Experimental investigation on Partial replacement of fine aggregate and coarse aggregate with agricultural waste by using Ansys software

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Abstract: **This study explores the feasibility of using agricultural waste as partial replacement of fine and coarse aggregate in concrete, aiming to enhance sustainability in construction practices. Agricultural by-products, such as sugarcane bagasse ash, Dates seed, were integrated into concrete mixtures at different proportions. In this study, different mixes of concrete were prepared by placing fine and coarse aggregate with in sugarcane bagasse ash and Dates seed percentages of 2.5%, 5% and 7.5%.The mechanical properties, including compressive strength, flexural strength, and durability, were assessed using ANSYS software to simulate structural performance under load conditions. The results demonstrated promising outcomes, highlighting the potential of agricultural waste to reduce dependency on conventional aggregates, lower environmental impact, and offer cost-effective alternatives for eco-friendly construction. This research emphasizes the dual benefit of waste management and sustainable material development in modern construction**

Keywords: Agricultural by-products, Lower environmental impact, Partial replacement, Strength Properties.

I.INTRODUCTION

The construction industry heavily relies on natural resources, with sand and gravel forming a significant part of concrete mixtures as fine and coarse aggregates. However, the excessive extraction of these materials has led to environmental degradation, resource scarcity, and increased costs. In response, researchers and engineers are exploring sustainable alternatives to traditional materials, focusing on reducing the ecological footprint of construction practices. One promising approach involves the partial replacement of fine and coarse aggregates with agricultural waste materials, which not only alleviates environmental strain but also provides an effective waste management solution.

Agricultural waste, such as sugarcane bagasse ash, Dates seed and rice husk ash is generated in large quantities globally and is often discarded or burned, contributing to pollution. Using these materials in concrete could help mitigate environmental issues, reduce landfill waste, and promote a circular economy. This study aims to investigate the potential of agricultural waste materials as partial substitutes for fine and coarse aggregates, analyzing how they impact the mechanical and structural properties of concrete.

Ansys software, a powerful engineering simulation tool, is utilized to simulate various concrete mixtures with agricultural waste substitutions. By examining factors like compressive strength, durability, and load-bearing capacity, this research seeks to identify optimal replacement ratios that maintain or enhance concrete performance. The results are expected to provide valuable insights into the viability of incorporating agricultural waste into concrete, thereby supporting sustainable development and eco-friendly construction practices.

II. OBJECTIVE

This study explores the use of agricultural waste as partial concrete replacements, evaluating its mechanical properties and durability. Using ANSYS software, the study aims to optimize replacement levels, promote sustainable concrete production, and contribute to eco-friendly construction practices, ultimately promoting sustainable production and improved concrete quality. The scope of the work includes knowing the strength parameters of concrete such as Compressive strength, Split tensile strength, Flexural strength in which sugarcane bagasse ash and Dates seed replaced with fine aggregate and coarse aggregate by (2.5%+2.5%), (5%+5%) and (7.5%+7.5) using M25 grade of concrete.

III. MATERIALS USED

CEMENT

Ordinary Portland cement is composed of calcium silicate, calcium aluminate and alumina ferrite. It is obtained by blending predetermined proportions lime stone clay and other minerals in small quantities which is pulverized and heated at high temperature-around 1500 degree centigrade to produce clinker. The clinker is then ground with small quantities of gypsum to produce a fine powder called Ordinary Portland cement (OPC).

Table 1 Properties of Cement

Properties	Results
Specific Gravity	3.15
Fineness	7.2%
Initial Setting time	40 min
Final Setting time	10 hours

AGGREGATE

Normally Sand is used as fine aggregate for preparing concrete. An individual particle in this range is termed as Sand grain. These sand grains are between coarse aggregate (2mm to 64mm) and silt (0.004mm to 0.0625mm). Aggregate most of which passes through 4.75mm sieve is used. Angular Shape aggregate of size is 20mm and below. The aggregate which passes through 75mm sieve and retain on 4.75mm are known as coarse aggregate.

Table 2 Properties of Fine Aggregate

Properties	Results
Specific Gravity	2.40
Water Absorption	0.8%
Fineness	29.52%

Table 3 Properties of Coarse Aggregate

Properties	Results
Specific Gravity	2.36
Water Absorption	0.5%
Fineness	21.5%

SUGARCANE BAGASSE ASH

Sugarcane Bagasse Ash (SCBA) enhances concrete strength and durability due to its high silica content and pozzolanic activity. At 10–15% fine replacement, it improves compressive strength, reduces permeability, and increases chemical resistance. SCBA also lowers heat of hydration, making it suitable for mass concreting, while promoting eco-friendly and sustainable construction practices.

Fig.1 Sugarcane Bagasse Ash

Table 4 Properties of Sugarcane Bagasse Ash

Properties	Results
Specific Gravity	2.36
Water absorption	0.4%

DATES SEED

Date seeds, when used as partial replacement for coarse aggregate, can enhance concrete's sustainability and reduce weight. At optimal replacement levels (typically up to 20%), they maintain adequate compressive strength and improve impact resistance due to their fibrous texture. Though lighter and less dense, treated date seeds can contribute to eco-friendly, lightweight concrete with acceptable structural performance.

Fig.2 Dates Seed

Table 5 Properties of Dates Seed

Properties	Results
Specific Gravity	2.33
Water Absorption	0.2%

IV. EXPERIMENTAL METHODS

1. Concrete Mix Design

The mix design is done by the various proportions of materials for M25 grade concrete which is used in the present study. Then the mix design is designed as per IS 10262-2009 standards.

Cement kg/m³	Fine Aggregate kg/m³	Coarse Aggregate kg/m³	Water kg/m³
425.733	593.184	1119.184	191.58
1	1.39	2.4	0.45

Table 6 Mix Design Proportions

2. Casting of Specimen

Cubes of Size 150mm x150mm x150mm, Cylinder of size 200mm x 300mm, Beam of size 700mm x 150mm x 150mm were casted. The materials which are mixed by coarse aggregate, fine aggregate, cement, sugarcane bagaase ash, dates seed and water. After the moulds were casted and compacted. Demoulding was done after 24 hours of casting and specimens were allowed to cured in a water tank.

V.CONCRETE TESTS AND RESULTS

FRESH CONCRETE TESTS

SLUMP CONE TEST in M25 Grade Concrete

Table 7 Slump Cone Test

S.NO	% Replacement	Slump (mm)
1	0% SBA + 0% DS	0
2	2.5%SBA + 2.5%DS	35
3	5% SBA + 5% DS	50
4	7.5%SBA + 7.5%DS	75

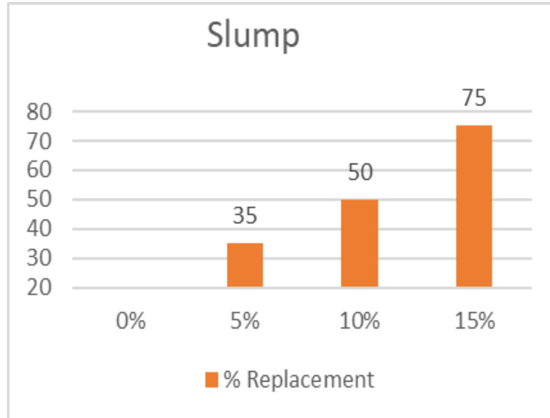

Fig.3 slump cone test

COMPACTION FACTOR TEST in M25 Grade

Table 8 Compaction Factor Test

S.NO	% Replacement	Compaction factor
1	0% CS + 0% ESP	0.92
2	2.5%SBA + 2.5%DS	0.90
3	5% SBA + 5% DS	0.88
4	7.5%SBA + 7.5%DS	0.85

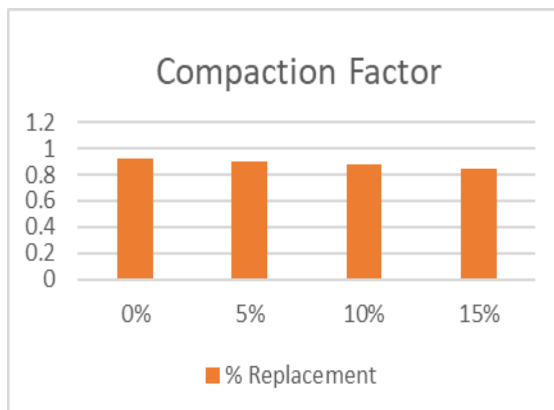

Fig 4 Compaction factor Test

HARDENED CONCRETE TEST

The individual variations of specimen was not more than ± 15 percent of the average. The specimen stored in water was tested immediately on the removal from the tank. The specimen were wiped off and the dimensions of the specimen and their weight were recorded before testing. The bearing surface of the testing machine were wiped clean the other materials, which may come in contact with the compression plates. While placing in the cube in the machine, care was taken such that the load was applied to opposite side of the cube as casted and not to the top and the bottom. The maximum load applied to the specimen was recorded and any usual appearance in the type of failure was noted.

COMPRESSIVE STRENGTH OF CONCRETE

Table 9 Compressive strength test

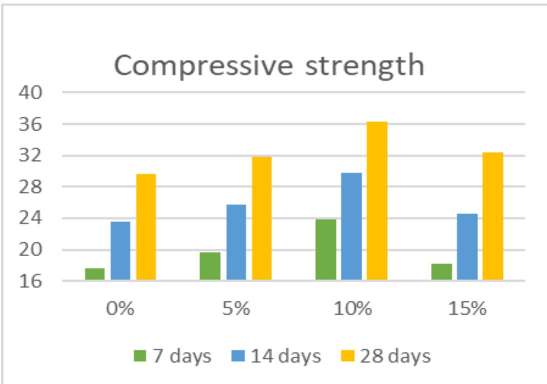

Fig.5 Compressive strength

SPLIT TENSILE STRENGTH TEST

Table 10 Split Tensile strength test

S.NO	% Replacement	Tensile Strength		
		7 days	14 days	28 days
1	0% SBA + 0% DS	2.25	2.77	3.32
2	2.5%SBA+2.5%DS	2.61	2.95	3.72
3	5% SBA + 5% DS	3.52	3.65	4.05
4	7.5%SBA+7.5%DS	3.24	3.12	3.85

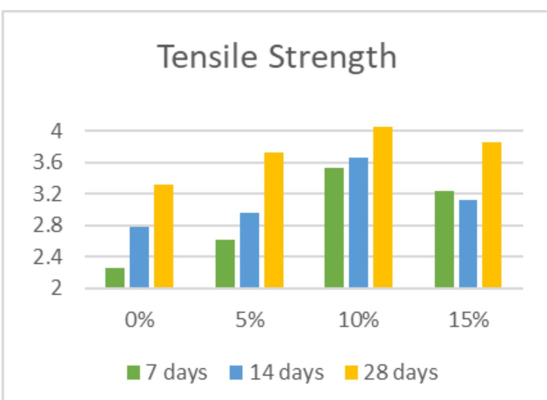

Fig.6 Tensile strength

FLEXURAL STRENGTH TEST

Table 11 Flexural strength test

S.NO	% Replacement	Compressive Strength		
		7 days	14 days	28 days
1	0% SBA + 0% DS	3.52	4.45	5.35
2	2.5%SBA+2.5%DS	3.24	4.11	4.63
3	5% SBA + 5% DS	2.65	3.35	4.32
4	7.5%SBA+7.5%DS	2.96	3.95	4.75

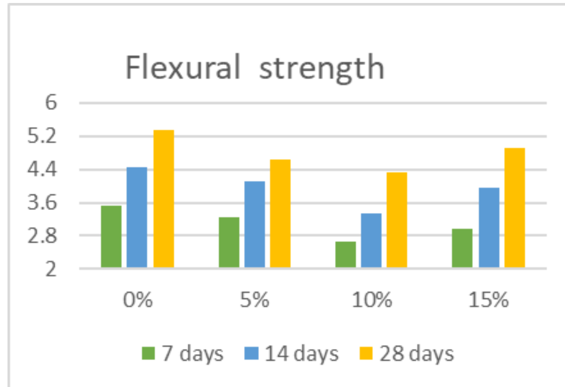

Fig.7 Flexural strength

FLEXURAL STRENGTH RESULT BY USING ANSYS SOFTWARE

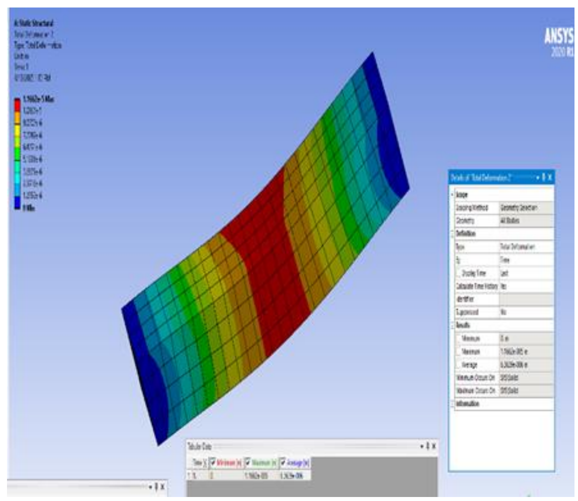

Fig 8 Flexural strength of Beam

VI.CONCLUSION

The experimental investigation on partial replacement of fine and coarse aggregates with sugarcane bagasse

S. NO	% Replacement	Compressive Strength		
		7 days	14 days	28 days
1	0% SBA + 0% DS	17.65	23.49	29.56
2	2.5%SBA+2.5%DS	19.71	25.68	31.75
3	5% SBA + 5% DS	23.88	29.84	36.35
4	7.5%SBA+7.5%DS	18.21	24.56	32.35

ash and date seed at 5%, 10%, and 15% replacement levels revealed that mechanical properties such as compressive, split tensile, and flexural strength decreased slightly with increasing replacement but remained within acceptable limits for structural and semi-structural applications. The 5% replacement mix showed compressive strength of 31.75 MPa, split tensile strength of 3.72 MPa, and flexural strength of 4.63 MPa at 28 days, closely matching the control mix. Even at 15% replacement, the strengths were adequate for non-structural use. This study concludes that up to 10% replacement offers a sustainable and environmentally beneficial alternative to conventional aggregates with minimal compromise in strength, making it suitable for eco-friendly concrete applications.

ACKNOWLEGMENT

First of all, I acknowledge with heartfelt gratitude, GOD ALMIGHTY for all His blessings and guidance with which I could complete my work successfully.

With profound respect and pride, I express my sincere thanks to our honourable Chairman, Shri. GERALD SELVARAJA for facilitating us with this opportunity. I am greatly and profoundly thankful to our Director, Er. T. ISAN, for his kind support to take up this project.

I record my sincere thanks to our Principal, Dr. S. EMMY PREMA, for expressing her keen support during this project work.

I would like to express my sincere thanks and deep sense of gratitude to our Head of the Department, Civil Engineering, Mr. S. SHIJILIN PREM SHIROLD, for his valuable guidance and suggestions paved way for the successful completion of the project work.

I extend my gratitude to my project coordinator, Mrs. P.M. ESO KUMARY PAUL, for his support and timely suggestions for the completion of project.

I also convey my immense gratitude to my project guide Mrs.P.SHARMINI, for her/his constant technical support and stupendous encouragement which enabled me to complete my project successfully.

I am also grateful to all our department faculty members, my beloved parents and my friends for their valuable suggestions in bringing out this project.

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