MECHANICAL PROPERTIES OF CONCRETE ON PARTIAL REPLACEMENT OF CEMENT WITH ACACIA NILOTICA ASH

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Abstract
Today, concrete is the most widely used construction material due to its good compressive strength and durability. Cement, fine aggregate, coarse aggregate and water are the constituents of concrete. Nowadays, many researchers have found alternative for cement due to its cost and pollution during its manufacturing process. Here in this project, Acacia Nilotica ash had been replaced for cement. Acacia Nilotica is a species of tree which has aggressive root system. Due to this, the roots are very invasive and they damage sidewalks and building foundation. It also have the property of absorbing water from the surrounding land. Not only the roots, the seeds and rhizomes of Acacia tree have also the same invading property, and it alters the nitrogen in the soil and hence causes no native plants to grow in the area. The effective use of the Acacia Nilotica ash had been considered and hence, it is used as a replacement of cement in concrete. Concrete of M30 grade were cast by replacing cement with Acacia Nilotica ash by 0%, 5%, 7.5%, 10%, 12.5%, and 15%. In this study, compressive strength, split tensile strength, modulus of rupture and flexural behaviour of concrete with varying quantity of Acacia Nilotica ash is evaluated and compared with the conventional concrete specimens.
Key words: Acacia Nilotica ash;reinforced concrete; compressive strength; split-tensile strength; flexural strength.

1. Introduction

Concrete is a construction material basically a mixture of coarse aggregate, fine aggregate and cement. Concrete plays a vital role in many structures such as buildings, bridges, canals etc. Concrete becoming an interior part of any type of construction works, the usage of concrete is becoming more due to development of construction industry. The performance of concrete depends upon the properties of aggregates in order to reduce the consumption of concrete components. Usage of pozzolan such as flyash, rice husk ash, bagasse ash, acacia nilotica ash by replacing cement at a certain amount produces good concrete. The usage of concrete is twice as compared to aluminium, plastic, wood etc. Concrete is a versatile material used in all type of structural works. Since the human advancement began in this world, man has dependably been included in some type of the development exercises, which likewise straightforwardly includes the utilization of cement concrete. In this present day world, the specialized adjustments have upset the development business and development exercises. Development industry, comprise of vertical development and flat development. Vertical development alludes to the building development and flat development alludes to the substantial development. Development of building structure like open and private structures private and non-private building structures goes under the building development. Huge numbers of the biggest and tremendous structures goes under the substantial development which incorporates structures like railroads, interstates, air terminals, harbours, dams, trenches, spans and numerous other significant open works. Different incidental speciality structures of the development business incorporate mechanical development, marine development and so on. Accordingly in development of these major and stupendous structures, expansive and overwhelming measure of cement concrete is required. Cement concrete is one of the world's most adaptable and generally utilized development material.

1.1Role of Cement in Concrete

In concrete, cement is the binding material which give good binding among aggregates and also give high strength. But for manufacturing one ton of cement the amount of CO_2 released is 1.2 ton which is hazard to environment. The amount of CO_2 released from cement manufacturing unit source contributes 8% among total CO_2 released to atmosphere. Also, the amount of electricity required to produce one ton of cement is high. The cost of one bag of cement is also high. To minimize the electricity requirement and to reduce the amount of CO_2 released to atmosphere and for economic construction, cement is going to be replaced by waste material i.e., Acacia Nilotica ash.

1.2 Acacia Nilotica Ash

Acacia, commonly known as the wattles or acacias, is a large genus of shrubs, lianas and trees in the subfamily Mimosoideae of the pea family Fabaceae. Initially it comprised a group of plant species native to Africa and Australia, with the first species A. nilotica described by Linnaeus. Controversy erupted in the early 2000s when it became evident that the genus as it stood was not monophyletic, and that several divergent lineages needed to be placed in separate genera. It turned out that one lineage comprising over 900 species mainly native to Australia was not closely related to the mainly African lineage that contained A. nilotica—the first and type species. This meant that the Australian lineage (by far the most prolific in number of species) would need to be renamed. Botanist Les Pedley named this group Racosperma, which was inconsistently adopted. Australian botanists proposed that this would be more disruptive than setting a different type species (A. penninervis) and allowing this large number of species to remain Acacia, resulting in the African lineage being renamed to Vachellia. This was officially adopted, but many botanists from Africa and elsewhere disagreed that this was necessary. Acacia Nilotica ash is an ash obtained by burning of acacia trees. It is a waste material of size less than 90μ. The specific gravity is 1.67.

1.3 Advantages of Using Acacia Nilotica Ash In Concrete

- Acacia ash has very small particles which makes the concrete highly dense and reduces the permeability of concrete.
- It is highly economical.
- Use of acacia ash is environment friendly as the waste materials from the environment are effectively being used to create quality binding materials.
- It can add greater strength to the building.
- The concrete mixture generates a very low heat of hydration which prevents thermal cracking.
- Acacia ash is resistant to acid and sulphate attacks.
- The shrinkage of acacia ash concrete is very less.
- The use of acacia ash gives concrete good workability, durability and finish.

2. Literature review

M. S. Channakeshavrao, et al., (2009), explained about Green concrete using Agro industrial waste (SCBA). In this research, physical and chemical properties of fine aggregates, coarse aggregates and SCBA was properly characterized. In this research, OPC was replaced by Bagasse ash at 0%, 5%, 10% and 25%, with the water cement ratio 0.42. Cubes of dimension 150 mm × 150 mm × 150 mm, and cylinder size 150 mm dia, 300 mm height and beams of 100 mm × 100 mm × 150 mm were cast and cured in the curing tanks. Compressive strength, tensile strength and flexural strength were tested at 7, 28, and 98 days. It was observed that compressive strength at 15% replacement of cement with SCBA at 28 days showed good strength when compared to others. Split tensile strength at 20% and 25% replacement at 28 days decreased.

R. Srinivasan and K. Sathiya (2010) had done an experimental study on bagasse ash in concrete to analyze the performance of bagasse ash as a replacement of cement in concrete works. In his experimental work, a total of 180 numbers of concrete specimens were cast. The specimens considered in this study consisted of 36 numbers of 150mm side cubes, 108 numbers of 150mm diameter and 300mm long cylinders, and 36 numbers of 750mm×150mm× 150mm size prisms. The mix design of concrete was done according to Indian Standard (IS) guidelines M_{20} grade for the granite stone aggregates and the water cement ratio was 0.48. The results showed that the SCBA in blended concrete had significantly higher compressive strength, tensile strength, and flexural strength compare to that of the concrete without SCBA. It was found that the cement could be advantageously replaced with SCBA up to maximum limit of 10%. Although, the optimal level of SCBA content was achieved with 1.0% replacement. Partial replacement of cement by SCBA increases workability of fresh concrete; therefore use of super plasticizer was not essential. The density of concrete decreased with increase in SCBA content, low weight concrete can be produced in the society with waste materials (SCBA).

Ahmed Habib, et al., (2012), discussed about the usage of Sugar cane Bagasse ash as pozzolanic cement binder. In this study, SCBA was obtained from Sudanese sugar company. In Sudan, sugar cane production was more than 70,000 tonnes per year. In this research cement and aggregates were chosen as per the British standards, Bagasse ash was properly sieved and size was less than 63 microns. Concrete cubes of size 150 mm × 150 mm × 150mm were prepared and cured. OPC was replaced with 10%, 20% and 30%, of sugar cane bagasse ash. In this study, mix design adopted was in the ratio of 1:2.33:3.5. After the proper curing of cubes, the cubes were tested for the compressive strength and results showed 10% replacement of sugar cane bagasse ash had the clear developing strength while compared to the other replacements.

Dr. B. G. Nareshkumar (2012) investigated experimentally the fresh and hardened properties of lightweight concrete using sugarcane bagasse ash (SCBA) as replacement for cement by weight at 0%, 5%, 10%, 15% and 20% and expanded polystyrene (EPS) beads as 100% replacement for coarse aggregate respectively. From the result, it was found that there was marginal increase in workability with bagasse ash content up to 10% beyond that, there was possibility of reduction in slump value. The compressive strength of lightweight concrete increased with bagasse content up to 15% and beyond that there was possibility of drastic reduction in strength and 15% bagasse ash replacement strength was slightly less than OPC based lightweight concrete at 28 days but this value was comparable. He also added that if the bagasse was burnt again at controlled temperature fineness of ash would increase and hence it would improve the fresh and hardened properties of concrete.

Abdul Kadir, et al., (2013), evaluated that the OPC could be partially replaced by the SCBA to some extent. In this 34.6kg of SCB was obtained from sugar factory and burnt at 700 degrees Centigrade and then total 2.7 kg of SCBA was obtained after passing through 45microns sieve. Chemical test was conducted on SCBA to evaluate its composition. In this study, cement was replaced with SCBA at the ratio of 0%, 10%, and 20%. In this study, 48 pieces of 100mm size cubes were cast at the mix design of 1: 1.66: 2.77. Cubes were properly cured and tested on 7, 14 and 21 and 28 days for the compressive strength results. The required compressive strength was obtained after 28 days of curing at the replacement of cement with SCBA at 10%.

U.R.Kawade (2013) investigated the effect of use of bagasse ash on strength of concrete. In his experimental work, a total of 56 numbers of concrete specimens were cast. The standard size of cube 150 mm × 150 mm × 150 mm was used. The mix design of concrete was done according to Indian Standard guidelines for M_{20}, M_{30} and M_{40} grade. Based upon the quantities of ingredient, the results showed that the SCBA concrete had significantly higher compressive strength compared to that of the concrete without SCBA. It was found that the cement could be advantageously replaced with SCBA up to maximum limit of 15%. The optimal level of SCBA content was achieved with 15.0% replacement, Partial replacement of cement by SCBA increased workability of fresh concrete, therefore use of super plasticizer was not essential.

S. Abdulkadhir (2014) in his paper conducted various physical and chemical test on SCBA for the partial replacement of cement in concrete production. He concluded that calculated target mean strength of 31.56 N/mm^2 was not achieved. This might be due to some factors like mixing, compaction etc. From the density result, the SCBA concrete can be classified as normal weight concrete. The percentage reduction in density for 10%, 20% and 30% replacement of cement with SCBA were 2.7%, 6.7% and 8.47% respectively. He concluded that the SCBA was a pozzolanic material. It had the potential to be used as a partial cement replacement material up to 20% and could contribute to the environmental sustainability.

Dr. D. B. Raijiwala (2015) studied the sugar cane bagasse ash which was taken from one of the sugar mill of South Gujarat (INDIA) used in M25 grade of concrete by replacing cement 5% by weight and compare with normal M25 grade of concrete to check the feasibility of sugar cane bagasse ash in concrete. For the experimental work, concrete cubes of size 150 mm × 150 mm × 150 mm, were prepared. The 53 grade OPC was replaced with 0% and 5% SCBA, a total of 36 concrete specimens were cast and tested. M25 Grade of concrete was adopted throughout the study with w/c ratio of 0.49. Specimens were tested for compressive strength at an interval of 7th day, 14th day, 28th day and 56th day of curing in compressive testing machine. The experimental result showed that there was increase in the strength of concrete with use of sugar cane bagasse ash. Therefore, with the use of sugar cane bagasse ash in partially replacement of cement in concrete, we can increase the strength of concrete with reduced the consumption of cement. Also it was the best use of sugar cane bagasse ash instead of land filling and this would make environment clean.

3. Scope and Objective of Work

- To study the mechanical property of concrete with partial replacement of cement with Acacia Nilotica Ash.
- The replacement of cement with Acacia Nilotica Ash is by 5%, 7.5%, 10%, 12.5% and 15%.
- To study the compressive strength of cubes, split tensile strength of cylinders and flexural strength of prisms.

4. Experimental programme

The experimental programme was designed to find the mechanical properties of concrete such as compressive strength, split tensile strength and flexural strength on partial replacement of cement with acacia nilotica ash. The details of number of specimens and size of specimens are shown in Table 1.

Table 1: *Specimen description for cubes, cylinders and prisms*

Specimen	Size of Specimen	M30 grade concrete with replacement of cement with Acacia Nilotica Ash at					
		0%	5%	7.5%	10%	12.5%	15%
Cube	150×150×150 mm	6	6	6	6	6	6
Cylinder	300×150 mm	3	3	3	3	3	3
Prism	100×100×500 mm	3	3	3	3	3	3

4.1. Materials used

4.1.1. Cement: In this investigation, cement used was 53 grade ordinary Portland cement confirming IS: 12269: 1987.

4.1.2. Coarse aggregate: Aggregate which passes through 75mm IS Sieve and retained on 4.75mm IS Sieve was used. The coarse aggregate according to IS: 383-1970 was used. Maximum coarse aggregate size used is 20 mm.

4.1.3. Fine aggregate: Aggregate obtained from a nearby river source was used as a fine aggregate. The fine aggregate conforming to zone II according to IS: 383-1970 was used.

4.1.4. Acacia Nilotica Ash: Acacia, commonly known as the wattles or acacias, is a large genus of shrubs and trees in the subfamily Mimosoideae of the pea family Fabaceae. Initially it comprised a group of plant species native to Africa and Australia, with the first species A. Nilotica described by Linnaeus. The acacia tree is burned to form ashes that are used for various construction works.

4.1.5. Water: Water used for mixing and curing shall be clean and free from oils, acids, alkalis, salts etc. The water should conform to IS 456-2000 standards. The water inside the college campus is used for this study.

4.2. Casting programme

Casting of the specimens were done as per IS:10086-1982, preparation of materials, weighing of materials and casting of cubes, cylinders, prisms. The mixing, compacting and curing of concrete are done according to IS 516: 1959. The samples of cubes, cylinders and prisms were cured for 28 days in water pond. The M30 grade of concrete is designed and the material required per cubic meter of concrete is shown in Table 2.

Table 2: *Mix Design*

	Cement	Water	Fine Aggregate	Coarse Aggregate
kg/m³	465	0.4	619.698	1157.64
Ratio	1	0.4	1.33	2.49

4.3. Testing

4.3.1 Slump Test: Slump test is the most commonly used method of measuring consistency of concrete which can be employed either in laboratory or at site of work. It does not measure all factors contributing to workability. However, it is used conveniently as a control test and gives an indication of the uniformity of concrete from batch to batch.

4.3.2. Compressive strength: The cube specimens were tested on compression testing machine.The bearing surface of machine was wiped off clean and sand or other material removed from the surface of the specimen. The specimen was placed in machine in such a manner that the load was applied to opposite sides of the cubes as casted that is, not top and bottom. The axis of the specimen was carefully aligned at the centre of loading frame. The load applied was increased continuously at a constant rate until the resistance of the specimen to the increasing load breaks down and no longer can be sustained. The maximum load applied on specimen was recorded. $f_c = P/A$, where, P is load and A is area.

4.3.3. Split tensile strength: The cylinder specimens were tested on compression testing machine.The bearing surface of machine was wiped off clean and looses other sand or other material removed from the surface of the specimen. The load applied was increased continuously at a constant rate until the resistance of the specimen to the increasing load breaks down and no longer can be sustained. The maximum load applied on specimen was recorded. $f_{split}=2P/\pi DL$, where P=load, D= diameter of cylinder, L=length of the cylinder.

4.3.4. Modulus of rupture: The beam specimens were tested on universal testing machine for two-point loading to create a pure bending. The bearing surface of machine was wiped off clean and sand or other material is removed from the surface of the specimen. The two point bending load applied was increased continuously at a constant rate until the specimen breaks down and no longer can be sustained. The maximum load applied on specimen was recorded. The modulus of rupture depends on where the specimen breaks along the span. If the specimen breaks at the middle third of the span then the modulus of rupture is given by frup. = $(WL)/(bd^2)$. If the specimen breaks at a distance of 'a' from any of the supports then the modulus of rupture is given by $f_{rup} = (3Wa)/(bd^2)$, where W = load at failure, a = crack width (mm), L = length of specimen (400mm), b = width of specimen (100mm), d=depth of specimen (100mm).

5. Results and discussion

1. For the different fractions of replacement of cement by acacia nilotica ash (0%, 5%, 7.5%, 10%, 12.5% and 15%), the results were represented in table 3, 4, 5 and 6. The graphical representation of the results is as shown in figures.

- The 7 days compressive strength value of M30 grade concrete with 5% replacement of cement with acacia nilotica ash decreased when compared with conventional concrete (M30). The compressive strength value increased for 7.5% replacement of cement when compared with 5% replacement. The compressive strength decreased further with increase in percentage of replacement.
- The 28 days compressive strength value of M30 grade concrete with 5% replacement of cement with acacia nilotica ash decreased when compared with conventional concrete (M30). The compressive strength value increased for 10% replacement of cement when compared with 5% and 7.5% replacement. The compressive strength decreased further with increase in percentage of replacement.
- The split tensile strength value of M30 grade concrete with 5% replacement of cement with acacia nilotica ash decreased when compared with conventional concrete (M30). The split tensile strength value increased for 10% replacement of cement when compared with 5% and 7.5% replacement. The split tensile strength decreased further with increase in percentage of replacement.
- The flexuralstrength value of M30 grade concrete with 5% replacement of cement

with acacia nilotica ash decreased when compared with conventional concrete (M30). The flexural strength value increased for 10% replacement of cement when compared with 5% and 7.5% replacement. The flexural strength decreased further with increase in percentage of replacement.

***Table 3:**7 days compressive strength of cube specimens*

Sl No.	M30 grade concrete with percentage replacement with acacia nilotica ash	Average Compressive Strength (N/mm²)
1	0	26.6
2	5	25.25
3	7.5	25.7
4	10	25.4
5	12.5	25.2
6	15	24.28

***Table 4:**28days compressive strength of cube specimens*

S. No.	M30 grade concrete with percentage replacement with acacia nilotica ash	Average Compressive Strength (N/mm²)
1	0	37.8
2	5	36.1
3	7.5	36.7
4	10	36.9
5	12.5	35.8
6	15	34.8

***Table 5:**Split tensile strength of cylinder specimens*

S. No.	M30 grade concrete with percentage replacement with acacia nilotica ash	Average Split tensile strength (N/mm²)
1	0	3.18
2	5	2.8
3	7.5	2.9
4	10	2.98
5	12.5	2.86
6	15	2.71

***Table 6:**Flexural strength of prism specimens*

S. No.	M30 grade concrete with percentage replacement with acacia nilotica ash	Average Flexural strength (N/mm²)
1	0	4.5
2	5	4.2
3	7.5	4.3
4	10	4.38
5	12.5	4.1
6	15	4

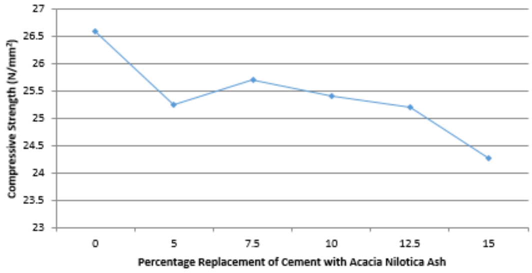

***Figure 1:**Variation of Compressive Strength at 7 days*

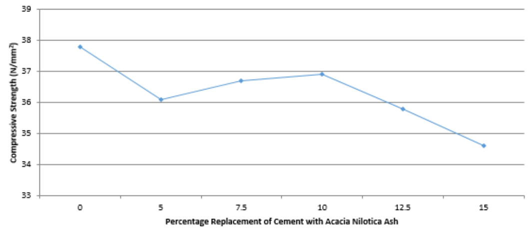

***Figure 2:** Variation of Compressive Strength at 28 days*

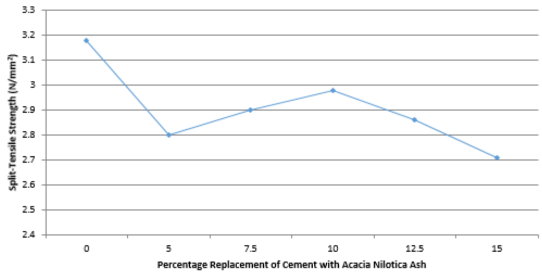

***Figure 3:**Variation of split tensile Strength*

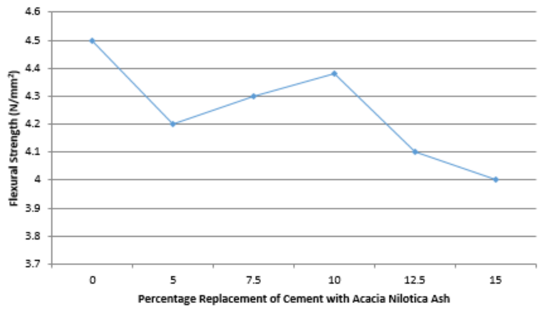

***Figure 4:**Variation of flexural strength*

6. Conclusion

1. The use of Acacia nilotica ash in concrete and their effects had been thoroughly studied from reputed journals for initiating the phase I work. The preliminary investigations were done for basic ingredients of controlled concrete and with different fractions of replacement of cement (0%, 5%, 7.5%, 10%, 12.5%, 15%) with acacia nilotica ash.

2. From the material property results, mix proportions were arrived for controlled concrete of M30 grade. Mix ratio is 1 : 1.039 : 2.21 : 0.45.

3. Compressive Strength, Split Tensile Strength and Flexural Strength test was found for controlled specimen for the verification of mix ratio.
4. The results were obtained for compressive strength, split tensile strength and flexural strength of concrete.
5. Further expansion of this project, regarding increasing the strength of concrete with partial replacement of cement by acacia nilotica ash at 10% by the addition of steel fibers should be done.

7. References

1. Harun Mallisa and Gidion Turuallo, “The maximum percentage of fly ash to replace part of Original Portland Cement in producing High Strength Concrete”, AIP Conference Proceedings 1903, 030012 (2017); doi 10.1063/1.5011519
2. Karthik M. P. and Arul Gnanapragasam A., “Experimental Study on Rice Husk Ash in Concrete by Partial Replacement” ISSN: 0974-4290, Vol.10, No.8, pp 812-819, June 2017
3. Lakshmaiah.K.N and D.Anitha, “An Experimental Study on Partial Replacement of Rice Husk Ash (RHA) With Cement of Concrete” ISSN (Online): 2319-7064, Index Copernicus Value(2015):78.96, Impact Factor (2015): 6.391
4. Prasanna and Prof. Maneeth P D, ”Experimental Investigation on Partial Replacement of Cement by Sugar Cane Bagasse Ash in Cement Concrete”, ISSN (online): 2321-0613 , Vol. 3, Issue 11, 2016
5. Pratheba.S and Deepeka.K, “An Experimental study on Bagasse ash as partial replacement forCement in Concrete” ISSN: 2395-0056 ,Volume: 05, Issue: 03, Mar-2018
6. Santosh Bharathy.V and Arun Kumar.S, “Strength Characteristics Comparision of Flyash and Acacia ash Interlocking bricks” ISSN: 1314-3395, Vol.119, No.15, 2018
7. Sathish Kumar.K and S.Dilli Babu, “Experimental Study on Partial Replacement of Cement by Palm Ash” ISSN: 0974-5645, Vol.8, November 2015
8. Subramani.T andAnbuchezian, “Experimental Study Of Palm Oil Fuel Ash As CementReplacement Of Concrete”, ISSN 2319 - 4847 Volume 6, Issue 3, March 2017
9. Vennila.R and R.Anuradha, “Compressive Strength on Interlocking Concrete Blocks With Acacia Nilotica Ash and Broken Tiles” ISSN: 0974-4290, Vol.10, No.8, pp 355-358, 2017
10. Vinod Goud and Niraj Soni, “Partial Replacement of Cement with Fly Ash In Concrete And Its Effect” ISSN: 2250-3021, Vol. 06, Issue 10(Oct. 2016)