An Experimental Study on Partial Replacement of Cement with Sugarcane Bagasse Ash and Addition of Asbestos Fibers

Rimple Jalla [1] Sourabh Lalotra[2]

[1]*PG Scholar, Sri Sai College of Engineering and Technology, Pathankot, India.*
[2]*Assistant Professor, Sri Sai College of Engineering and Technology, Pathankot, India.*

ABSTRACT: The cost of constructing a building is increasing day by day as cost of building materials are increasing, the use of any alternative material that has tendency to partially replace the building material may reduce the cost of the construction to certain level. In this research we have selected two materials Sugarcane Bagasse Ash and Asbestos Fiber for partially replacement with cement. Both the materials are easily available, renewable, and cheap. The grade of concrete on which the investigation will be performed will be M-35 grade. The main aim of this research is to check if the two above materials can be used instead of cement up to certain percentage. In this project, the workability, compressive strength, flexural strength as well as split tensile strength of conventional concrete (CC), concrete made up from Sugarcane Bagasse and Asbestos Fiber varying percentage has been studied. The compressive and the flexural strength was calculated at 3 days, 7 days and 28 days of normal curing, while the split tensile test was calculated after 7 days and 28 days of normal curing at recommended temperature. The percentage replacement for the cement with Sugarcane Bagasse Ash used is 4%, 8%, 12%, 16%, 20% and 24% by weight of cement. The addition of Asbestos Fiber used is 0.2%, 0.4%, 0.6%, 0.8%, 1.0%, and 1.2%. For calculating the compressive strength and Flexural Strength, cubes of size 150 x 150 x 150 mm and beams of size 500 x 100 x 100 mm were casted and were tested using Compression Testing Machine and Flexural Testing Machine with two-point loading. In this project the distribution of cubes and beams respectively casted are – 9 are CC, 9 are SBA (4%) with AF (0.2%), 9 are SBA (8%) with AF (0.4%), 9 are SBA (12%) with AF (0.6%), 9 are SBA (16%) with AF (0.8%), 9 are SBA (20%) with AF (1.0%), 9 SBA (24%) with AF (1.2%). For calculating the Split Tensile Strength, cylinder of size 150 mm x 300 mm was casted and were tested under Compressive Testing Machine. The distribution of cylinders casted are – 6 are CC, 6 are SBA (4%) with AF (0.2%), 6 are SBA (8%) with AF (0.4%), 6 are SBA (12%) with AF (0.6%), 6 are SBA (16%) with AF (0.8%), 6 are SBA (20%) with AF (1.0%), 6 SBA (24%) with AF (1.2%).

Keywords: Concrete, SBA – Sugarcane Bagasse Ash, AF – Asbestos Fiber, Workability, Compressive Strength, Flexural Strength, Tensile Strength.

1. INTRODUCTION

Decreasing the content of cement concrete is one of the continuing problems of 21st century global sustainability. Of all the concrete ingredients (which are the main ingredients in cement, additives that make up cement, water, and fine and coarse aggregates), cement has the biggest steps when it comes to carbon dioxide emissions and energy consumption. While the prevalence of high levels of caterpillar (greater than 50%) cement replacement by fly ash, a by-product of coal-fired residues, has been demonstrated in the laboratory and in practice, questions remain about the stability of high-level fly ash availability local deficits experienced in recent parts of the U.S. Similarly, high slag replacement compounds have shown good performance, but global supply of slag is limited compared to the annual demand for concrete for new construction and renovation. Much research is being made in which researcher aim to partially replace the cement with any product that is easily available and has impact on the environment also. These materials that researcher is trying to use instead of cement can cause environmental hazard in coming time and hence need to be taken care of at earliest. Many research has been conducted by replacing cement with brick kiln powder, waste agricultural leaves, coconut fibre, bamboo ash, chalk powder, marble waste and much more.

Cement is a green concrete. Consumption of cement has increased dramatically year by year due to infrastructure development. When cement is widely used in concrete, the risk of environmental impact on the earth increases. The problem can be solved by replacing the cement with Sugarcane Bagasse Ash. With the use of SCBA, carbon emissions will be reduced and natural resources such as limestone will not be limited to use.

Figure 1: Sugarcane Bagasse Ash and Asbestos Fiber

2. NOMINAL MIX DESIGN

Target mean strength of concrete

For a tolerance factor of 1.65 and using table 1 from IS 10262-2000, the standard deviation S = 5 N/mm^2. So, Target mean strength can be given by,

Characteristic cure strength = 35 + (5x1.65) = 43.25 N/mm^2.

Selection of water cement ratio

From table 5 from IS 456-2000, maximum water cement ratio = 0.45

Based on trial, adopt water cement ratio as 0.40

0.40 < 0.45 Hence ok.

Selection of water cement content

From table 2 of IS 10262-2009, maximum water content is 186 liter (for 75-100mm) slump range for 20 mm aggregate.

Estimate water content for (75-100mm) slump = 186 kg/m^3

Required water content = 186 + 11.16 = 197 kg/m^3

Calculation of cement content

Water cement ratio = 0.40

Water = 197 Kg/m^3

Cement = $\left[\frac{197}{0.40}\right]$

Cement content = 495 kg/m3

From table 5 of IS 456, minimum cement content,

Content for 'very severe' exposure condition = 450 Kg/m^3

Hence consider 450 Kg/m^3

Proportion of volume of coarse and fine aggregate

From table 3, of IS 10262 volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate corresponding to zone – II, and water cement ratio of 0.50 = 0.60

Volume of fine coarse aggregate = 1 – 0.62 = 0.38

3. Mix calculation

The calculations per unit volume of concrete shall be as follows;

a) Volume of concrete = 1 m^3

b) Volume of cement = $\left[\frac{mass\ of\ cement}{specific\ gravity\ of\ cement}\right] \times \left[\frac{1}{1000}\right] = \left[\frac{450}{3.15}\right] \times \left[\frac{1}{1000}\right]$ = 0.142 m^3

c) Volume of water = $\left[\frac{mass\ of\ water}{specific\ gravity\ of\ water}\right] \times \left[\frac{1}{1000}\right] = \left[\frac{197}{1000}\right]$ = 0.197 m^3

d) Volume of all in aggregate = $[a - [b + c + d]]$

= 1- [0.142 + 0.197] = 0.661 m^3

e) Mass of coarse aggregate = 0.661 x 0.62 x 2.60 x 1x 1000 = 1114.7 Kg

f) Mass of fine aggregate = 0.661 x 0.38 x 2.53 x 1000 = 635.48 kg

g) Slight Correction: Initial moisture content in fine aggregate = 1.9%

Initial water content in coarse aggregate = 0.5% and Mass of fine aggregate = 635.48 - (635.48*1.9/100) = 623.4kgs, Mass of coarse aggregate = 1114.7-(1114.7*0.5/100) = 1109.13kgs and Total water content = 197+18 = 215 litres.

Table 1: Conventional mix proportion.

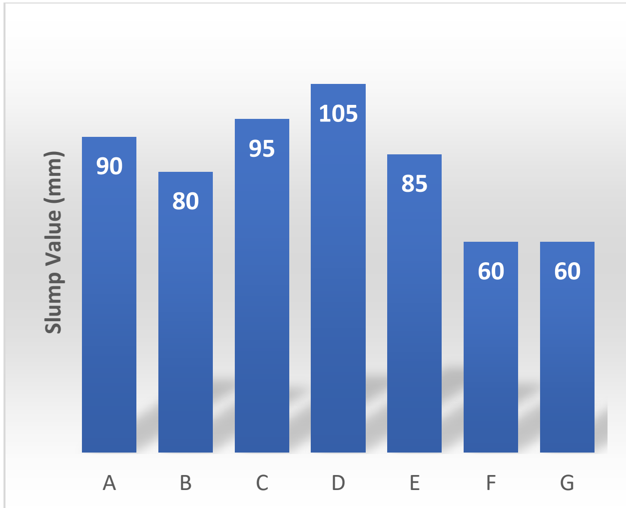
	Cement	Fine aggregate	Coarse aggregate	Water
Weight (kg/m^3)	450	623	1109	215 L
Mix Ratio	1	1.38	2.46	0.40

4. RESULTS

A. Results of Workability Tests

Table 2: Slump value for concrete mix

Sample	Replacement (%)	Addition (%)	Slump Value (mm)
A	0	0	90
B	4	0.2	80
C	8	0.4	95
D	12	0.6	105
E	16	0.8	85
F	20	1.0	60
G	24	1.2	60



Graph 1: Slump Value for concrete mix.

B. Results of Compressive Strength Test

Table 3: Compressive strength (N/mm²) values

Sample	3 Days	7 Days	28 Days
A	14.22	23.10	41.25
B	16.88	24.44	44.29
C	19.33	27.40	49.18
D	20.88	28.51	51.9
E	18.07	26.34	43.25
F	16.07	23.25	39.99
G	13.62	20.14	35.69

C. Results of Flexural Strength Test

Table 4: Flexural strength (N/mm²) values

Sample	3 Days	7 Days	28 Days
A	3.20	3.95	7.90
B	3.68	4.35	8.57
C	4.26	4.94	8.83
D	5.08	5.92	9.48
E	5.05	5.69	8.65
F	4.40	5.20	8.02
G	3.65	4.56	7.34

D. Results of Split Tensile Strength Test

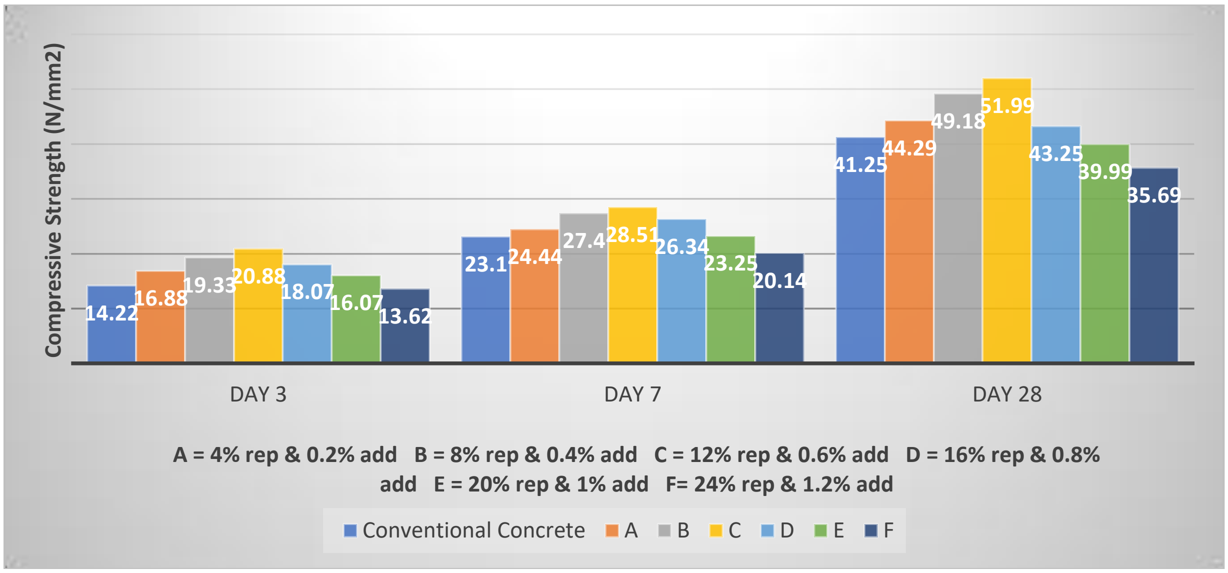
Table 5: Split Tensile strength (N/mm²) values

Sample	7 Days	28 Days
A	1.59	5.28
B	1.80	6.31
C	2.05	7.78
D	2.42	8.96

E	2.26	7.73
F	1.91	6.31
G	1.71	5.65

5. DISCUSSIONS

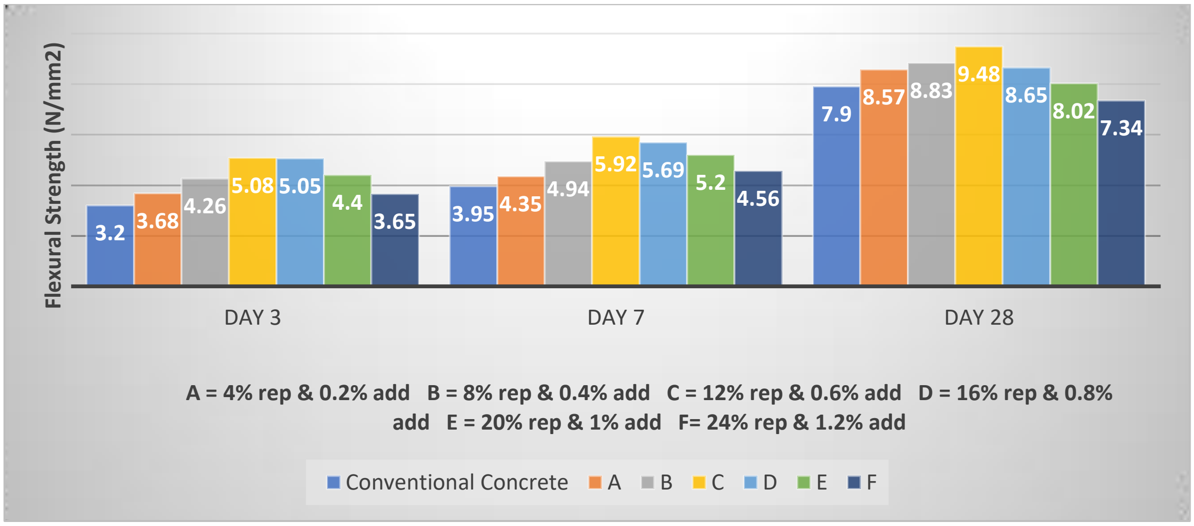
A. Comparison of Compressive Strength of Conventional Concrete with concrete containing replacements of cement with Sugarcane Bagasse Ash and asbestos fiber.



Graph 2: Comparison of Compressive Strength of Conventional Concrete with concrete containing replacements of cement with Sugarcane Bagasse Ash and asbestos fiber.

The above graph represents compressive strength comparison of conventional concrete containing replacement of cement with Sugarcane Bagasse Ash and addition with Asbestos fibers. The compressive strength of the conventional concrete after 3 days curing is 14.22 N/mm2. If we compared it with concrete containing replacement for cement, we noticed that there is an increment of 18%, 35%, and 46% for 4% replacement with 0.2% addition, 8% replacement with 0.4% addition and 12% replacement with 0.6% addition. Further increasing the percentile, the strength starts getting decreased and the optimum strength was found 20.88 N/mm2. For 16% replacement with 0.8% addition and 20% replacement with 1.0% addition the strength is around 27% and 13% higher than conventional, but on further increasing to 24% replacement and 1.2% addition the strength gets decreased by 5% on comparing with conventional concrete. After 7 days of curing the compressive strength for the conventional concrete is 23.10 N/mm2. On comparing it with other samples we found that there is increment in the percentile of 6%, 18% and 23% for replacements in samples A, B and C respectively. The optimum strength is obtained on Sample C. Beyond that the strength starts to get decreased. For Sample D and E the increment is about 14% and 0.6%, and for Sample F the strength gets decreased by 13% when compared with conventional concrete. For day 28, the conventional concrete compressive strength was found to be 41.25 N/mm2. On comparing it with other samples we found that there is increment in the percentile of 7%, 19% and 26% for replacements in samples A, B and C respectively. The optimum strength is obtained on Sample C. Beyond that the strength starts to get decreased. For Sample D the increment is about 4%. For Sample E and F the strength gets decreased by 0.3% and 13% when compared with conventional concrete.

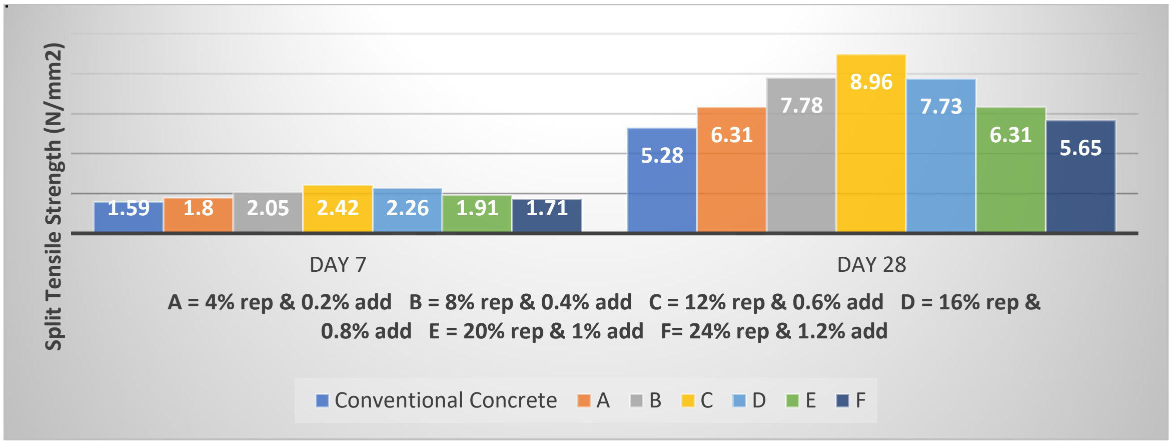
B. Comparison of Flexural Strength of Conventional Concrete with concrete containing replacements of cement with Sugarcane Bagasse Ash and asbestos fiber.



Graph 3: Comparison of Flexural Strength of Conventional Concrete with concrete containing replacements of cement with Sugarcane Bagasse Ash and Asbestos Fiber.

The above graph represents flexural strength comparison of conventional concrete containing replacement of cement with Sugarcane Bagasse Ash and addition with Asbestos fibers. The flexural strength of the conventional concrete after 3 days curing is 3.20 N/mm2. If we compared it with concrete containing replacement for cement, we noticed that there is an increment of 15%, 33%, and 58% for 4% replacement with 0.2% addition, 8% replacement with 0.4% addition and 12% replacement with 0.6% addition. Further increasing the percentile, the strength starts getting decreased and the optimum strength was found 5.08 N/mm2. For 16% replacement with 0.8% addition, 20% replacement with 1.0% addition and 24% replacement and 1.2% addition the strength is around 57%, 37% and 14% higher than conventional. After 7 days of curing the flexural strength for the conventional concrete is 3.95 N/mm2. On comparing it with other samples we found that there is increment in the percentile of 10%, 25% and 49% for replacements in samples A, B and C respectively. The optimum strength is obtained on Sample C. Beyond that the strength starts to get decreased. For Sample D, E and F the increment is about 44%, 31% and 13% respectively. For day 28, the flexural concrete strength was found to be 7.90 N/mm2. On comparing it with other samples we found that there is increment in the percentile of 8%, 11% and 20% for replacements in samples A, B and C respectively. The optimum strength is obtained on Sample C. Beyond that the strength starts to get decreased. For Sample D and E the increment is about 9% and 1%. For Sample F the strength gets decreased by 7% when compared with conventional concrete.

C. Comparison of Split Tensile Strength of Conventional Concrete with concrete containing replacements of cement with Sugarcane Bagasse Ash and asbestos fiber



Graph 4: Comparison of Split Tensile Strength of Conventional Concrete with concrete containing replacements of cement with Sugarcane Bagasse Ash and asbestos fiber

The above graph represents split tensile strength comparison of conventional concrete with other replacement materials at different percentage. The tensile strength of the conventional concrete after 7 days curing is 1.59 N/mm2. On comparing it with other samples we found that there is increment in the percentile of 13%, 29% and 52% for replacements in samples A, B and C respectively. The optimum strength is obtained on Sample C. Beyond that the strength starts to get decreased. For Sample D, E and F the increment is about 42%, 20% and 7% respectively. For day 28, the split tensile strength of concrete was found to be 5.28 N/mm2. On comparing it with other samples we found that there is increment in the percentile of 19%, 47% and 69% for replacements in samples A, B and C respectively. The optimum strength is obtained on Sample C. Beyond that the strength starts to get decreased. For Sample D, E and F the increment is about 46%, 19% and 5%.

6. CONCLUSIONS

Based on the experimental research that has been conducted following are the conclusion that could be drawn:

Addition of Sugarcane Bagasse Ash and asbestos fiber increases the workability of the concrete even at water cement ratio of 0.40. Asbestos fiber acted as a reinforcement and hence acted as resistance to the cracks, thus increasing the flexural strength. On filling up the moulds hand compaction should be opted, as to reduce the segregation of the fibre in the concrete mould. By replacing the cement with the Sugarcane Bagasse Ash and Asbestos fiber strength gets increased, also the replacement can be taken into consideration up to certain percentage, workability factors gets enhanced as well. The cost factor can be decreased by using Sugarcane Bagasse, as cement cost is increasing day by day and replacement is much needed to make concrete economical. India being largest producer of Sugarcane and every year huge tons of Sugarcane Bagasse is dumped, hence resulting in environmental hazards, so by using the waste material in concrete also improve the environment and hence the decomposition will be safe. In case of compressive strength test conducted on cubes of size 150 x 150 x 150 mm, the compressive strength increases up to certain replacement and later on starts to get decreased as well. The compressive strength of the concrete on comparing with conventional concrete gets increased till 12% of cement was replaced with Sugarcane Bagasse Ash and for reinforcement 0.6% of asbestos fiber was used. The strength obtained at 3rd day is 20.88 N/mm^2. After 7 days of curing, the maximum compressive strength obtained was 28.51 N/mm^2 for same replacements and addition. After 28 days of curing, maximum compressive strength obtained was 51.99 N/mm^2. In case of compressive strength, the optimum percentage that was noticed, was at 12% of replacement with Sugarcane Bagasse Ash and with 0.6% of addition with asbestos fiber. In case of flexural strength test conducted on beams of size 150 x 100 x 100 mm, the flexural strength increases up to certain replacement and later on starts to get decreased as well. The flexural strength of the concrete on comparing with conventional concrete gets increased till 12% of cement was replaced with Sugarcane Bagasse Ash and for reinforcement 0.6% of asbestos fiber was used. The maximum strength obtained at 3rd day is 5.08 N/mm^2. After 7 days of curing, the maximum flexural strength obtained was 5.92 N/mm^2 for same replacements and addition. After 28 days of curing, maximum flexural strength obtained was 9.48 N/mm^2. In case of flexural strength, the optimum percentage that was noticed, was at 12% of replacement with Sugarcane Bagasse Ash and with 0.6% of addition with asbestos fiber. The split tensile strength conducted on cylinder of size 150 x 300 mm. After 7 days of curing, the maximum tensile strength obtained was 2.42 N/mm^2 for same replacements and addition. After 28 days of curing, maximum tensile strength obtained was 8.96 N/mm^2. In case of tensile strength, the optimum percentage that was noticed, was at 12% of replacement with Sugarcane Bagasse Ash and with 0.6% of addition with asbestos fiber.

REFERENCES

1. Jordi Paya, Lourdes Soriano, "Waste and Supplementary Cementitious Materials in Concrete", Science Direct, 2018.

2. Qing Xu, Tao Ji, San-Ji Gao, Zhengxian Yang and Nengsen Wu, "Characteristics and Applications of Sugar Cane Bagasse Ash Waste in Cementitious Materials", MDPI, Jan 2019.

3. Laurie Kazan-Allen, "Asbestos: Properties, Uses and Problems", International Ban Asbestos Secretariat.

4. Robert L. Virta, "Asbestos: Geology, Mineralogy, Mining, and Uses", USGS.

5. B Hailu and A Dinku, "Application of sugarcane bagasse ash as a partial cement replacement material", Zede Journal, Vol. 29, 2012.

6. Sunrerng Rukzon and Prinya Chindaprasirt, "Utilization of bagasse ash in high-strength concrete", Materials & Design - Elsevier, Vol. 34, Feb. 2012.

7. R Basker, "Crack width study on Asbestos fibre RCC beams", International Journal of Structural and Civil Engineering Research, Vol. 01, Nov. 2012.

8. U.R.Kawade, V.R.Rathi and Vaishali D. Girge, "Effect of use of Bagasse Ash on Strength of Concrete", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 2, July 2013.

9. Prashant O Modani and M R Vyawahare, "Utilization of Bagasse Ash as a Partial Replacement of Fine Aggregate in Concrete", SciVerse ScienceDirect – Elsevier, 2013.

10. Samir Bauharoun, Nordine Leklou and Pierre Mounanga, "Use of asbestos-free fibre-cement waste as a partial substitute of Portland cement in mortar", ResearchGate, June 2014.

11. S Mukhopadhyay and S Khatana, "A review on the use of fibres in reinforced cementitious concrete" Journal of Industrial Textiles, April 2014.

12. A. Bahurudeen and Manu Santhanam, "Performance Evaluation of Sugarcane Bagasse Ash-Based Cement for Durable Concrete", International Conference of Durability of Concrete Structures, 2014.

13. R. A. Shuaibua, R. N. Mutuku and T. Nyomboi, "Strength Properties of Sugarcane Bagasse Ash Laterised Concrete", International Journal of Civil and Environmental Research, Aug. 2014.

14. Torres Agredo, Mejia De Gutierrez, Escandon Giraldo, And Gonzalez Salcedo, "Characterization of sugar cane bagasse ash as supplementary material for Portland cement", Ing. Investig, Vol. 34, 2014.

15. Dr.M.Vijaya Sekhar Reddy, K.Ashalatha, M.Madhuri and P.Sumalatha. "Utilization Of Sugarcane Bagasse Ash (SCBA) In Concrete by Partial Replacement of Cement", IOSR Journal of Mechanical and Civil Engineering, Dec. 2015.

16. A Bahurudeen, Deepak Kanraj, V.Gokul Dev and Manu Santhanam, " Performance evaluation of sugarcane bagasse ash blended cement in concrete", Cement and Concrete Composites – Elsevier, Vol. 59, May 2015.

17. A Bahurudeen and Manu Santhanam, "Influence of different processing methods on the pozzolanic performance of sugarcane bagasse ash", Cement and Concrete Composites – Elsevier, Vol. 56, Feb 2015.

18. Asvin Raj.K, "Experimental Study on Effect of Fibres for Reinforced Concrete", International Journal of Engineering Research & Technology, 2016.

19. E. Siva Subramanian, V.R. Vaishnave, V.T.S Vignesh, "Experimental Investigation of Concrete Composite Using Nylon Fibre", International Journal of Engineering Sciences & Research Technology, Dec. 2016.

20. G. Nithin Kumar Reddy, G. Harsha Vardhan and S. Vijaya Bhaskar Reddy, "Partial Replacement of Cement in Concrete with Sugarcane Bagasse Ash and its Behaviour in Aggressive Environments", IOSR Journal of Mechanical and Civil Engineering, 2016.

21. M.Vinodhini, K.Shanthi, B.Jose Ravindraraj, "Rc Column Strengthening By Fibres", International Journal Of Engineering Sciences & Research Technology, 2017.

22. Sajjad Ali Mangi, N Jamaluddin, M H Wan Ibrahim, Abd Halid Abdullah, A S M Abdul Awal, Samiullah Sohu and Nizakat Ali, "Utilization of sugarcane bagasse ash in concrete as partial replacement of cement", IOP Conference Series: Materials Science and Engineering, 2017.

23. Lathamaheswari, R., Kalaiyarasan, V and Mohankumar, G, "Study on Bagasse Ash As Partial Replacement of Cement in Concrete", International Journal of Engineering Research and Development, Vol 13, Issue 1, Jan 2017.

24.https://www.researchgate.net/figure/Physical-and-chemical-properties-of-selected-asbestos-fibers-1-2-8_tbl1_220048035

25. https://inspectapedia.com/hazmat/Rosato_Table_2.1s.jpg

26. https://www.wikipedia.org/

27. A textbook on Concrete Technology Theory and Practice by M.S. Shetty.

28. A textbook on Materials Science and Engineering by William Callister.

29. IS 456-2000, Code of Practice for Plain and Reinforced Concrete, Bureau of Indian Standards, New Delhi,India.

30. IS 1199-1959, Methods of Sampling and Analysis of Concrete, Bureau of Indian Standards, New Delhi,India.

31. IS 10262-1982, Recommended Guidelines for Concrete Mix Design, Bureau of Indian Standards, New Delhi,India.

32. IS 516-1959, Indian standard methods of tests for strength of concrete, Bureau of Indian Standards, New Delhi,India.

33. IS 8112:1989, 43 Grade Ordinary Portland cement Specification (First Revision), IS 8112:1989, Bureau of Indian Standards, NewDelhi.

34. IS 10262. (2009). Concrete mix proportioning. New Delhi:BIS

35. IS 8112. (2013). Ordinary Portland cement, 43 grade specification. NewDelhi: BIS

36. IS 4031 (Part-4). (1988). Determination of consistency of standard cement paste. New Delhi: BIS.

37. IS 516. (1959). Methods of tests for strength of concrete. New Delhi:BIS