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STUDY OF STRENGTH CHARACTERISTICS OF CONCRETE USING RELIABILITY METHODS

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Abstract
The three primary components that are utilized in the production of concrete are Portland cement, sand, and coarse aggregates. As a direct consequence of the severe lack of available materials, there is a significant increase in the demand for alternative materials (CA and FA). As a result, oil palm shells are utilized as a replacement for the chemical compound C. A for varying degrees of replacement, ranging from 0% to 100%. An investigation was conducted to determine the split tensile strength of concrete cylinder specimens at different ages and with varying amounts of replacement. despite the fact that the correlation method can't be used to predict split-tensile strength with any degree of accuracy. The properties of strength that concrete possesses are utilized in the discovery of a correlation that was found to be more accurate.
Keywords: Concrete, Strength, Correlation, Reliability.

I. INTRODUCTION
Concrete is a composite material that is made up of fine and coarse aggregates that are bonded together with a fluid cement (cement paste), and then allowed to harden over time. The fine aggregates make up the majority of concrete, while the coarse aggregates make up the remainder. The term "curing" refers to this process. Concrete is the substance that is used the most in the world, and it is the material that is utilised in the construction industry the majority of the time. Water is the substance that is used the most. In the palm oil industry, oil palm shell is regarded as a form of biosolid waste that possesses the potential to be utilised as an aggregate in concrete mixture. According to earlier studies, ops, also known as oil palm shell, should not be used in full quantities as coarse aggregate when making concrete; as a result, the amount of ops that should be included in concrete should be maximised. Because of this, ops cannot be used in place of all coarse aggregate in the mixture used to make concrete.

During the course of this research project, the percentage of coarse aggregates that were replaced with ops varied from 0% to 100%, with a gap of 20% between each substitution.
Both ops replaced concrete and convectional concrete are subjected to a test to determine the splitting tensile strength of the material. After that, the findings are put to use in an investigation

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of the correlation that exists between the data on the tensile strength of convectional concrete splitting and the data on the tensile strength of ops-replaced concrete. This investigation is carried out after the previous step has been completed.

According to the findings, the optimal value for tensile strength could be achieved by replacing 20% of the ops with another material. This would bring the value closer to what was originally desired. In addition, there is a positive correlation, which indicates that the correlation is good for the data that was used. This was a very important finding. Using correlation coefficients, it is possible to assess both the strength and the direction of linear relationships that exist between different sets of variables. In statistical analysis, these coefficients play an important role. If both variables have a normal distribution, then Pearson's correlation coefficient should be used; otherwise, spearman's correlation coefficient should be used.

II LITERATURE REVIEW

N. Arioglu, Z. C. Girgin, and E. Arioglu, (2006), "Evaluation of the relationship between splitting tensile strength and compressive strength for concrete up to 120 MPa and its application in strength criteria." A large-scale regression analysis was performed using experimental data obtained from numerous sources to identify the link between the ratio of splitting tensile strength to cylinder compressive strength as a function of concrete's compressive strength. The integral absolute error was utilised to assess the correctness of the proposed equation, which was based on experimental data ranging from 580 to 17,400 psi and 4 to 120 MPa (IAE). It is also shown that the failure envelope for exceptionally high-strength concrete may be established using Johnston's strength criterion without doing triaxial compression tests by utilising only compressive strength and the tensile-to-compressive strength ratio. A numerical illustration shows how Johnston's strength criteria are used.

U. J. Alengaram, B. A. A. Muhit, and M. Z. b. Jumaat, (2013), "A review of the use of oil palm kernel shell as a light-weight aggregate in concrete." The usage of oil palm kernel shell (OPKS) as a lightweight aggregate has been the subject of prior research, which is reviewed in this study (LWA). OPKS is a byproduct produced when the palm nut is crushed in palm oil mills to extract palm oil. In South East Asia and Africa, it is one of the most often generated waste products. Since 1984, researchers have experimented with using OPKS as lightweight aggregates (LWAs) to build lightweight concrete (LWC), and there are now a lot of researchers working in this field. The mechanical, functional, and functional qualities of the OPKS concrete, as well as its structural behavior, are all discussed in this study, along with its physical and mechanical properties (OPKSC). The findings demonstrate that OPKSC possesses mechanical characteristics and structural behavior that are equivalent to those of regular-weight concrete (NWC). According to a recent study on the utilization of crushed OPKS, OPKSC may be used to make medium and high-strength concrete. Many researchers are looking at the usage of OPKS as LWA because of sustainability concerns along with better ductility and aggregate interlock properties of OPKSC compared to NCW.

V. Alimohammadi, M. Sedighi, and E. Jabbari, (2017), An experimental examination into the efficient removal of total iron from sewage using magnetically controlled multiwalled carbon nanotubes. Using magnetic multi-walled carbon nanotubes, total iron was removed from wastewater samples (MMWCNTs). X-ray diffraction (XRD), transmission electron microscopy (TEM), Fourier transform infrared (FT-IR), and vibrating sample magnetometry (VSM) tests were used to characterise the samples. The generated magnetic adsorbent is easily magnetically disengaged from the medium after being loaded with adsorbate and may be equally dispersed in water. Response surface methodology (RSM) in combination with central composite design (CCD) was used to investigate the effects of operational factors such as D/C (adsorbent dosage per beginning concentration of pollutant ((mg)adsorbent/(mg/l)initial)) and pH on total iron removal (%). According to the RSM model, the best total iron removal occurred at pH 8.2 and D/C 5. The Langmuir and Freundlich adsorption models were utilised to evaluate the experimental data. The Langmuir isotherm model predicted a maximum adsorption capacity of 200 mg/g for complete iron removal. The current investigation illustrates the nanocomposite's unique characteristics in entirely removing iron from wastewater.
V. Alimohammadi, M. Sedighi, and E. Jabbari, (2017), "Optimization of sulphate removal from wastewater utilising magnetic multiwalled carbon nanotubes using response surface approach," says the paper. This study describes a simple approach for removing sulphate from wastewater using magnetic multi-walled carbon nanotubes (MMWCNTs). X-ray diffraction, Raman, transmission electron microscopy, Fourier transform infrared spectroscopy, and vibrating sample magnetometry were used to characterise multiwalled carbon nanotubes and MMWCNTs. The study revealed that MMWCNTs were effectively produced. The MMWCNTs may be readily adjusted in a magnetic field to achieve the necessary separation, resulting in sulphate removal from wastewater. The effects of D/C (adsorbent dose per starting concentration of pollutant (mgadsorbent/(mg/l)initial)) and pH on sulphate removal (%) were studied using response surface methodology (RSM) and a central composite design. Multiple regression analysis was used to derive a quadratic polynomial equation for sulphate removal using RSM technique. pH = 5.96 and D/C = 24.35 were the best combinations for maximal sulphate reduction (93.28%). The Langmuir and Freundlich adsorption models were used to analyse the experimental results. In the examined concentration range, sulphate adsorption capacity was 56.94 (mg/g). It was discovered that MMWCNTs might be a viable adsorbent for the removal of sulphate from wastewater.

III. Materials Used

In this present investigation materials used are Cement, Fine aggregate, Coarse aggregate, OPS and Water.

A. Cement:

Grade 53 ordinary Portland cement, as per, IS: 12269-1987, was utilized in this investigation. Throughout the investigation, the cement utilized was locally available Penna brand 53 Grade Ordinary Portland Cement, as shown in fig. It was fresh and free of lumps. The cement's physical characteristics as determined by different tests in accordance with Indian standard IS12269:1987. The cement was properly kept to avoid loss of its characteristics due to moisture interaction. As indicated in the table, the various tests performed on cement include initial and ultimate setting time, as well as specific gravity.

Table 1. Cement's Physical Characteristics

S.no	Property	Test result
1	Normal consistency	29%
2	Specific gravity	3.11
3	Initial setting time	65min
4	Final setting time	550min
5	Soundness	3mm
6	Fineness (sieve)	95%

B. Fine Aggregate:

The experiment employed naturally accessible river sand that passed through a 4.75mm IS mesh and conforms to grading zone II of IS: 383-1970. River sand fineness modulus and grain size distribution were determined using sieve analysis. The physical characteristics of fine aggregate are mentioned in the table and it can be transported from local suppliers.

Table 2. Fine aggregate physical characteristics

S.no	Property	Test result
1	Specific gravity	2.64
2	Fineness modulus	2.52
3	Zone	II
4	Water absorption	1%

C. Coarse Aggregate:

The coarse materials utilized in this research are 20 mm natural stone coarse aggregates that are locally available. Laboratory tests on coarse aggregate were performed as per IS: 2386 (part III)- 1963 to determine the various physical properties and they can be shown in the table as follows.

Table 3. Shows physical characteristics of Coarse aggregate

S.no	Property	Test result
1	Specific gravity	2.77
2	Water absorption	0.5%

Figure 1. Materials

D.Oil Palm shells:

As coarse aggregates, this study used OPS and crushed granite. After being exposed to the weather for about 7 months in order to remove the fibers, OPS aggregates were cleaned in the concrete mixer using a detergent powder to remove the oil and other pollutants from the surface. The granite and OPS were then sieved to ensure that they had the same grade.

Figure 2. Oil Palm Shells

Properties of OPS:

Table 4. Oil Palm shell's chemical composition(Teo et al,. 2007).

S.no	Component	Description	Content in oyster shell powder
1	SiO_2	Silica	0.0146%
2	Al_2O_3	Alumina	0.130%
3	Cao	Calcium Oxide	0.076%
4	MgO	Magnesium Oxide	0.035%
5	Na_2O	Sodium Oxide	0.00156%
6	K_2O	Potassium Oxide	0.000426%

7	SO_3	Sulfur trioxide	0.31%
8	Ash	Ash	1.53%
9	LOI	Loss of Ignition	98.5%

We conclude that the oil palm shell (OPS) has substantially the same properties as coarse aggregate based on the findings of the chemical examination of the OPS. in natural coarse aggregate, such as CaO, SiO2, Al2O3, Fe2O3, and others.

E. Water:

Concrete must be mixed with clean water that has no dangerous quantities of oils. acids, alkalis, organic compounds, or other deleterious chemicals. The presence of these contaminants in the water may affect cement setting time, concrete strength, and reinforcing corrosion. In this investigation, we used portable tap water from the college campus water plant that met the IS456-2000 standards for casting concrete and curing the specimens.

Figure 3. Water for Concrete**.**

III. METHODOLOGY

- ✓ In this study, a normal-weight concrete was used, and the normal coarse aggregate was replaced with OPS in increments ranging from 0% to 100%, with a 20% increment in between each substitution.
- ✓ The M20 grade of concrete is used in the design mix that is used for concrete.
- ✓ In order to determine the optimal percentage of OPS that should be present in concrete, a series of tests including splitting tensile strength test cylinder cured specimens were cast and splitting tensile strength test were carried out.The results of splitting tensile strength are tabulated.
- ✓ A reliability concept (correlation method) was used to understand the degree of correlation that exists between the variables.

CORRELATION METHOD:

- ➢ The statistical method that is known as correlation was developed with the intention of determining the degree of connection that exists between a number of different variables.

- The sign "+" (or "plus") or "-" (or "minus") indicates the direction in which the value is changing (-).
- The coefficient of correlation, denoted by the letter R, will have a value between minus one and plus one when it is expressed in its simplest form.
- The degree of association can be between dependent and independent variables, or between two independent variables.
- The correlation coefficient is most commonly used to investigate the degree of association between two variables, as well as the level of multicollinearity, and to reflect whether or not one variable is mediating or moderating the other. Another common use of the correlation is to determine whether or not one variable is mediating or moderating the other.

Method of studying the correlation

The correlation of two variables demonstrates their relationship. The correlation metric is displayed by the correlation coefficient. We employ the correlation formulae to compare two datasets. The Pearson formula is the most popular one. For linear dependencies between the data sets, the correlation coefficient is utilised. The coefficient's value ranges from -1 to +1. The data are regarded as unrelated when the coefficient reaches 0. While a value of +1 indicates a positive correlation between the data, and a value of -1 indicates a negative connection.

- The most frequent correlation coefficient is represented by the letter "r," which stands for Karl Pearson's Coefficient of Correlation.
- The degree of linear association between two variables, such as x and y, is measured by the coefficient of correlation, or "r."
- Karl Pearson's Coefficient of Correlation is represented by the symbols r -1 r +1.
- A value of represents the degree of correlation Coefficient

The following is Pearson's mathematical method for determining the strength of the connection (R) between the variables X and Y.

$$\frac{n(xy)-\xi(x)-\xi(y)}{\sqrt{n(\xi x^2)-(\xi \mathrm{x})^2}\sqrt{n(\xi y^2)-(\xi y)^2}} \quad \textbf{(1)}$$

- ✓ where, n = Number of observations
  x = Measures of Variable 1
  y = Measures of Variable 2
  Σxy = Sum of the product of respective variable measures
  Σx= Sum of the measures of Variable 1
  Σy = Sum of the measures of Variable 2
  Σx^2 = Sum of squared values of the measures of Variable 1
  Σy^2= Sum of squared values of the measures of Variable 2

IV. RESULTS & DISCUSSION

A. General:

The tests were done on both freshly mixed and hardened concrete. The Fresh concrete mixture was tested for slump and workability. Hardened concrete tests including tensile strength test was performed.

B. Fresh Properties of Concrete:

Workability is tested in terms of slump cone and compaction factor test, which decrease as Oil Palm shells are replaced with coarse aggregate. The slump cone and compaction factor test with % replacement is depicted in the graph below.

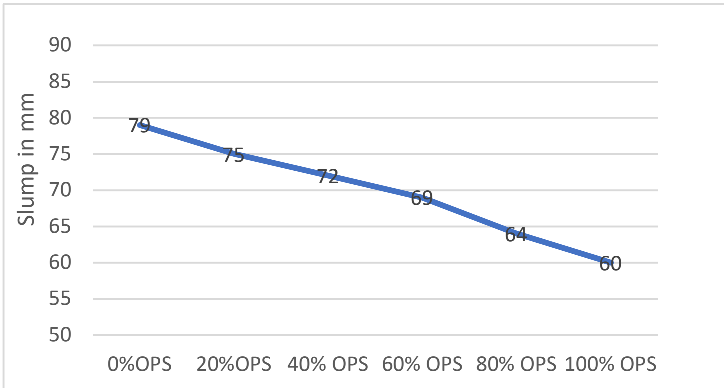


Figure 4. Slump with different mixed proportions of OPS.

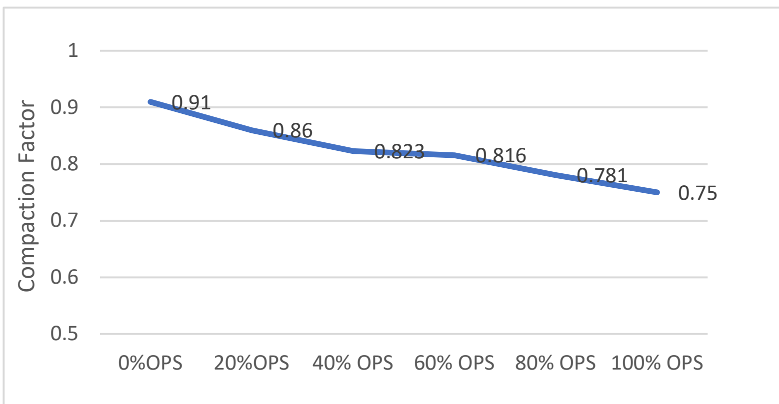


Figure 5. Compaction factor with different mixed proportions OPS.

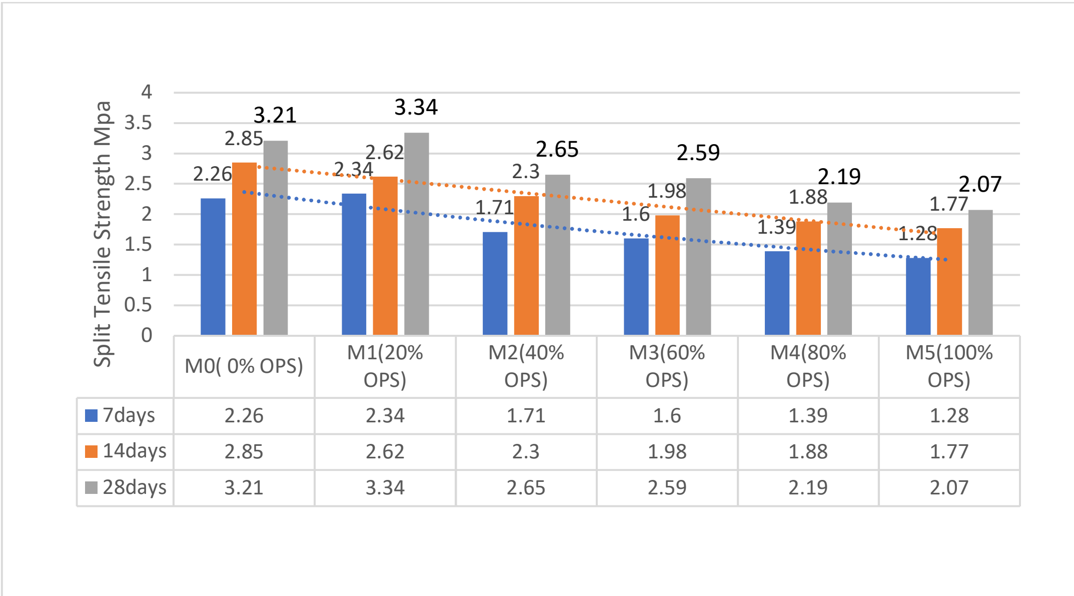
The workability test results show that the workability decreases as the percentage of Oil palm Shells increases. The slump value for the nominal mix (M0) was around 79 mm, and it steadily dropped to 60 mm. In terms of compacting factor, the nominal mix (M0) demonstrated the highest workability. The dropping of workability is mainly due to the Smooth form and surface structure or texture of Oil Palm shells. However, even with the use of Oil Palm shells, the workability obtained is sufficient for normal concrete works.

C. Hardened properties of concrete:

Testing hardened concrete is crucial for assessing and confirming the quality of cement concrete work. The test methodologies should be precise, simple, and easy to apply.

D. Split tensile Strength test:

This indirect test may be used to assess the tensile strength of concrete. After 7 and 28 days of water curing, concrete specimens were put to the test for splitting tensile strength on cylinders that were 150 mm in diameter and 300 mm in height.IS 5816-1999 was used to conduct the test. On the compression testing equipment, cylindrical specimens were placed horizontally and tested for splitting tensile strength. The splitting tensile strength values are graphed in Fig. 5.3 after the load was applied till failure.



	M0(0% OPS)	M1(20% OPS)	M2(40% OPS)	M3(60% OPS)	M4(80% OPS)	M5(100% OPS)
7days	2.26	2.34	1.71	1.6	1.39	1.28
14days	2.85	2.62	2.3	1.98	1.88	1.77
28days	3.21	3.34	2.65	2.59	2.19	2.07

Figure 6. Split tensile strength with different mixed proportions of OPS.

The above results show that the cylinder's splitting tensile strength was optimum at 20% and 20% of OPS replacement. The percentage increase in strength exceeds the nominal mix by 4%. The percentage strength was increased up to 20%OPS but then reduced due to a greater void space ratio in the specimens, resulting in a weaker bond between the concrete.

E. Reliability Approach:

By substituting the above formula we get r value

$R = r = 3(12.158) - (5.76)(6.28) / \sqrt{3(11.693) - (5.76)^2} \sqrt{3(13.325)^2 - (6.28)^2}$

$= 0.3012 / 1.0124$

$R = r = 0.423$

Correlation coefficient values(R) for splitting Tensile strength

Testing hardened concrete is crucial for assessing and confirming the quality of cement concrete work. The test methodologies should be precise, simple, and easy to apply.

Table 5. A comparison study of correlation values for 7,14,28 days.

% of oil palm shell added	7days	14days	28days
0	0.423	0.515	0.645
20	0.496	0.593	0.693
40	0.534	0.622	0.716
60	0.673	0.735	0.819
80	0.695	0.786	0.913
100	0.723	0.871	0.995

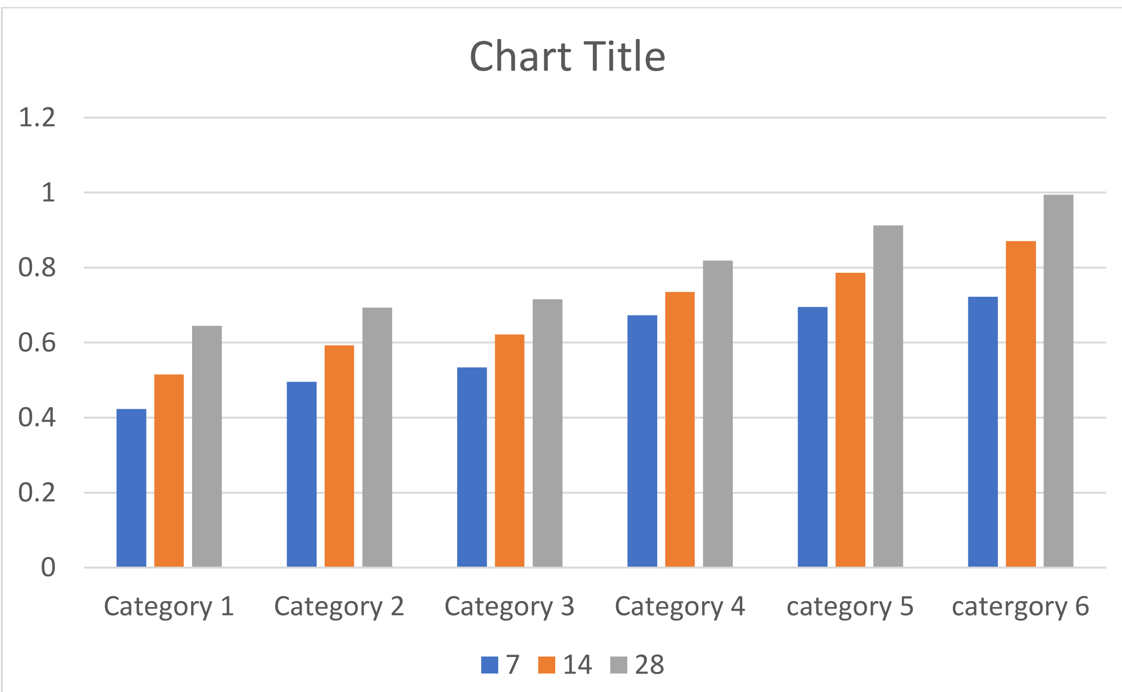


Figure 7. Graphical representation for correlation values for 7,14,28 days.

V. CONCLUSION

In this work, the effect of the use of Oil Palm shells to partially replace coarse aggregate was investigated. Based on the early research, mix 20%OPS was determined to be the optimum mix in terms of Split tensile strength. All mixes were put through a workability test. Mechanical characteristics such as cylinder splitting tensile strength was determined for all of the mixes.

The results obtained were compared to the control mix (M0) and Correlate with reliability approach. The following results were reached according to the experimental investigation.

i. The workability of the concrete as measured by the slump and compaction factor reveals that as Oil palm shell replacement increases, the slump decreases. The compaction factor also decreases as Oil Palm shell content increases, and the findings are within the typical range of concrete.
ii. The OPS obtained has lower specific gravity than the coarse aggregate they replaced, which means mass replacement will produce a significantly higher volume of coarse aggregate materials.
iii. It was reported OPS has almost the same percentage of all the key chemical elements of Coarse aggregate, meaning that it will act as an acceptable alternative if the proper proportion is used.
iv. Split tensile strength increased up to 20% with OPS substitution and then dropped at the remaining proportions. This strength was increased by around 4% on the 28th day compared to the control mix (M0).
v. Similarly, the correlation values 0.4 to 0.995 there is good correlation between the variables.

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