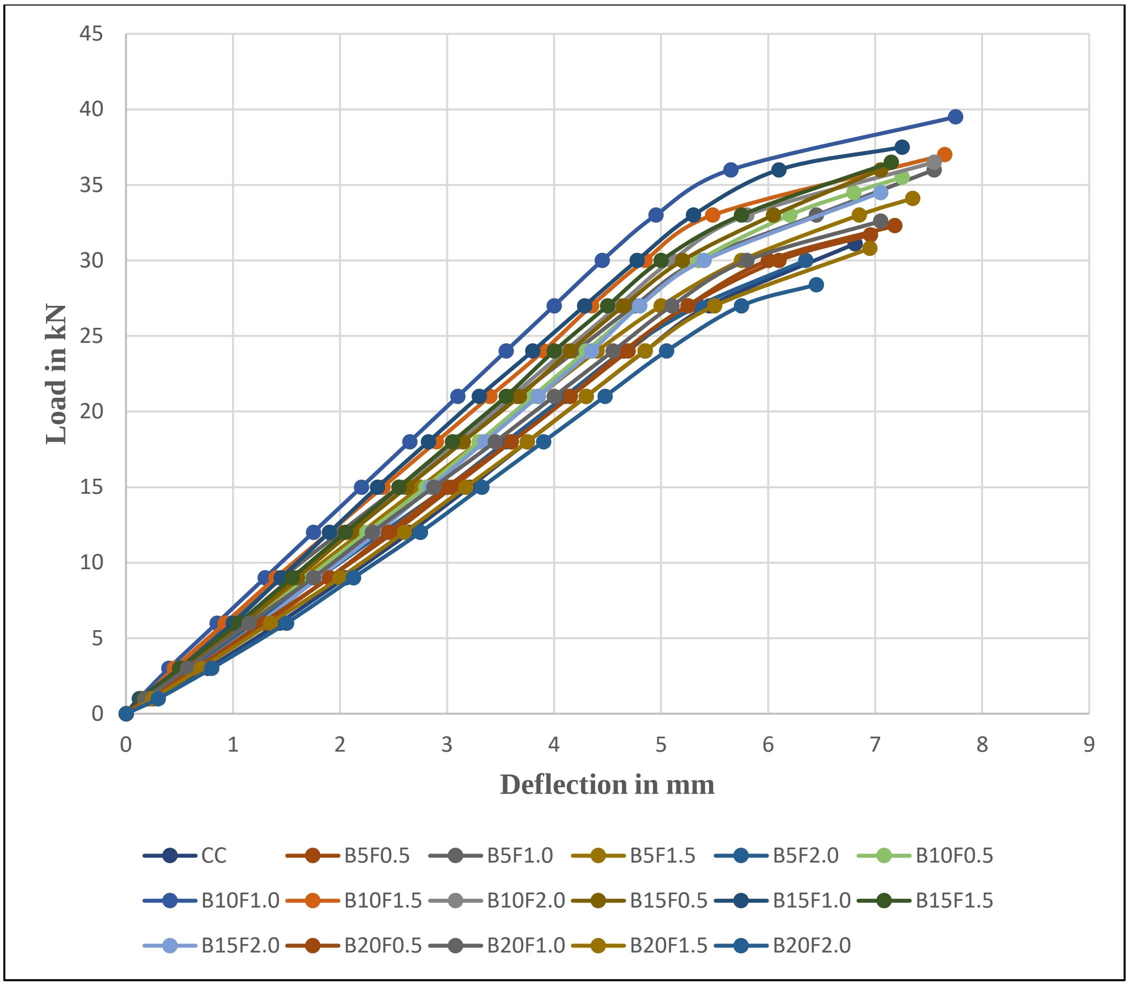

Figure 3. Load vs Deflection of Tested Beam

For specimen B5F0.5, which or this is a reinforced concrete beam with 5% of bagasse ash as a replacement of cement and 0.5% of bagasse fiber were observed the ultimate load of 32.30kN in the pure bending region. The steel reinforcement of the beam was yield at a load of 25.5kN and the deflection at the yield load was 5.45mm. The deflection of the beam at the ultimate load was 7.18mm. B5F0.5 beam was compared with the CC beam the yield and ultimate load was increased in the percentage of 4.08 and 3.86. At the deflection at yield and ultimate load of the B5F0.5 beam was decreased in the percentage of 3.30 and 11.80 when compared with the CC beam .

For specimen B5F1.0, which is a reinforced concrete beam with 5% of bagasse ash as a replacement of cement and 1.0% of bagasse fiber were observed the ultimate load of 36.00kN in the pure bending region. The steel reinforcement of the beam was yield at a load of 27.5kN and the deflection at the yield load was 4.75mm. The deflection of the beam at the ultimate load was 7.55mm. B5F1.0 beam was compared with the CC beam the yield and ultimate load was increased in the percentage of 12.24 and 15.76. At the deflection at yield and ultimate load of the B5F1.0beam was decreased in the percentage of 13.40 and 21.44 when compared with the CC beam [16].

For specimen B5F1.5, which is a reinforced concrete beam with 5% of bagasse ash as a replacement of cement and 1.0% of bagasse fiber were observed the ultimate load of

34.10kN in the pure bending region. The steel reinforcement of the beam was yield at a load of 26.5kN and the deflection at the yield load was 5.5mm. The deflection of the beam at the ultimate load was 7.55mm. B5F1.5 beam was compared with the CC beam the yield and ultimate load was increased in the percentage of 20.41 and 9.65. At the deflection at yield and ultimate load of the B5F1.5beam was decreased in the percentage of 7.22 and 15.57 when compared with the CC beam .

For specimen B5F2.0, which is a reinforced concrete beam with 5% of bagasse ash as a replacement of cement and 1.0% of bagasse fiber were observed the ultimate load of 31.50kN in the pure bending region. The steel reinforcement of the beam was yield at a load of 26.5kN and the deflection at the yield load was 5.35mm. The deflection of the beam at the ultimate load was 6.95mm. B5F2.0 beam was compared with the CC beam the yield and ultimate load was increased in the percentage of 8.16 and 1.29. At the deflection at yield and ultimate load of the B5F2.0beam was decreased in the percentage of 5.15 and 6.75 when compared with the CC beam [17].

For specimen B10F0.5, which is a reinforced concrete beam with 10% of bagasse ash as a replacement of cement and 0.5% of bagasse fiber were observed the ultimate load of 35.50kN in the pure bending region. The steel reinforcement of the beam was yield at a load of 30.5kN and the deflection at the yield load was 5.45mm. The deflection of the beam at the ultimate load was 7.25mm. B10F0.5 beam was compared with the CC beam the yield and ultimate load was increased in the percentage of 24.49 and 1415. At the deflection at yield and ultimate load of the B10F0.5 beam was decreased in the percentage of 11.34 and 22.17 when compared with the CC beam.

For specimen B10F1.0, which is a reinforced concrete beam with 10% of bagasse ash as a replacement of cement and 1.0% of bagasse fiber were observed the ultimate load of 39.5kN in the pure bending region. The steel reinforcement of the beam was yield at a load of 33.5kN and the deflection at the yield load was 4.65mm. The deflection of the beam at the ultimate load was 7.65mm. B10F1.0 beam was compared with the CC beam the yield and ultimate load was increased in the percentage of 36.73 and 27.01. At the deflection at yield and ultimate load of the B10F1.0beam was decreased in the percentage of 26.80 and 34.65 when compared with the CC beam.

For specimen B10F1.5, which is a reinforced concrete beam with 10% of bagasse ash as a replacement of cement and 1.0% of bagasse fiber were observed the ultimate load of 37.00kN in the pure bending region. The steel reinforcement of the beam was yield at a load of 28.5kN and the deflection at the yield load was 4.95mm. The deflection of the beam at the ultimate load was 7.65mm. B10F1.5 beam was compared with the CC beam the yield and ultimate load was increased in the percentage of 16.33 and 18.97. At the deflection at yield and ultimate load of the B10F1.5beam was decreased in the percentage of 18.56 and 28.34 when compared with the CC beam [18].

For specimen B10F2.0, which is a reinforced concrete beam with 10% of bagasse ash as a replacement of cement and 2.0% of bagasse fiber were observed the ultimate load of 36.50kN in the pure bending region. The steel reinforcement of the beam was yield at a load of 27.5kN and the deflection at the yield load was 5.05mm. The deflection of the beam at the ultimate load was 7.55mm. B10F2.0 beam was compared with the CC beam the yield and ultimate load was increased in the percentage of 12.24 and 18.97. At the deflection at yield and ultimate load of the B10F2.0 beam was decreased in the percentage of 13.40 and 24.38 when compared with the CC beam.

For specimen B15F0.5, which is a reinforced concrete beam with 15% of bagasse ash as a replacement of cement and 0.5% of bagasse fiber were observed the ultimate load of 36.00kN in the pure bending region. The steel reinforcement of the beam was yield at a load of 30kN and the deflection at the yield load was 5.10mm. The deflection of the beam at the ultimate load was 7.05mm. B15F0.5 beam was compared with the CC beam the yield and ultimate load was increased in the percentage of 22.45 and 15.76. At the deflection at yield and ultimate load of the B15F0.5 beam was decreased in the percentage of 14.43 and 25.11 when compared with the CC beam [19].

For specimen B15F1.0, which is a reinforced concrete beam with 15% of bagasse ash as a replacement of cement and 1.0% of bagasse fiber were observed the ultimate load of 37.5kN in the pure bending region. The steel reinforcement of the beam was yield at a load of 31.5kN and the deflection at the yield load was 5.05mm. The deflection of the beam at the ultimate load was 7.25mm. B15F1.0 beam was compared with the CC beam the yield and ultimate load was increased in the percentage of 28.57 and 20.58. At the deflection at yield and ultimate load of the B15F1.0beam was decreased in the percentage of 21.65 and 29.52 when compared with the CC beam.

For specimen B15F1.5, which is a reinforced concrete beam with 15% of bagasse ash as a replacement of cement and 1.0% of bagasse fiber were observed the ultimate load of 36.5kN in the pure bending region. The steel reinforcement of the beam was yield at a load of 30.5kN and the deflection at the yield load was 5.3mm. The deflection of the beam at the ultimate load was 7.15mm. B15F1.5 beam was compared with the CC beam the yield and ultimate load was increased in the percentage of 24.49 and 17.36. At the deflection at yield and ultimate load of the B15F1.5beam was decreased in the percentage of 15.46 and 25.84 when compared with the CC beam [20].

For specimen B15F2.0, which is a reinforced concrete beam with 15% of bagasse ash as a replacement of cement and 2.0% of bagasse fiber were observed the ultimate load of 34.50kN in the pure bending region. The steel reinforcement of the beam was yield at a load of 28.5kN and the deflection at the yield load was 5.40mm. The deflection of the beam at the ultimate load was 7.05mm. B15F2.0 beam was compared with the CC beam the yield and ultimate load was increased in the percentage of 10.31 and 10.93. At the deflection at yield and ultimate load of the B15F2.0beam was decreased in the percentage of 10.31 and 20.70 when compared with the CC beam.

For specimen B20F0.5, which is a reinforced concrete beam with 15% of bagasse ash as a replacement of cement and 0.5% of bagasse fiber were observed the ultimate load of 31.70kN in the pure bending region. The steel reinforcement of the beam was yield at a load of 26.50kN and the deflection at the yield load was 5.15mm. The deflection of the beam at the ultimate load was 6.95mm. B20F0.5 beam was compared with the CC beam the yield and ultimate load was increased in the percentage of 8.16 and 1.93. At the deflection at yield and ultimate load of the B20F0.5 beam was decreased in the percentage of 3.09 and 14.10 when compared with the CC beam.

For specimen B20F1.0, which or this is a reinforced concrete beam with 15% of bagasse ash as a replacement of cement and 1.0% of bagasse fiber were observed the ultimate load of 32.60kN in the pure bending region. The steel reinforcement of the beam was yield at a load of 27.5kN and the deflection at the yield load was 5.00mm. The deflection of the beam at the ultimate load was 7.05mm. B20F1.0 beam was compared with the CC beam the yield and ultimate load was increased in the percentage of 12.24 and 4.82. At the deflection at yield and ultimate load of the B20F1.0beam was decreased in the percentage of 6.19 and 16.30 when compared with the CC beam.

For specimen B20F1.5, which is a reinforced concrete beam with 15% of bagasse ash as a replacement of cement and 1.0% of bagasse fiber were observed the ultimate load of 30.80kN in the pure bending region. The steel reinforcement of the beam was yield at a load of 26.50kN and the deflection at the yield load was 5.3mm. The deflection of the beam at the ultimate load was 6.95mm. B20F1.5 beam was compared with the CC beam the yield and ultimate load was increased in the percentage of 8.16 and 0.96. At the deflection at yield and ultimate load of the B20F1.5beam was decreased in the percentage of 4.12 and 2.35 when compared with the CC beam [21].

For specimen B20F2.0, which is a reinforced concrete beam with 15% of bagasse ash as a replacement of cement and 2.0% of bagasse fiber were observed the ultimate load of 28.40kN in the pure bending region. The steel reinforcement of the beam was yield at a load of 25.5kN and the deflection at the yield load was 5.65mm. The deflection of the beam at the ultimate load was 6.45mm. B20F2.0 beam was compared with the CC beam the yield and ultimate load was increased in the percentage of 4.08 and 0.43. At the deflection at yield and ultimate load of the B20F2.0beam was decreased in the percentage of 0.12 and 0.29 when compared with the CC beam.

The behaviour of the beam clearly shows all the beams cause fails in flexural. All the beam attains its full flexural strength, shear links are sufficient to helps the beam compatibility and resistance of the failure. The reinforcement and concrete compatibility make the beam to deflection together. The flexure cracks begin to open at the contraflexure point (loading area) when the flexure strength exceeds loading on the concrete. Thereafter, the loads carrying by the tensile reinforcement. After the cracks develops on the beams the load deflection occurs due to change in slope. The yielding of the tensile steel continues up to the linear curve formation. After steel yielding the concrete devastating and spalling of cover zone of the concrete [22].

Conclusion

The influence of the bagasse ash and bagasse fiber in concrete experimental study on seventeen beams concludes that the addition of bagasse ash and bagasse fiber to concrete results in a significant increase in ultimate strength in the reinforced concrete beams. It is also observed that the bagasse ash fiber beams was more ductile the reinforced concrete beams. From the test results shows clearly that the 10% of bagasse ash concrete with 1% of bagasse fiber shows immense response on the flexural behaviour of the concrete beams. The bagasse ash and bagasse fibre enhance the behaviour of the concrete at yield and ultimate loading stages by increasing the strength, stiffness in the cracking stage and decreasing the deformation. The bagasse ash and bagasse fiber provides a good solution for the cement replacement to avoid environmental impact due to cement manufacturing.

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