EXPERIMENTAL INVESTIGATION OF QUARRY DUST AND ACACIA NILOTICA ASH'S PERFORMANCE IN CONCRETE

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Abstract

One of the most commonly used building materials worldwide is concrete. Concrete is made up of cement, coarse aggregates, fine aggregates, and water. Due to the price of cement and the environmental damage it causes during production, numerous researchers have discovered alternatives. Acacia Nilotica Ash had been swapped out for cement in this project. It consists of calcium, magnesium, and potassium salts and acts as a binding material. The crushing industry's waste is quarry dust that is produced in large quantities (about 200 million metric tonnes annually) and is a concentrated material in the form of dust. It serves as filler. As a result, cement and sand are used in place of acacia nilotica ash and quarry dust. Using 100% quarry dust and various concentrations of acacia nilotica ash, such as 0%, 5%, 10%, and 15%, M25 grade concrete was cast in a variety of shapes while maintaining a 0.45 for the water-to-cement ratio. This experiment examined the flexural behaviour, split tensile strength, and compressive strength of ash concrete manufactured from Acacia nilotica are evaluated and contrasted with specimens of typically used concrete.

Keywords: Acacia Nilotica ash; quarry dust; compressive strength; flexural strength and split-tensile strength.

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1. Introduction

Concrete is now used near to the water in modern construction. Cement, fine aggregate, coarse aggregate, and water make up the majority of this building material's constituents. In various structures, including buildings, bridges, canals, etc., concrete is essential. Due to the growth of the building industry, concrete is now a necessary interior component of all types of construction projects. Limiting the use of concrete materials, the qualities of the aggregate determine how well concrete performs. Concrete is used twice as often as plastic, wood, etc. Concrete is a multipurpose material that may be utilised for various kinds of structural work. Man has consistently engaged in some type of construction activity since the beginning of human evolution on this planet, which undoubtedly includes the usage of cement and concrete. Construction of open and private structures in buildings Building development includes both private and public building structures. The term "substantial development" refers to the construction of multiple large and impressive constructions, including railroads, interstates, airfields, harbours, dams, trenches, and many other enormous open works. Mechanical development, marine development, and other incidental specialty constructions are all part of the development industry. Accordingly, a large and overwhelming amount of cement and concrete is needed to build these enormous and magnificent monuments. Natural river sand of high quality is hard to come by today. It needs to be moved over a significant distance. These resources are also becoming scarce quickly. Therefore, a replacement for natural river sand must be found. Natural river sand forms over millions of years. Therefore, a material with qualities that are nearly identical to those of fine aggregate could be employed as a replacement in concrete to solve this issue. Additionally, crushers are producing an increasing amount of crushed stone dust as waste. This poses a significant environmental risk when it is disposed of. If we completely replace natural river sand with this crushed stone dust when building concrete, not only will construction costs be reduced, but the issue of how to dispose of this dust will also be resolved. On the other hand, using by-products has benefits such as lowering manufacturing costs, enhancing concrete quality, and reducing environmental burden and waste management costs. Numerous construction-related jobs have used quarry dust, including the building of roads and the production of lightweight aggregates, bricks, and tiles. Because of its advantages, such as efficient byproduct disposal, decreased consumption of river sand, increased strength characteristics, and improved workability of concrete, the use of quarry dust in construction is preferred.

1.1 Role of Cement in Concrete

Cement has a big impact on the most important elements of a concrete mixture, namely workability and durability. However, 1.2 tonnes of CO_2 are generated during the manufacture of one tonne of cement, endangering the environment. 8% of the total CO_2 released to the atmosphere comes from sources related to cement manufacturing. Additionally, a lot of electricity is needed to create one tonne of cement. One bag of cement costs a lot of money. Waste materials like Acacia Nilotica ash will be used in place of cement to cut down on the amount of electricity needed, lower the quantity of CO_2 released into the atmosphere, and improve the cost-effectiveness of construction.

1.2 Acacia Nilotica Ash

The Fabaceae subfamily of the pea family, often known as wattles or acacias, contains a sizable genus of trees, lianas, and shrubs called Acacia. Linnaeus first described the first species, Acacia Nilotica, which was originally a collection of plant species native to Australia and Africa. When it became clear that the genus as it existed was not monophyletic and that many divergent lineages needed to be allocated to new genera, controversy broke out in the early 2000s. One branch was found to be unconnected to the lineage and had over 900 species, the majority of which were local to Australia, which included the first and type species, Acacia nilotica, and over 900 species mostly native to Africa. The Australian lineage, which has by far the most species, has to be renamed because of this. Botanist Les Pedley gave this group the erroneous name Racosperma. The African lineage was renamed to Vachellia because Australian botanists thought this would be more disruptive than designating a particular type of plant and letting this large number of species stay Acacia. Acacia nilotica ash is the name given to the ash produced by acacia plants. It is a smaller than 90 µ waste product. The specific gravity of acacia nilotica is 1.67.

1.3 Benefits of Acacia Nilotica Ash-Based Concrete

- Concrete becomes more solid and impermeable thanks to acacia ash's inclusion of minuscule particles.
- It is incredibly economical.
- Utilizing acacia ash is environmentally friendly because it produces high-quality binding materials using waste from the environment.
- The building may become stronger as a result.
- The low heat of hydration produced by the concrete mixture minimises thermal cracking.
- Acid and sulphate attacks cannot harm acacia ash.

1.4 Role of Fine aggregate in Concrete:

Sand subdivides the paste of cementing materials into a thin film, which is the basic principle involved in using all cementing materials. Sand helps to make concrete free from voids. Sand offers the requisite surface area for the film of cementing materials to adhere and to spread. It means that sand helps to provide homogeneity to some extent, but however that concrete is a heterogeneous material.

1.5 Quarry Dust:

Quarry dust is a concentrated material that can be utilised as concrete components, particularly as fine aggregates. It is a byproduct of the crushing process. The rock is crushed into different sizes during quarrying operations; the dust that results from this process is known as quarry dust and it is produced as waste. As a result, it is rendered unusable and contributes to air pollution. Therefore, it is recommended to incorporate quarry dust in construction projects.

1.6 Advantages of Quarry dust:

- Because quarry dust doesn't contain any silt or clay particles, it has better abrasion resistance, more weight per unit, and lower permeability. It also causes less environmental disruption because less sand is mined from riverbeds.
- Robo sand's precise grading and cubical shape provide concrete its excellent strength and long-lasting quality.

Due to its consistent availability and minimal transportation costs, river sand is more economical.

1.7 Scope and Objective of Work:

- To investigate the strength of concrete when cement is totally replaced with quarry dust and cement is partially replaced with acacia nilotica ash.
- Acacia Nilotica Ash is used in place of cement to varied degrees (0%, 5%, 10%, 15%).
- To research the workability of concrete's cube-compressing strength, cylinder-splitting strength, and prism-flexural strength.

2. Experimental Programme

The purpose of the experimental programme was to determine the strength characteristics of the concrete, such as compressive strength, split tensile strength, and flexural strength, when cement was partially replaced with acacia nilotica ash and sand was completely replaced with quarry dust. Table 1 displays specifics regarding the quantity and size of specimens.

Table 1: Description of the cube, cylinder, and prism specimens

Specimen	Size of specimens	M25 grade of ANA Concrete			
		0%	5%	10%	15%
Cube	150x150x150mm	3	3	3	3
Cylinder	300x150mm	3	3	3	3
Prism	100x100x500	3	3	3	3

3. Materials Used

3.1 Cement: According to IS: 12269: 1987, 53-grade regular Portland cement was utilised in this experiment.

3.2 Coarse aggregate: After going through a 75mm IS Sieve, the aggregate was kept on a 4.75mm IS Sieve. The coarse aggregate that was used complied with IS 383-1970. 20 mm is the most typical size for coarse material.

3.3 Acacia Nilotica Ash:
The huge genus Acacia, also known as wattles or acacias, belongs to the Fabaceae subgroup of peas. Linnaeus first described the first species, A. Nilotica, which was a group of endemic plant species from Australia and Africa. Several building projects use the ashes left behind from burning acacia trees.

3.4 Quarry Dust: As a fine aggregate, quarry dust from the neighboring Bavpet quarries was employed.

3.5 Water: Salts, acids, alkalis, and oils must all be absent from the water used for both curing and mixing. The water should meet IS 456-2000 requirements. For this investigation, water from the college campus is being used.

Table 2 Properties of Cement and Acacia Nilotica ash:

Sl.No	**Properties**	**Cement**	**A.N ash**
1	Fineness	92%	93%
2	Standard consistency	33%	35%
3	Specific gravity	3.24	3.04
4	Initial setting time	30min	35min
5	Final setting time	600min	630min

Table 3 Properties of Fine aggregate Quarry dust and coarse aggregate

Sl. No	**Properties**	**F.A**	**Quarry dust**	**C.A**
1	Fineness modulus	3.07	3.23	6.66
2	Specific Gravity	2.64	2.59	2.68
3	Water absorption	1.35%	2.1%	0.81%
4	Bulking	15.6	14.29	Negli.

4. Casting Programme:

The specimens were cast in accordance with IS:10086- 1982, which included material preparation, material weighing, and the casting of cubes, cylinders, and prisms. Concrete is mixed, compacted, and cured in accordance with IS 10262:2009. The samples of prisms, cubes, and cylinders were cured in a water pond for 28 days. The material needed for each cubic metre of concrete in the M25 grade is designed and displayed in Table 4.

Table 4 Concrete Mix (M25)

	Cement	**Quarry dust**	**Coarse aggregate**
Ratio	1	1	2

Water ratio is 0.45 times of the cement.

4.1 Testing

4.1.1 Slump Test:

The most popular technique for determining the consistency of concrete is the slump test, which may be carried out both in a laboratory and on the job site. It does not take into consideration all factors affecting workability. Despite this, it serves as a good control test because it may be used to determine whether concrete is homogeneous from batch to batch.

4.1.2 Compressive strength:

The cube specimens were tested using a compression testing machine to determine the maximum compressive stress that a particular solid material can sustain before breaking under a load that is applied gradually. The centre of the loading frame was precisely where the specimen's axis was located. Continuously and at a steady pace, the applied stress was increased until the specimen's ability to withstand the growing load broke down. On the specimen, the maximum load that was applied was noted. P is the load, and A is the area, therefore fc = P/A.

4.1.3 Split tensile strength:

A method for testing the concrete tensile strength that involves slicing a cylinder in 50 percent along its entire circumference. The applied force was steadily raised until the specimen's ability to tolerate the rising weight was reached, which is a poor approach for determining the strength of the tensile fibres in concrete. On the specimen, the maximum load that was applied was noted. f_{split}=2P/DL, where P is the weight of the cylinder, D is its diameter, and L is its length.

4.1.4 Flexural Strength:

The flexural test offers an informal assessment of the concrete's tensile properties. It evaluates a concrete beam's or slab's resistant to flexural failure. On a universal testing device, the beam was put to the test. The formula for flexural strength is f = (WL)/ (bd2). where W = load at failure, L = prism length (500mm), b = prism width (100mm), and d = prism depth (100mm).

5. Findings and Analysis

5.1 Slump Cone test:

Additionally, the slump values were assessed using different concentrations of acacia nilotica ash (ANA) and 100 percent of quarry dust.

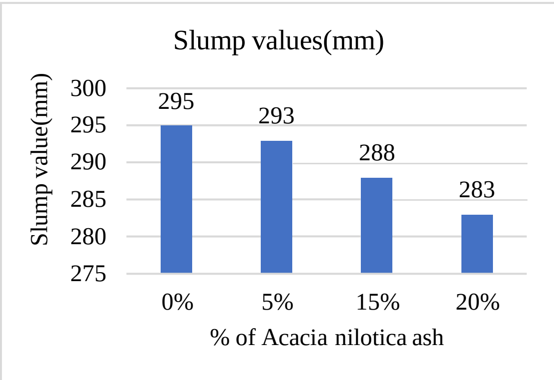

Fig.1 Slump value with replacing 0%,5%,10%,15% of ANA with Cement

5.2 Compaction factor test:

To evaluate whether freshly mixed concrete will work, M25 grade of concrete is created by replacing 0%, 5%, 10%, and 15% ANA with cement and fine aggregate with 100% of quarry dust.

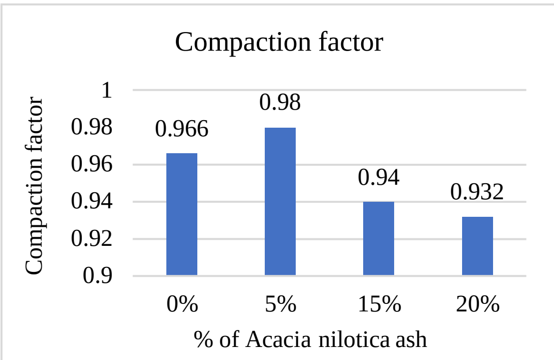

Fig.2 Compaction factor with replacing 0%,5%,10%,15% of ANA with Cement

5.3 Compressive Strength of Cube:
After casting, ANA was partially replaced with cement (0%, 5%, 10%, 15%) and quarry dust was completely replaced with sand. Following 7, 14, and 28 days, the cubes strength of concrete was assessed.

Table 3 Compressive strength of cubes(Mpa)

Grade of concrete	% of ANA	CS 7days (Mpa)	CS 14days (Mpa)	CS 28days (Mpa)
M25	0	17.42	23.9	30.2
M25	5	18.66	26.8	32.6
M25	10	19.33	28.9	34.5
M25	15	18.13	24.0	30

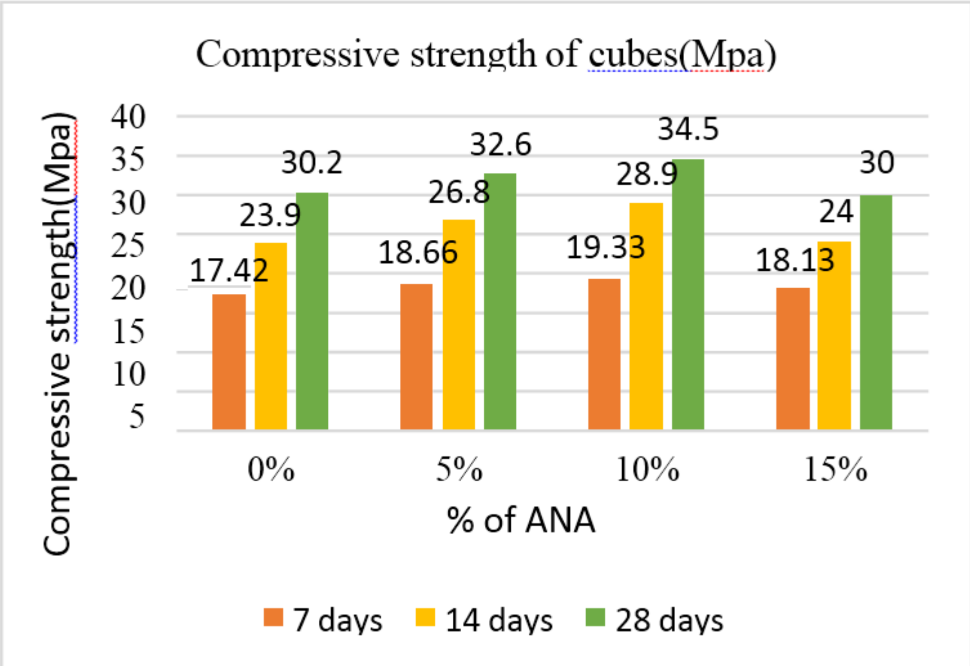

Fig.3 Variation of compressive strength of cubes for 7,14,28 days

5.4 Split tensile strength of Cylinder: After casting, ANA was partially replaced with cement (0%, 5%, 10%, 15%) and quarry dust was completely replaced with sand. The cylinders underwent seven, fourteen, and twenty-eight day split tensile strength tests.

Table 3 Split tensile strength of cylinders(Mpa)

Grade of Concrete	% of ANA	TS 7days (Mpa)	TS 14days (Mpa)	TS 28days (Mpa)
M25	0	2.00	2.6	3.18
M25	5	2.20	2.8	3.22
M25	10	2.60	3.2	3.90
M25	15	2.06	2.6	3.10

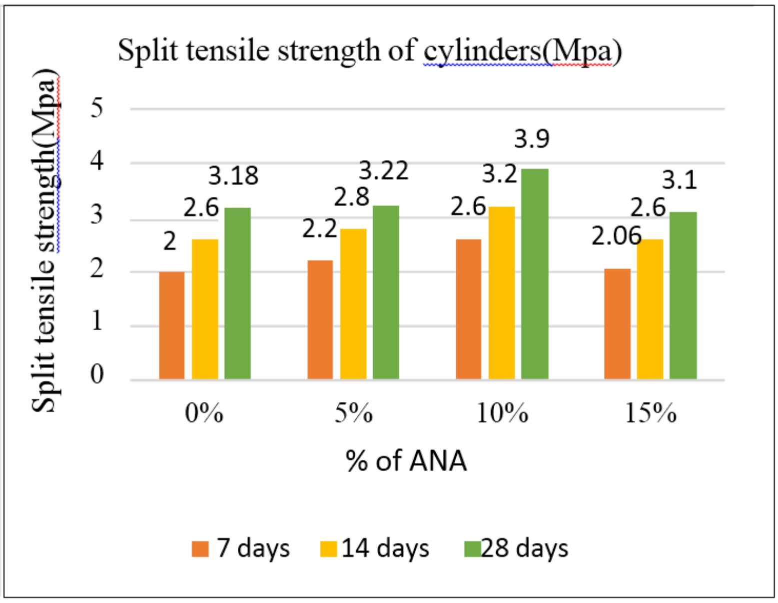

Fig.4 Variation of Split tensile strength of cylinder for 7,14,28 days

Flexural strength of Prism:
After casting, ANA was partially replaced with cement (0%, 5%, 10%, 15%) and quarry dust was completely replaced with sand. The prism was put through flexural strength tests for 7, 14, and 28 days.

Table 3 Flexural strength of Prisms(Mpa)

Grade of concrete	% of ANA	FS 7days (Mpa)	FS 14days (Mpa)	FS 28days (Mpa)
M25	0	17.42	23.9	30.2
M25	5	18.66	26.8	32.6
M25	10	19.33	28.9	34.5
M25	15	18.13	24.0	30

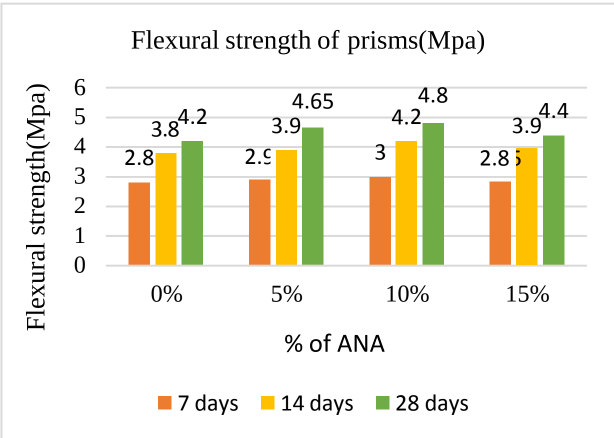

Fig.5 Variation of Flexural strength of Prisms for 7,14,28 days

6. Conclusions

1. Before starting the project, credible journals had been used to conduct extensive research on the impacts of using ash from Acacia nilotica in concrete. The initial research focused on the fundamental components of controlled concrete and varied replacement fractions for cement (0%, 5%, 10%, and 15%) with

acacia nilotica ash.

2. The compressive strength of a typical cube made of 100% quarry dust is 30.2 Mpa, however a cube made of 10% acacia nilotica ash has a higher compressive strength was achieved as 34.5 Mpa for 28 days. There was increase in the strength nearly equal to 4-5% for 28days.
3. The conventional cylinder's split tensile strength is 3.18 Mpa while the cylinder with 10% acacia nilotica ash substitution over a 28-day period, a split tensile strength of 3.90 Mpa was attained.
4. The Flexural strength of the prism with replacing 10% of acacia nilotica ash was obtained as 4.8 Mpa for 28days and theFlexural strength of the conventional cylinder (100% Quarrydust) is 4.2 Mpa.
5. When the strength value reaches its peak and 10% of the Acacia Nilotica Ash has been replaced. The cylinder's split tensile strength, the cube's compressive strength, and the prism's flexural strength decreased to 30 MPa, 3.10 MPa, and 4.4 MPa, respectively, as the percentage of acacia nilotica ash grew above 10%.
6. The maximum value of strength obtained with replacing 10% of Acaia nilotica ash with cement and 100% quarry dust with sand.

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