International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8 Issue-6, March 2020

# Bottom Ash based Steel Fiber Reinforced Concrete

**Sujatha Takkellapati, Tej Sai Moturu, Haroon Ali Khan, Chava Srinivas**

***Abstract*: *Concrete is the most significant material for construction and by incorporation of various industrial by products may improve its properties. Normally fine aggregates have been obtained from natural sources like river beds, now days there is a lot of scarcity for getting natural aggregates. So to overcome this problem, aggregates are partially replaced with alternative materials like bottom ash, recycled aggregates and some natural aggregates .In present study, fine aggregate was replaced with bottom ash and steel fibres are used to improve strength characteristics of concrete. M25 grade concrete was prepared for control specimens, and also bottom ash based fiber reinforced concrete specimens were prepared in different proportions 0%, 10%, 20%, 30% and 40% with bottom ash by weight of fine aggregate and a 1.0% and 1.5% of steel fibers were added by weight of cement. To examine bottom ash based steel fiber reinforced concrete specimens were tested under flexural, split tensile, and compression. The mechanical property of bottom ash based steel fiber reinforced concrete was compared with control mix to examine optimal combination of bottom ash and fibers. It was noticed that 10% replacement of bottom ash has shown the maximum improvement in Compressive, split tensile and flexural strength. Hence, bottom ash based steel fiber reinforced concrete can be used as construction material.***

***Keywords*: *Concrete, Bottom Ash, Steel Fibers, Fiber reinforced***

## I. INTRODUCTION

Bottom ash is an outgrowth obtained from combustion of coal-based thermal industry. The vast majority of the base debris is utilized as land filler material before multi-decade .After that bottom ash is used as construction material ,so it provide a solution to dispose of this material. By replacing bottom ash, slump of concrete was decreased with increased percentage of bottom ash content Abdul Hameed Umar Abu-Bakr [1]. If Bottom ash is combined with concrete it gives later age strength. When compared with conventional concrete, bottom ash based concrete has more water absorption P.Agrwal [2].Bottom ash specific gravity is low compared with fine aggregate, so density of concrete was decreased with increased percentage of bottom ash content Mohd Syahrul Hisyam bin Mohd Sani [3] . Split tensile strength didn't show any perceptible change with increasing bottom ash content for any fiber content. By increasing fiber content, the flexural strength increased for any percentage of bottom ash. Addition of steel fibers the failure resisting of the beams was increased and also ductile behavior has been enhanced.B.R. Phanikumar, A. Sofi[4] . Bottom ash contains both receptive, little particle and non-receptive or ineffectively receptive enormous particles, because of which it loses its general pozzolanic. Bottom ash had a place with the low receptive gathering. Pond ash contains some unburnt particles, so it's not a good reactive pozzolana and does not give good strength for concrete R.V. Ranganath, B. Bhattacharjee, and S. Krishnamoorthy [5].Fire resistance of concrete was improved because of 1%steel fibers. From his experimentation that there is an additional reduction in workability due to steel fibers .Because of higher deformability of Steel fiber reinforced concrete during the cracking phase. Bottom ash based steel fiber reinforced concrete show a higher flexural rigidity than conventional concrete. Fracture surfaces are also different from that of conventional concrete. Due to addition of steel fibres to concrete there is no improvement its long-term cube strength. The average cube strength of bottom ash based steel fiber reinforced concrete was improved than conventional concrete [4] . P. Tang [6] studied on High Performance of Concrete in HPC workability decreased gradually with more replacement percentage of bottom ash with fine aggregate. The amount of CSH gel in the mortar increases with the addition of pond ash. He stated that the strength of mortar was reduced by increased content of bottom ash replacement beyond 10% with cement Dhirajkumar Lal a, Aniruddha Chatterjee b, Arunkumar Dwivedi c[7].]. Grounded bottom ash is also used for back filling of excavations, tunnels, sewers, and other underground facilities. Coal ash can be used for making of roller-compacacted concrete. Utilization of bottom ash in construction, it helps to reduce the transportation cost as well as reduces environmental hazardous. Fibres were distributed randomly in the concrete during mixing, and thus enhance flexure properties and toughness of concrete. The maximum dry density reduces and the optimum mois ture content increases with the addition of admixtures, but the inclusion of fibers shown only marginal effect Arvind Kumar, Deepak Gupta [8].

Manuscript received on March 15, 2020.
Revised Manuscript received on March 24, 2020.
Manuscript published on March 30, 2020.
* Correspondence Author
**Sujatha Takkellapati***, Civil department, VR Siddhartha Engineering College, Vijayawada, India. Email: kilarusujatha@gmail.com
**Tej Sai Moturu**, Civil department, VR Siddhartha Engineering College, Vijayawada, India. Email: tejsaimoturu@gmail.com
**Haroon Ali Khan**, Civil department, VR Siddhartha Engineering College, Vijayawada, India. Email: haroonalikhan1323@gmail.com
**Dr.Chava Srinivas**, Civil department, VR Siddhartha Engineering College, Vijayawada, India. Email: chavasrinivas@yahoo.co.in

## II. MATERIALS AND TESTS

### A. Materials

The materials used for this study were mentioned in the Table.1.

**Table- I: Materials adopted**

| | |
|---|---|
| Cement | OPC 53 grade. |
| Coarse aggregate (CA) | HBG Stone of size 20mm as per IS-383 specifications. |
| Fine aggregate (FA) | River Sand confirming to zone-II as per IS-383 specifications |
| Bottom ash | Bottom ash generated at the Vijayawada thermal power station |
| Steel fibers | Corrugated fibers of aspect ratio 70 (17.5mm long and 0.25mm diameter) |

### B. Tests on materials

I. Cement:

**Table- II: Test results of cement**

| | | |
|---|---|---|
| Specific gravity | | 3.05 |
| Initial setting time | | 45 mins |
| Final setting time | | 210 mins |
| Fineness | | 5.0% |
| Consistency | | 29% |
| Compressive strength | 7 days | 34.4 N/mm$^2$ |
| | 28 days | 44.2 N/mm$^2$ |

II. Fine aggregate (FA)

**Table- III: Test results of FA**

| | |
|---|---|
| Specific gravity | 2.65 |
| Fineness modulus | 3.0 |
| Zone | II |

III. Coarse Aggregate (CA)

**Table- IV: Test results of CA**

| | |
|---|---|
| Specific gravity | 2.90 |
| Fineness modulus | 5.8 |
| Water absorption | 0.7% |

IV. Bottom Ash

**Fig .1. Bottom Ash**

**Table- V: Test results of Bottom ash**

| | |
|---|---|
| Specific gravity | 2.10 |
| Fineness modulus | 2.56 |

V. Steel Fibers

**Fig .2. Steel Fibers**

**Table- VI: Properties of Steel fibers**

| | |
|---|---|
| Fiber type | Hooked end type |
| Length of fiber | 17.5mm |
| Diameter | 0.25 mm |
| Aspect ratio | 70 |
| Tensile strength | 1020 N/mm$^2$ |

### C. Mix Proportion

The following mix proportion was adopted.

**Table- VII: Mix proportion details**

| Materials | Cement (kg/m$^3$) | FA (kg/m$^3$) | CA (kg/m$^3$) | Water (kg/m$^3$) |
|---|---|---|---|---|
| Quantity | 394 | 648.8 | 1254.6 | 197 |
| Proportion | 1 | 1.64 | 3.18 | 0.5 |

## III. RESULT AND DISCUSSION

Various properties of fresh and hardened concrete were studied and the results were provided in tabular and graphical forms.

### A. Workability

Concrete workability was done by slump cone test. Tables VIII, IX and Fig. 3 and 4 shows the slump values obtained for various mixes.

**Table- VIII: Slump SF1%**

| Mix Designation | Slump (mm) |
|---|---|
| B0%SF1% | 82 |
| B10%SF1% | 74 |
| B20 %SF1% | 66 |
| B30 %SF1% | 60 |
| B40 %SF1% | 48 |

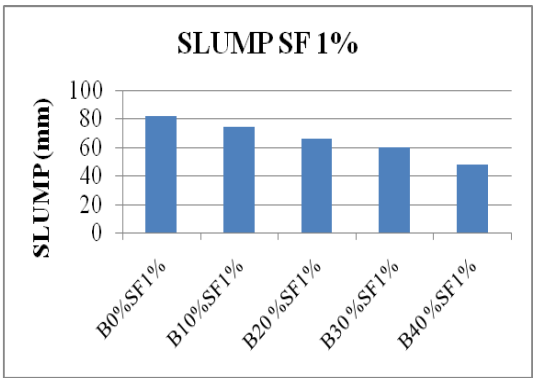


**Fig. 3. Slump SF1%**

The above figure shows slump variations in concrete having 0% bottom ash and 1% steel fibers

**Table- IX: Slump SF1.5%**

| Mix Designation | Slump (mm) |
|---|---|
| B0%SF1.5% | 75 |
| B10%SF1.5% | 62 |
| B20 %SF1.5% | 55 |
| B30 %SF1.5% | 40 |
| B40 %SF1.5% | 35 |

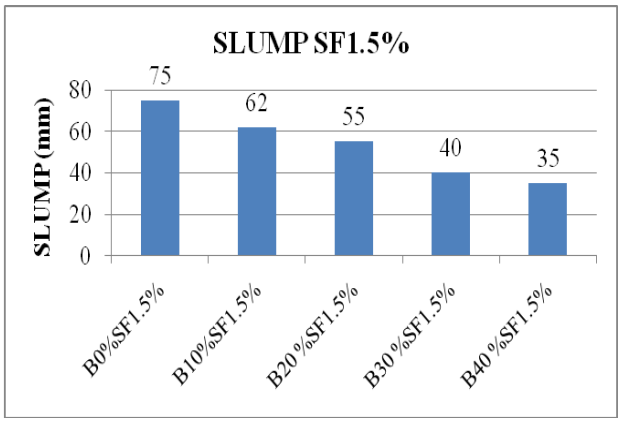


**Fig. 4. Slump SF1.5%**

Above figure shows slump variations in concrete having bottom ash and 1.5% steel fibers.

### B. Cube Strength

Cubes of 150mm X 150mm X 150mm were casted and tested. Tables X, XI and Fig. 5 and 6 shows cube strength of various specimens at 7 and 28 days.

**Table- X: Cube strength with SF1%**

| Mix Designation | Compressive Strength (N/mm$^2$) | |
|---|---|---|
| | 7 days | 28 days |
| B0%SF1% | 28.74 | 33.77 |
| B10%SF1% | 29.03 | 39.25 |
| B20 %SF1% | 27.62 | 35.85 |
| B30 %SF1% | 26.07 | 34.44 |
| B40 %SF1% | 25.92 | 33.03 |

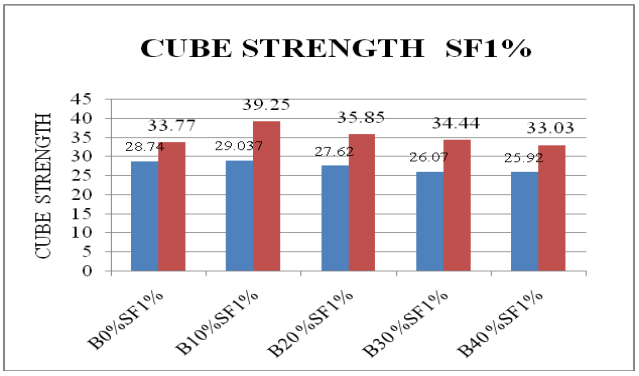


**Fig. 5. Cube strength with SF1%**

Compressive strength of concrete with 10% bottom ash and steel fibers of 1.5% at 7 days is more and there is less percentage increase at 30 and 40 % of replacement and compressive strength with 10% bottom ash and steel fibers of 1% is more at 28 days also while compared with other percentages of bottom ash. Concluded that from above graph bottom ash 10% and steel fibers of 1% is optimum.

**Table- XI: Cube strength with SF1.5%**

| Mix Designation | Compressive Strength (N/mm$^2$) | |
|---|---|---|
| | 7 days | 28 days |
| B0% SF1.5% | 28.00 | 32.90 |
| B10%SF1.5% | 30.55 | 40.28 |
| B20 %SF1.5% | 29.72 | 39.80 |
| B30 %SF1.5% | 28.56 | 37.55 |
| B40 %SF1.5% | 25.52 | 35.59 |

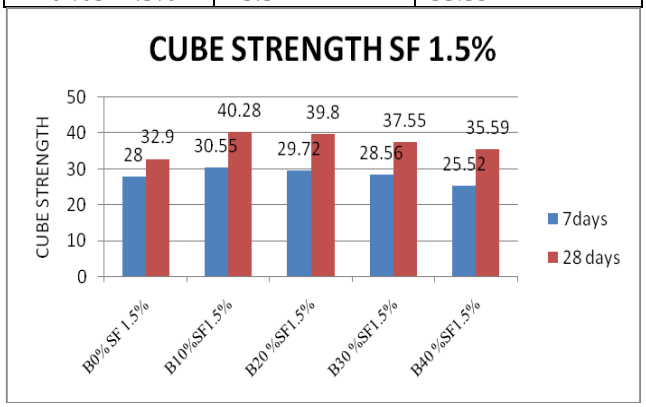


**Fig. 6. Cube strength with SF1.5%**

Concluded that from above graph bottom ash 10% and steel fibers of 1% is optimum.

### C. Split Tensile Strength

Cylinders specimen of size 300mm height and 150mm diameter were casted to evaluate the split tensile strength. Tables XII, XII and Fig. 7 and 8 shows split tensile strength of various specimens at 7 and 28 days.

**Table- XII: Split tensile strength with SF1%**

| Mix Designation | Split Tensile Strength (N/mm$^2$) | |
|---|---|---|
| | 7 days | 28 days |
| B0%SF1% | 2.30 | 2.88 |
| B10%SF1% | 2.59 | 3.05 |
| B20 %SF1% | 2.93 | 3.11 |
| B30 %SF1% | 2.63 | 3.06 |
| B40 %SF1% | 2.21 | 2.85 |

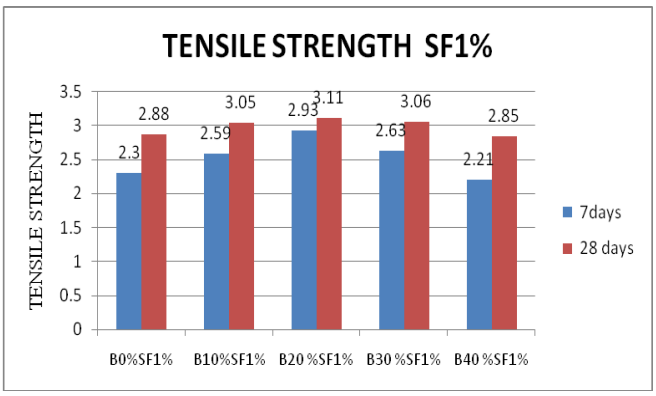


**Fig. 7. Split tensile strength with SF1%**

Tensile strength of concrete with 20% bottom ash and steel fibers of 1% at 7 & 28 days is more. So it is concluded that from above graph bottom ash 20% and steel fibers of 1% is optimum for tensile strength.

**Table-XIII: Split tensile strength with SF1.5%**

| Mix Designation | Split Tensile Strength (N/mm$^2$) | |
|---|---|---|
| | 7 days | 28 days |
| B0%SF1.5% | 2.50 | 2.90 |
| B10%SF1.5% | 2.92 | 3.95 |
| B20 %SF1.5% | 2.83 | 3.9 |
| B30 %SF1.5% | 2.80 | 3.82 |
| B40 %SF1.5% | 2.92 | 3.90 |

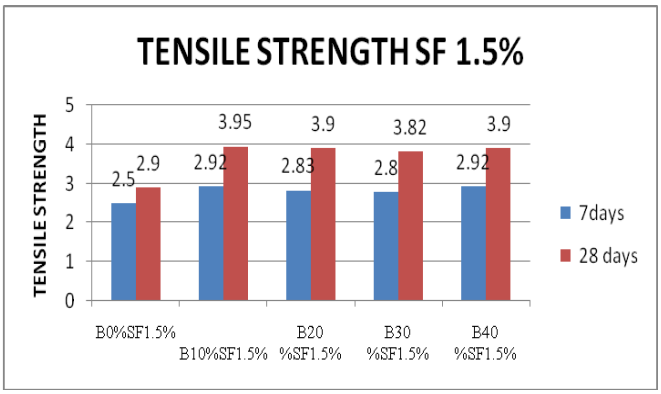


**Fig. 8.Tensile strength with SF1.5%**

So it is concluded that from above graph bottom ash 20% and steel fibers of 1.5% is optimum for tensile strength. The tensile strength at 40% replacement of bottom ash has obtained the same.

### D. Flexural Strength

Beams 100mm x100mm and 500mm length were casted for 7 & 28 days. Tables XIV, XV and Fig. 9 and 10 shows split tensile strength of various specimens at 7 and 28 days.

**Table- XIV: Flexural strength with SF1%**

| Mix Designation | Flexural Strength (N/mm$^2$) | |
|---|---|---|
| | 7 days | 28 days |
| B0%SF1% | 4.62 | 6.66 |
| B10%SF1% | 4.89 | 6.80 |
| B20 %SF1% | 4.80 | 6.88 |
| B30 %SF1% | 4.69 | 6.95 |
| B40 %SF1% | 4.55 | 6.53 |

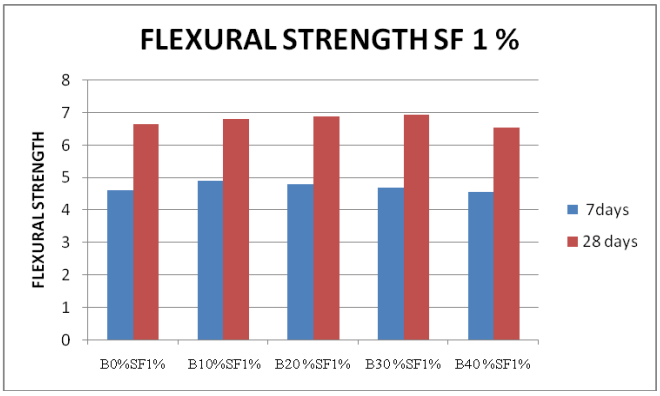


**Fig. 9. Flexural strength with SF1%**

From above Graph flexural strength of concrete with 30% bottom ash and steel fibers of 1% at 7 & 28 days is more. It is concluded that bottom ash 30% and steel fibers of 1% is optimum for flexural strength.

**Table- XV: Flexural strength with SF1.5%**

| Mix Designation | Flexural Strength (N/mm$^2$) | |
|---|---|---|
| | 7 days | 28 days |
| B0%SF1.5% | 4.55 | 6.20 |
| B10%SF1.5% | 4.75 | 6.55 |
| B20 %SF1.5% | 4.40 | 6.62 |
| B30 %SF1.5% | 4.69 | 6.75 |
| B40 %SF1.5% | 4.50 | 6.66 |

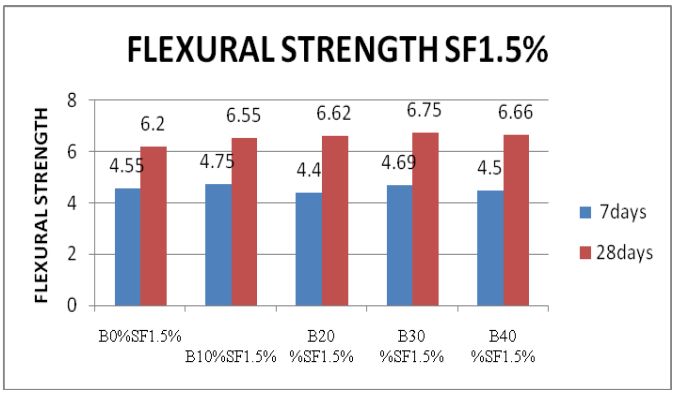


**Fig. 10. Flexural strength with SF1.5%**

It is observed the 30% replacement and steel fibers of 1.5% is optimum.

## IV. CONCLUSION

The following conclusions were drawn from the above results and discussions:

- Workability of concrete has been reduced with increased percentage of bottom ash content and steel fiber.
- The compressive, split tensile and flexural strength of concrete for both 7 and 28 days with various replacement percentages of bottom ash have achieved target strength, but at 40% replacement of bottom ash and 1% steel fibers is maintained equal to conventional concrete.
- Concluded that the optimum percentage of bottom ash is 10% for cube strength and at 1.5% steel fibers for flexural strength.

## ACKNOWLEDGMENT

We are thankful to our Organization V R Siddhartha Engineering College for providing all the resources for successful completion of this research without any obstacles.

## REFERENCES

1. Abdul Hameed Umar Abu-Bakr and Khairul Salleh Baharudin, "Properties of Concrete Using Tan Jung Bin Power Plant Coal Bottom Ash and Fly Ash", International Journal of Sustainable Construction Engineering & Technology (IJSCET), ISSN: 2180-3242, Volume 3, Issue 2, 2012, pp.56-69.
2. P. Aggarwal, Y. Aggarwal and S.M. Gupta, "Effect of Bottom ash as replacement of fine aggregates in concrete", Asian Journal of Civil Engineering(Building and Housing) (AJCE), ISSN: 1563-0854, Volume 8, No. 1, 2007, pp.49-62.
3. Mohd Syahrul Hisyam bin Mohd Sani, Ahmad Rasidi Osman, Fadhluhartini bt Muftah, Comparison Study of Bottom Ash Aggregate and Washed Bottom Ash Aggregate in Concrete: Physical Aspec 2011 IEEE Symposium on Business, Engineering and Industrial Applications (ISBEIA), Langkawi, Malaysia t

4. Phanikumar BR, Sofi A, Effect of pond ash and steel fibre on engineering properties of concrete, Ain Shams Eng J (2015), http://dx.doi.org/10.1016/j.asej.2015.03.009
5. 'R.VRanganathA11BBhattacharjeeASKrishnamoorthy A'Influence of Size Fraction of Ponded Ash on its Pozzolanic Activity,volume8,Issue 5,Pg749-761, https://doi.org/10.1016/S0008-8846(98)00036-2
6. P. Tang, Q.L. Yu, R. Yu and H.J.H. Brouwers, "The application of MSWI bottom ash fines in high performance concrete", 1st International Conference on the Chemistry of Construction Materials, Berlin, October 2013, pp.435-438
7. Dhiraj kumar Lala Aniruddha Chatterjeeb Arun kumar Dwivedi, Investigation of properties of cement mortar incorporating pond ash – An environmental sustainable material https://doi.org/10.1016/j.conbuildmat.2019.03.049
8. Deepak Gupta, Arvind Kumar, ' Performance evaluation of cement-stabilized pond ash-rice husk ash-clay mixture as a highway construction material. https://Doi: 10.1016/j.jrmge.2016.05.010
9. Andrade LB, Rocka JC, Cheriaf M., Influence of coal bottom ash as fine aggregate on fresh properties of concrete. Construction and Building Materials 2009;23:609–14.
10. Isaia GC, Gastaldini A, Moraes R., Physical and pozzolanic action of mineral additions on the mechanical strength of high-performance concrete. Cem Concr Compos 2003;25(1):69–76.
11. IS 456-2000 code of practice for reinforced concrete sections
12. IS10262-2012 code of mix design methods.

## AUTHORS PROFILE

**Sujatha Takkellapati** is currently working as Asst professor,V R Siddhartha Engineering College.Her area of interest is Experimental work on concrete .She has recived M,tech ,Structural Enginnering.

**Tej Sai Moturu** is currently working as Assistant Professor in V R Siddhartha Engineering College has completed his M.Tech in 2014. He has 5 years of experience in academics and 4 publications in various journals.

**Haroon Ali Khan** has completed his Masters in Texas A&M University, Kingsville in the year 2016. He is working as Assistant in V R Siddhartha Engineering College.

**Dr.Chava Srinivas** has obtained Ph.D from Andhra University. He is working as Professor and Head of the Department, Civil Engineering in V R Siddhartha Engineering College.