UTILIZATION OF SUGARCANE BAGASSE ASH & RECYCLED COARSE AGGREGATE AS A PARTIAL REPLACEMENT IN CONCRETE

P. SAILU[1], J. SUMA SREE[2]

[1]PG student, Department of Civil Engineering, Gayatri vidya parishad college of Engineering(A), Visakhapatnam-530048, India

[2]Assistant professor, Department of Civil Engineering, Gayatri vidya parishad college of Engineering(A), Visakhapatnam-530048, India

---

Abstract—*Population growth results in increasing the demand of construction materials like cement and aggregate which leads to research all over the world to develop sustainable materials like utilizing industrial waste and demolished waste as a source of raw materials. Sugar cane bagasse ash, the by-product of sugarcane contains alumina and silica, which is a fibrous material. Using recycled aggregate in concrete can be useful for environmental protection and also for the future. Recycled aggregate can be replaced up to 30%. Cement is partially replaced with 0%, 6%, 7%, 8%, 9%, 10%, 11%, & 12%bagasse ash by weight. The w/c ratio in all the mixes was kept at 0.45. The fresh concrete tests such as compaction factor and slump cone tests were undertaken as well as hardened concrete tests are performed. Using the combination of SCBA and RCA up to 10% SCBA, and 25% RCA gives the higher strength of 48.59N/mm^2 at 56days.*

Key words: Sugarcane Bagasse Ash (SCBA), Recycled Coarse Aggregate (RCA), Compressive strength.

1. INTRODUCTION:

The growing worldwide generation of waste is very much worrying and requires management strategies that focus on environmental sustainability. Ordinary Portland cement, Portland pozzolana cement is the major construction material all over the world. In addition, agricultural & industrial wastes like Sugar Cane Bagasse Ash (SCBA), rice husk ash, glass powder, copper slag, hazel nutshell, ground granulated blast furnace and wheat straw ash contribute for the development of concrete by acting as pozzolanic materials. Presently, the study is to utilize SCBA, the waste from sugarcane is burned by the sugar industry of temperature 600-800^{0}C, therefore ash is produced containing high amounts of amorphous silica and alumina [16] which have pozzolanic properties [18]. As a result, SCBA can be replaced as cement material which improves concrete properties such as workability and strength [19]. So, it can be used as supplementary cementitious material in concrete [6]. The investigation was initiated by Glus hge in Russia in 1946 on recycled waste concrete. In the 1970s the people located in populated areas started refusing broken concrete for landfills so the construction industry thought of using the refused broken concrete therefore started crushing it to make an aggregate for use in new concrete. The recycled concrete aggregate, produced by crushing concrete from demolished concrete structures can be a solution to this problem. Use of RCA can reduce the cost of coarse aggregate and it decreases CO_2 emissions associated with aggregate transportation & therefore it reduces landfills [16]. RCA increases the drying shrinkage, creep & porosity to water and decreases the compression strength of concrete when compared to that of natural aggregate concrete. It can be replaced with nearly 10-30% of natural aggregate [5].

Various research works have reviewed the physical properties and mechanical properties of SCBA and RCA. SCBA can be replaced up to 15% as cement substitution which gives better strength compared to normal concrete and also it is a pozzolanic material is studied from **Lavanya M R et al (2012)**. SCBA in concrete as a partial replacement of cement up to 10% can gives the best results compared to conventional concrete and also it helps in increasing the resistivity towards attack like sulphate is observed from **G Nitin Kumar Reddy et al**.RCA in making concrete the Mix design methodology depends up on water absorption as well as density of aggregate since these properties depend on the adhered mortar content. Some Research works on RCA have concluded that if the aggregate contains adhered mortar more than 65% on concrete it may not be evaluated and also, they concluded that 25%-30% may not have any effect on concrete properties gives information by **Pathak et at (2009)** .Use of RCA up to 30% may not affect the functional requirement of the structure. Due to use of RCA in construction, it reduces the cost and transportation of natural resources is found from **Dr Sunil et al (2013).** It is suggested that coarse aggregate can be replaced up to 30% RCA, cement can be advantageously replaced with SCBA up to maximum limit of 15%feasible from their research Suriya **M et al (2018).**

2. EXPERIMENTAL PROGRAM

2.1 Materials:

The details of the materials which are used in this experimental program are explained below.

2.2 Cement

Ordinary Portland Cement (OPC) of 53grade conforming to Indian standard code IS:12269 was used in concrete. The physical properties of cement are mentioned in table1.

2.3 Sugarcane Bagasse Ash (SCBA)

Sugarcane bagasse ash is black in colour. The ash collected is sieved through IS standard size sieve 90µm. SCBA contains approximately 50% of cellulose, 25% of hemicellulose, and 25% of lignin. Each ton of sugarcane approximately generates 26% of bagasse, and 0.62% residual ash. The physical properties of SCBA are mentioned in Table1.

Table 1: Physical Properties of Cement and Sugarcane Bagasse Ash (SCBA)

S.NO	PROPERTIES	CEMENT	SCBA
1.	Fineness	96%	94%
2.	Specific gravity	3.09	2.18
3.	Normal consistency	32%	33%
4.	Initial setting time	35min	34min
5.	Final setting time	180min	178min

2.4 Fine aggregate

The fine aggregate used for the experimental program was locally procured and conformed to Indian Standard Specifications IS: 383-1970 to Zone II. The fine aggregate belongs to zone II. The properties of fine aggregate were tabulated in table 2.

Table 2: Physical Properties of Fine Aggregate

S.NO	PROPERTY	FINE AGGREGATE
1.	Specific gravity	2.64
2.	Fineness modulus	3.08
3.	Water absorption (%)	0.6
4.	Compacted Bulk density (gm/cc)	2.0
5.	Loose Bulk density(gm/cc)	1.8

2.4. Coarse aggregate (CA)

Crushed granite aggregate with a maximum size of 20mm, has been used and two fractions of CA 20mm&10mm are used and are tested as per IS 383-1970. The physical properties are mentioned in Table 3.

2.5. Recycled coarse aggregate (RCA)

The RCA is from demolished building concrete consisting of crushed stone aggregate with old mortar adhering to it. Various techniques of processing the wastes and effects on the properties of concrete are to be explored. The properties of recycled concrete aggregate are mentioned in Table 3.

Table 3: Physical Properties of Coarse Aggregate

S.NO	PROPERTIES	CONVENTIONAL CA	RCA
1.	Fineness	7.89	5.85
2.	Specific gravity	2.67	2.57
3.	Water absorption (%)	0.62	1.02
4.	Crushing stone (%)	27	21
5.	Impact strength (%)	10.3	14.6

3. PREPARATION OF MIX

Sugarcane bagasse ash and recycled coarse aggregate were used for this study. Mix design of concrete was done as per IS 10262:2009 and the mix ratio is mentioned in Table 5.

The replacement level of cement by SCBA was selected as 0% (control mix), 6%, 7%, 8%, 9%, 10%, 11% and 12% for specimens and constant w/c ratio in all mixes was considered as 0.45 for M30 grade.

Similarly, the replacement level of coarse aggregate by RCA was selected as 0% (control mix), 25%, 45%, 50%, 55%, and 75%for specimens and constant w/c ratio in all mixes was considered as 0.45 for M30 grade.

Mix details of SCBA and RCA were mentioned in Table 4. Based on the compressive strength of the percentage replacement level of SCBA and RCA, the maximum and minimum values were used together for this study. 150mmx150mmx150mm cube moulds were used to cast the specimen and a vibrating table was employed. 3 cubes were cast and its compressive strength is tabulated at 7, 28, and 56 days.

TABLE 4: Mix Details

Mix Designation	Cement (kg/m3)	Fine Aggregate (kg/m3)	SCBA (kg/m3)	Coarse Aggregate (kg/m3)	RCA (kg/m3)	w/c ratio	Water (kg/m3)
M0	390.55	705.96	-	833.5	-	0.45	197.16
S1 (6%SCBA)	367.17	705.96	23.433	833.5	-	0.45	197.16
S2 (7%SCBA)	363.2	705.96	27.33	833.5	-	0.45	197.16
S3 (8%SCBA)	359.30	705.96	31.24	833.5	-	0.45	197.16
S4 (9%SCBA)	355.4	705.96	35.14	833.5	-	0.45	197.16
S5 (10%SCBA)	351.49	705.96	39.055	833.5	-	0.45	197.16
S6 (11%SCBA)	347.5	705.96	42.96	833.5	-	0.45	197.16
S7 (12%SCBA)	343.68	705.96	46.86	833.5	-	0.45	197.16
R1 (25%RCA)	390.55	705.96	-	625.12	208.37	0.45	197.16
R2 (45%RCA)	390.55	705.96	-	458.07	375.07	0.45	197.16
R3 (50%RCA)	390.55	705.96	-	416.75	416.75	0.45	197.16
R4 (55%RCA)	390.55	705.96	-	375.07	458.42	0.45	197.16
R5 (75%RCA)	390.55	705.96	-	208.97	625.12	0.45	197.16
S5&R1 (10%RCA&25% RCA)	351.49	705.96	39.055	625.12	208.37	0.45	197.16
S5&R2 (10%RCA&45% RCA)	351.49	705.96	39.055	458.07	375.07	0.45	197.16
S6&R1 (11%RCA&25% RCA)	347.5	705.96	42.96	625.12	208.37	0.45	197.16
S6&R2 (11%RCA&45% RCA)	347.5	705.96	42.96	458.07	375.07	0.45	197.16

TABLE 5: Mix Ratio

Water (kg/m³)	Cement (kg/m3)	Fine aggregate (kg/m³)	Coarse aggregate (kg/m³)
197.16	390.55	705.96	833.5
0.45	1	1.80	2.13

4. RESULTS & DISCUSSION

Concrete cubes of size 150mmx150mmx150mm are casted for different ages, the results are shown below

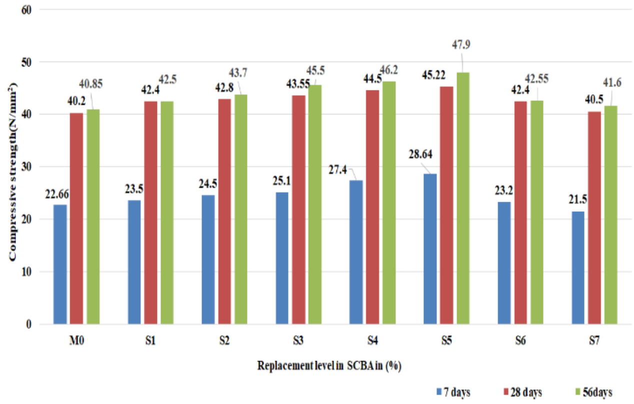

Fig.1.VARIATION OF COMPRESSIVE STRENGTH USING SCBA

By comparing the above results from the Fig.1, for 7days, 28days, &56day of constant water cement ratio with 10% replacement of cement with sugarcane bagasse ash the compressive strength increases to 28.64 N/mm², 45.22 N/mm², 47.9N/mm² gives the higher value when compared to conventional concrete. Further increasing the %replacement level causes a decrease in compressive strength of concrete.

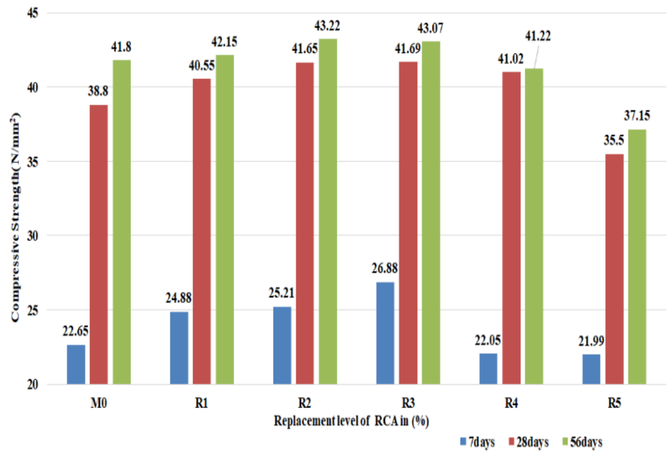

Fig.2.VARIATION OF COMPRESSIVE STRENGTH USING RCA

By comparing the above results from Fig.2, for 7days,28days&56days of constant water cement ratio with 50% replacement of aggregate with recycled coarse aggregate the compressive strength increases to 28.64N/mm², 45.22 N/mm², 47.9N/mm² gives the higher value when compared to conventional concrete. Further increasing the %replacement level causes a decrease in compressive strength of concrete.

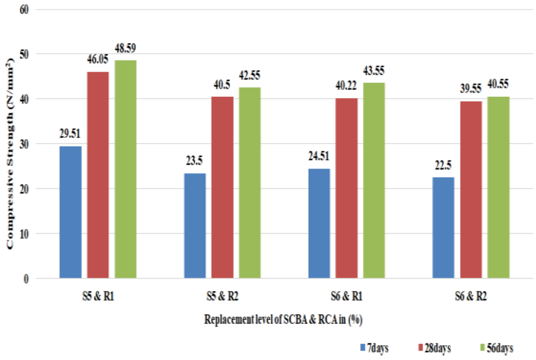

Fig.3.VARIATION OF COMPRESSIVE STRENGTH USING SCBA & RCA

The SCBA gives the best result up to 10%, and similarly the RCA gives the best result up to 50%. By comparing, the above results from the Fig.3. So using the combination of SCBA and RCA with constant water cement ratio for 7days, 28days, &56days the %replacement level of 10%SCBA, and 25%RCA gives the higher value of 29.51N/mm^2, 46.05N/mm^2, 48.59N/mm^2 when compare to nominal mix, and 10%SCBA, & 45%RCA, 11%SCBA, & 25%SCBA, and 11%SCBA, & 45%RCA the % replacement level decrease the value. So therefore, up to 10%SCBA, and 25%RCA combination is feasible.

5. CONCLUSIONS

From the present investigations, the results are concluded as

i) At 10% replacement of cement with sugarcane bagasse ash, the compressive strength of concrete at 56days which is 47.9N/mm^2 is higher when compared to nominal mix which is 40.85N/mm^2.

ii) At 50% replacement of coarse aggregate with recycled coarse aggregate, the compressive strength of concrete at 56days which is 44.5N/mm^2.

iii) When compared with a nominal mix, the compressive strength of concrete increases for replacement of cement with sugarcane bagasse ash up to 10%. There is a decrease in compressive strength beyond 10% replacement of cement with sugarcane bagasse ash.

iv)When compared with nominal mix, the compressive strength of concrete increases for replacement of coarse aggregate with recycled coarse aggregate up to 50%. There is a decrease in compressive strength beyond 50% replacement of coarse aggregate with recycled coarse aggregate.

v) The combination of SCBA and RCA which is 10%scba and 25%rca give the strength of 48.59N/mm^2 at 56days which is higher when compared to the other combinations. Therefore, use of SCBA up to 10% and RCA up to 25% is feasible.

6. References

1. Amin, N. U. (2011). “Use of bagasse ash in concrete and its impact on the strength and chloride resistivity”. Journal of materials in civil engineering, 23(5), 717-720.

2. Butler, L., West, J. S., & Tighe, S. L. (2013). “Effect of recycled concrete coarse aggregate from multiple sources on the hardened properties of concrete with equivalent compressive strength”. Construction and Building Materials, 47, 1292-1301.

3. Bhutta, M. A. R., Hasanah, N., Farhayu, N., Hussin, M. W., bin Md Tahir, M., & Mirza, J. (2013). “Properties of porous concrete from waste crushed concrete (recycled aggregate)”. Construction and building materials, 47, 1243-1248.

4. Çakır, Ö., & Sofyanlı, Ö. Ö. (2015). “Influence of silica fume on mechanical and physical properties of recycled aggregate concrete”. HBRC Journal, 11(2), 157-166.

5. Dr. Sunil S. Pimplikar (2013). “Use of Recycled Aggregate in Concrete” .International Journal of Engineering Research & Technology (IJERT), 2(1), 1-9.

6. Ganesan, K., Rajagopal, K., & Thangavel, K. (2007). “Evaluation of bagasse ash as supplementary cementitious material”. Cement and concrete composites, 29(6), 515-524.

7. Gursimran Singh, Nirbhay Thakur & Nitish Kumar Sharma (2019). “Experimental Research on the Strength Parameters of Concrete using Sugarcane Bagasse Ash, Marble Waste Powder and Recycled Concrete Aggregate”, International Journal of Innovative Technology and Exploring Engineering (IJITEE), (Vol.8 no.8, pp.2278-3075)

8. IS 456: 2000, “Indian Standard, Plane and reinforced concrete - Code of practice”, Bureau of Indian Standards, New Delhi.

9. IS 516:1959, "Method of Tests for Strength of concrete", Bureau of Indian Standards, New Delhi, India.

10. IS 383 -1970, "Specifications for Coarse and Fine Aggregates from Natural Sources for Concrete", Bureau of Indian Standards, New Delhi, India.

11. IS 12269-1987," Specification for 53 Grade Ordinary Portland Cement", Bureau of Indian Standards, New Delhi, India.

12. IS 10262 -2009 "IS Method of Mix Design", Bureau of Indian Standards, New Delhi, India.

13. Lavanya, M., B. Sugumaran, and T. Pradeep. "An Experimental study on the compressive strength of concrete by partial replacement of cement with sugarcane bagasse ash." **International Journal of Engineering Inventions 1**, no. 11 (2012): 2319-6491.

14. Mangi, S. A., Jamaluddin, N., Ibrahim, M. W., Abdullah, A. H., Awal, A. S. M. A., Sohu, S., & Ali, N. (2017, November). "Utilization of sugarcane bagasse ash in concrete as partial replacement of cement". **In IOP Conference Series: Materials Science and Engineering** (Vol. 271, No. 1, pp. 1-8). IOP Publishing.

15. Opara, H. E., Eziefula, U. G., & Ugwuegbu, C. C. (2016). "Experimental study of concrete using recycled coarse aggregate". **International Journal of Materials and Structural Integrity**, 10(4), 123-132.

16. Payá, J., Monzó, J., Borrachero, M. V., Díaz-Pinzón, L., & Ordonez, L. M. (2002). Sugar-cane bagasse ash (SCBA): "studies on its properties for reusing in concrete production". **Journal of Chemical Technology & Biotechnology: International Research in Process, Environmental & Clean Technology**, 77(3), 321-325.

17. Pandurangan, K., A. Dayanithy, and S. Om Prakash. "Influence of treatment methods on the bond strength of recycled aggregate concrete." **Construction and Building Materials** 120 (2016): 212-221.

18. Priya, K. L., & Ragupathy, R. (2016). "Effect of sugarcane bagasse ash on strength properties of concrete". **Int. J. Res. Eng. Technol**, 5(4), 159-164.

19. POON, C. S., & CHAN, D. (2007). "The use of recycled aggregate in concrete in Hong Kong". **Resources, conservation and recycling**, 50(3), 293-305.

20. Reddy, G. Nithin Kumar, 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 (IOSR-JMCE)** e-ISSN: 2278 1684 (2015).

21. Suriya.M, Sneha.M, Mohan kumar. G (2018). "Study on the properties of concrete with demolished wastes and sugarcane bagasse ash". **International Journal of research granthalayah** (Vol. 6, No. 3, pp.220-227).

22. Torres, A., & Burkhart, A. (2016). "Developing sustainable high strength concrete mixtures using local materials and recycled concrete". **Materials Sciences and Applications**, 7(02), 128.

23. Yadav, S. R., & Pathak, S. R. (2009). "Use of recycled concrete aggregate in making concrete–an overview".**In 34th Conference on our world in concrete & structures** (Vol. 16, pp. 18).