An Experimental Investigation on Strength Characteristics of Self Curing Concrete by Using Super Absorbent Polymer

M. Venkata Chaitanya[1], S. Ramya Mounika[2], A. Bhagavan Sai Teja[3], G. Nagaraju[4], D. Jeevarathnam[5]

[1]Assistant Professor, Department of Civil Engineering, VSM College of Engineering, Ramachandrapuram – 533255

[2,3,4,5] UG Students, Department of Civil Engineering, VSM College of Engineering, Ramachandrapuram - 533255

ABSTRACT

This high demand for concrete has also increased the price of the material making it almost impossible for low-income earners to own houses and leaving many homeless. Also, increased in population has increased agricultural activities across the globe in order to tackle the problem of food insecurity amongst which include palm farming.

This study investigates the mechanical properties of concrete incorporating oil palm kernel shell (OPKS) as a partial replacement for coarse aggregate and coconut shell ash (CSA) as a partial replacement for cement. The aim is to develop sustainable and eco-friendly concrete by utilizing agricultural waste materials. Various concrete mixes were prepared with different replacement levels of OPKS (15%, 20%, and 25%) and CSA (5%, 10%, and 15%) are done using M25 grade concrete. The mechanical properties, including compressive strength, tensile strength, were evaluated and compared to conventional concrete. The addition of CSA improved the workability of the concrete mix and reduced the environmental impact associated with cement production. Overall, the study demonstrates the feasibility of using OPKS and CSA as alternative materials in concrete production, contributing to waste management and resource conservation.

Keywords: oil palm kernel shell, coconut shell ash, compressive strength, tensile strength.

INTRODUCTION

Concrete is the most widely used construction material globally due to its strength, and durability. In recent years, there has been a growing interest in utilizing agricultural and industrial waste materials in concrete to reduce environmental impact and promote sustainability. Among these materials, oil palm kernel shell (OPKS) and coconut shell ash (CSA) have gained attention due to their availability and potential to replace traditional concrete components. In the present study, an attempt has been made to investigate the strength parameters of concrete by replacing coarse aggregate with oil palm kernel shell and cement with coconut shell ash. In this work, the concrete specimens are casted, cured and tested to know the strength characteristics by performing destructive tests like compressive strength, spilt tensile test.

The use of oil palm kernel shell (OPKS) as a partial replacement for coarse aggregate and coconut shell ash (CSA) as a partial replacement for cement in concrete driven by over conventional concrete. OPKS is a lightweight material with a high strength-to-weight ratio, reducing the overall density of concrete while maintaining adequate mechanical properties. This makes the concrete ideal for lightweight structural applications, reducing the dead load on buildings and infrastructure. Additionally, OPKS improves impact resistance and energy absorption, making it suitable for applications requiring enhanced toughness.

On the other hand, CSA, which is rich in silica (SiO_2), alumina (Al_2O_3), and other pozzolanic compounds, contributes to the chemical enhancement of concrete by reacting with calcium hydroxide ($Ca(OH)_2$) released during cement hydration to form additional calcium silicate hydrate (C-S-H) gel. This reaction, known as the pozzolanic reaction, improves the strength and durability of concrete by reducing the presence of free lime, which is responsible for micro cracking and long-term deterioration.

Additionally, the presence of alumina (Al_2O_3) in CSA can react with calcium hydroxide and sulfate ions to form calcium aluminate hydrates, which improve sulfate resistance in aggressive environments. The reduction of free lime in the concrete matrix also minimizes the risk of alkali-silica reaction (ASR), thereby enhancing the long-term durability of the concrete.

MATERIAL USED

Cement

Cement is a binding agent is used to make concrete because it hardens after contact with water. The main benefit of cement is that it is a resistant, durable material has a wide variety of application. The cement used was ordinary Portland cement of 53 grade (Nagarjuna) as shown in figure. Tests are conducted as per the norms of standard specifications given in IS 4031 and the results are tabulated.

Fine Aggregate

The aggregates are passed on 4.75mm sieve is termed as Fine Aggregate. Fine aggregates are natural or manufactured. A fine aggregate contribute to the ease of mixing, handling, and application of concrete and also contributes to its strength, durability and workability. In this project, river sand with a fineness modulus of 2.32 and zone - II compliance per IS: 383(1970) is employed. The fine aggregate is the key component of the concrete. It make up to 35-45% of the total volume of concrete mixture.

Coarse Aggregate

Coarse aggregates are crucial in the construction industry and Aggregates are the major ingredients of concrete. In most cases, Coarse is naturally occurring and can be obtained by blasting quarries or crushing them by hand or crushers The material whose particles are of size are retained on IS sieve of size 4.75mm is termed as coarse aggregate and containing only so much finer material as is permitted for the various types described in IS:383-1970 is considered as coarse aggregate.

The coarse aggregate used in this experimental investigation is 20mm and 10mm size, crushed and angular in shape as the aggregates are free from dust before used in the concrete.

The Coarse aggregate are obtained from a local quarry is used. The coarse aggregate with a maximum size 20 mm having a specific gravity 2.67, fineness modulus of 7.01.

Oil palm kernel shells

Oil palm kernel shells are the hard, woody shells that encase the seeds (kernel) of the oil palm fruit. These shells are a by-product of the palm oil industry, generated during the extraction process of palm oil. Oil palm kernel shells are lighter than conventional coarse aggregates. The shells are irregular in shape and a rough texture, aiding in bonding with the concrete mix and lighter than conventional aggregates, which helps in reducing the overall weight of concrete.

They are generally dark brown to black in color and have a specific gravity ranging from 1.2 to 1.4 which is lower than that of conventional coarse aggregates. OPKS has a bulk density between 600 to 800 kg/m^3, making it suitable for lightweight concrete applications.

Coconut shell ash

Coconut shell ash (CSA) is obtained by burning cleaned coconut shell at high temperature and grinding them into a fine powder that passes through a 75mm sieve. It is a pozzolanic materials containing silica (SiO_2) , alumina (Al_2O_3), and calcium oxide (CaO), which react with calcium hydroxide in cement hydration to enhance strength. CSA is lightweight, durable, and eco- friendly, making it sustainable as a partial cement replacement. It use improves compressive strength, durability, and resistance to chemical attacks while reducing the environmental impact of concrete production.

Water

Water is one of the most important ingredients in concrete. it plays a virtual role in development of strength in concrete. Hydration of cement in concrete to form hard gel responsible for strength in concrete is impossible without water. Water aids in binding, thus it is important to assess both its quality and amount precisely. Water's PH level should thus be kept between 6 and 8. Water levels are also precisely controlled since excessive water levels might make an area more workable but can also harm a slump. If it is low, the mix's design is harmed. Thus, it is important to maintain the ideal water content.

EXPERIMENTAL STUDY

Table 4.1 - Physical Properties of Cement

S. No	Physical Property	Test Result	Requirements as per IS Code Books
1	Specific Gravity	3.14	3.10 - 3.15
2	Normal consistency	31%	26%-33%
3	Initial Setting Time	45 min	30 min
4	Final Setting Time	12 hours	10 hours

Table 4.2 – Physical Properties of Fine Aggregate

S. No	Physical Property	Test Result	Requirements as per IS Code Books
1	Specific Gravity	2.62	2.60 – 2.80
2	Fineness Modulus	2.32	2.3 – 3.1
3	Bulking of Sand	8.00%	Good
4	Grading	Zone-II	Zone-I – Zone-II

Table 4.3 – Physical Properties of Coarse Aggregate

S. No	Physical Property	Test Result	Requirements as per IS Code Books
1	Specific Gravity	2.67	2.6 – 2.7
2	Fineness Modulus	7.01	6.5 – 8.0
3	Nominal maximum size	20mm	10mm – 20mm

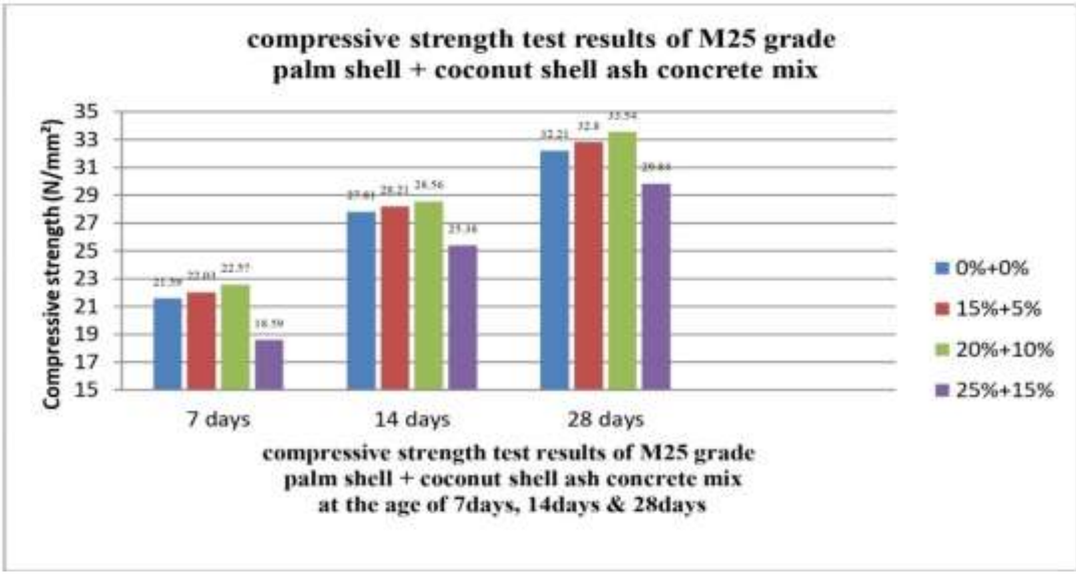
Table 4.4 - Physical Properties of Oil palm kernel shells

S. No	Physical Property	Test Result	Requirements as per IS Code Books
1	Specific Gravity	1.37	1.2 – 1.5
2	Fineness Modulus	6.53	5.0 – 6.0
3	Moisture content	12.45%	10% – 15%

TESTS AND RESULTS

Table 6.1 – Compressive strength test results of M25 grade Palm shell + coconut shell ash concrete mix

Oil palm kernel shells + coconut shell ash	7 days	14 days	28 days
0% + 0%	21.59	27.81	32.21
15% + 5%	22.03	28.21	32.8
20% + 10%	22.57	28.56	33.34
25% + 15%	18.59	25.38	29.84



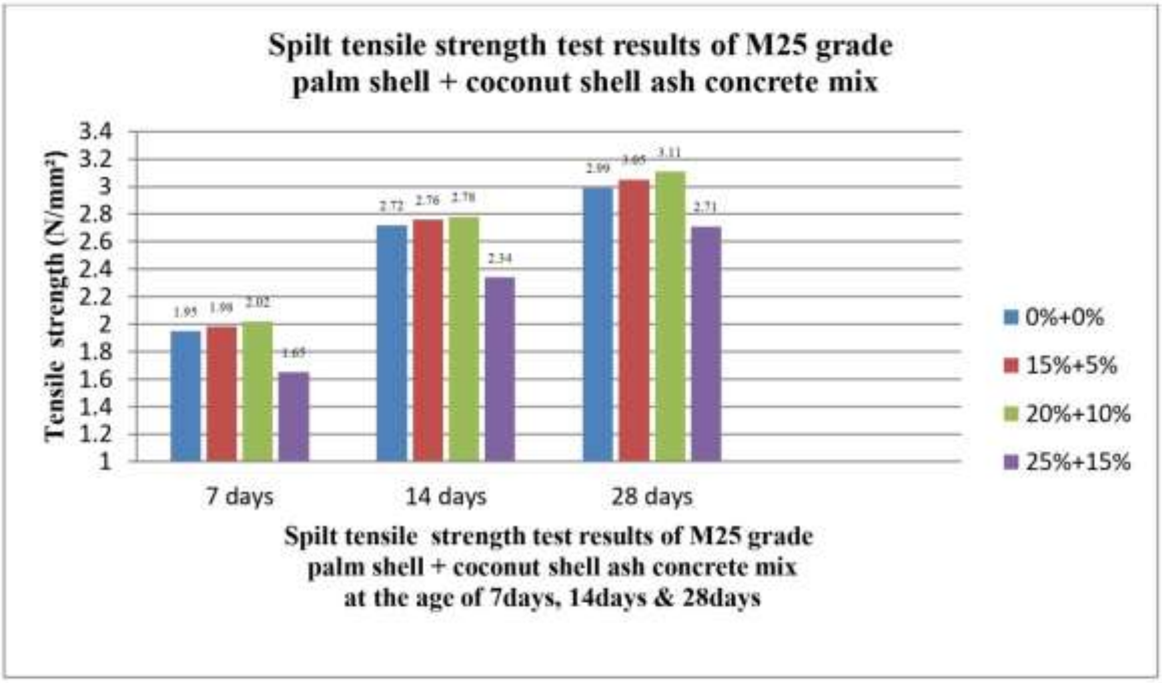
Graph 6.1 – Compressive strength test results of M25 grade Palm shell + coconut shell ash concrete mix

International Journal for Multidisciplinary Research (IJFMR)

E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Table 6.2 – split tensile strength test results of M25 grade Palm shell + coconut shell ash concrete mix

Oil palm kernel shells + coconut shell ash	7 days	14 days	28 days
0% + 0%	1.95	2.72	2.99
15% + 5%	1.98	2.76	3.05
20% + 10%	2.02	2.78	3.11
25% + 15%	1.65	2.34	2.71



Graph 6.2 – split tensile strength test results of M25 grade Palm shell + coconut shell ash concrete mix

CONCLUSION

From experimental work and testing of specimen following conclusions have been concluded:

- It may be concluded that use of palm Shells or Combination of Palm Shells and coconut shell ash are better to replacement of Coarse Aggregates in production of not only for high strength concrete but also for Low/Moderate strength concrete as based on Requirement.
- The best performance was observed the combination of OPKS and CSA at (15%+20%), (5%+10%), achieving improved compressive and tensile strength compared to conventional concrete.
- The highest compressive strength of 33.34 N/mm² at 28 days was achieved with 20% OPKS and 10% CSA, slightly exceeding that of conventional concrete (32.21N/mm²). Beyond this percentage, strength gradually decreased.
- The split tensile strength also showed improvement at 20% OPKS, 10% CSA, reaching 3.11 N/mm², compared to 2.99N/mm² in conventional concrete.
- OPKS improved the workability of fresh concrete due to its lightweight nature, while CSA

contributed to better cementitious properties.

- The use of OPKS and CSA promotes waste utilization, reduces environmental pollution, and lowers material costs by replacing natural aggregates and cement.
- The use of OPKS and CSA promotes waste utilization, reduces environmental pollution, and lowers material costs by replacing natural aggregates and cement.
- The maximum Split tensile Strength values obtained for M25 grade of concrete at the age of 7 and 14 days, 28 days are at the combination of OPKS and CSA at (15%+20%), (5%+10%), replacement of coarse aggregate by Palm Shells and cement by coconut shell ash.
- These proportions are given Good Results as compared with normal Conventional Coarse and fine aggregate in concrete.

REFERENCES

1. **Li et al. (2017)** investigated the mechanical properties of concrete when OPKS was used as a partial replacement for coarse aggregate. The study found that incorporating OPKS up to a certain percentage (e.g. 20%) resulted in higher compressive strength compared to conventional concrete. However, higher replacement percentages led to a decrease in strength due to the lower density and higher porosity of OPKS compared to traditional aggregates.
2. **Ismail et al. (2018)** looked at the durability of concrete when OPKS was used as a partial replacement for coarse aggregate. The study found that incorporating OPKS up to a certain percentage (e.g. 15%) improved the resistance to chloride ion penetration and increased the durability of concrete. However, higher replacement percentages led to a decrease in durability due to the lower strength and higher porosity of OPKS.
3. **Awal et al. (2016)** investigated the use of OPKS as a partial replacement for coarse aggregate in lightweight concrete. The researchers found that incorporating OPKS up to 25% by weight resulted in a lightweight concrete with comparable compressive strength to conventional concrete.
4. **Ahmad et al. (2015)** found that replacing up to 15% of cement with coconut shell ash resulted in higher compressive strength compared to conventional concrete.
5. **Ramesh et al. (2019)** reported that mortar mixes with up to 10% CSA replacement had higher compressive strength compared to control mixes.
6. **Kumar et al. (2017)** investigated the compressive strength of concrete mixes with CSA replacements ranging from 5% to 15%. They found that concrete mixes with up to 10% CSA replacement exhibited higher compressive strength compared to control mixes.

LIST OF IS CODE RECOMMENDATIONS

1. **IS:12269(1987)**, Indian Standard Ordinary Portland cement, 53 Grade Specification.
2. **IS:383(1970)**, Indian Standard Specification for Course And Fine Aggregates from Natural Sources for Concrete.
3. **IS:10262(2019)**, Indian Standard Concrete Mix Proportioning - Guidelines, Bureau of Indian Standards, New Delhi.
4. **IS: 2386(1963)**, Methods of test for aggregates for concrete.
5. **IS:516(1959)**, Methods of test for strength of concrete.