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Influence of Palm Kernel Shell on Mechanical Properties on The Achievement of Kernelrazzo Concrete Floor Finish Production

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ABSTRACT

The purpose of this research report is to disseminate the findings of a study on the consequences of palm kernel shell on the mechanical properties of kernelrazzo concrete floor finishes made using the Department of Environment (DoE) design method combinations of cement, quarry dust, as well as palm kernel shell in place of some marble chippings. The use of palm kernel shell, which is readily available as a coarse aggregate substitute, is the only option allowed for this research project to minimize the self-weight or dead load of the floors and to cut the cost of construction. Quarry dust was used as a fine aggregate, while marble chips and palm kernel shell were used as coarse aggregates. There were six distinct concrete mixtures created, and it is significant to note that, when considering the degree of workability values, the results of their slump tests are quite good. The possible significance of this research is that just 19 mm granite with a water-cement ratio of 0.5 was obtained at 28 days, the compressive strength grade of 30.50 N/mm^2, 22.32N/mm^2, 26.46 N/mm^2, 19.72N/mm^2, 16.47N/mm^2 and 12.96N/mm^2 respectively while flexural strength concrete grade of 5.44 N/mm^2, 3.85N/mm^2, 4.56 N/mm^2, 3.01N/mm^2 and 2.46N/mm^2. There is no result at 50% palm kernel shells, concrete is good in compression but weak in tension. The research work's contribution to knowledge is in the awareness it provides regarding the potential use of agro-waste materials, prevention of epidemic and other related diseases that may arise from waste palm kernel shells and source of income generation and reduction of economic loss that may result from early kernelrazzo concrete floor finishes failure in urban and rural communities, in yards for offices and factories due to incorrect concrete proportioning with a maximum of 33% quarry dust and 20% palm kernel shell replacement with marble chippings.

1. Introduction

The floor is one of the basic structural elements of a building that forms the carrying sustaining base for the live loads (weight of pieces of furniture and occupants of the building). The bulk of official and unofficial activities of building occupants take place on it. Kernelrazzo concrete is a combination of partial or total replacement of palm kernel shell (PKS) with marble chippings in some extent of

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terrazzo with cement, POFA, quarry, dust and water for flooring. A building is a mechanism designed and created for human use and protection. Schools, hospitals, mosques, churches, industrial and commercial buildings, public buildings, domes, silos, housing estates, etc. are examples of buildings. Infrastructural facilities include estate roads, drainage systems, and general utilities.

A structure must serve as an enclosure against environmental hazards like fire or flooding as well as deterioration of the environment brought on by moisture, temperature, airflow, radiation, chemical attack, and biological attack. The employment of complex design, newly introduced building materials such as kernelrazzo concrete to reduce the cost of flooring, and contemporary construction technology has undergone a great and progressive revolution in modern building [1]. The quality and rich past of a place's physical environment have a definite impact on its social, commercial, and cultural attractiveness. Buildings need to satisfy interior occupancy requirements and the fundamental characteristics of comfort. A study of the connection between the built environment's quality and value in terms of people's health, society, the economy, and the environment are investigated by Carmano [2].

One among the most crucial and fundamental human necessities has traditionally been recognized as housing. The term "housing" refers to more than just a place to live. It includes not only physical building but also the environmental infrastructure, charitable deeds, and other welfare activities that greatly enhance a good life. Undoubtedly, housing is one of a person's basic wants is a place to live [3] and a house is an important mechanism to assist provide for the necessities of life and no more. It is impossible to overstate the importance of the right to housing as a fundamental need because all nations on the planet place a high priority on protecting and sheltering their populations. Housing is a process and a finished good, similar to housing as a device for sustaining life; for the goal of providing people with shelter, it is a mechanism for the provision of living quarters, protection, and comfort for the occupant(s); it is also the planning or provision made by a government body, with associated meanings. When studying the physical elements that contribute to acceptable living conditions in a home, we should keep in mind that the house is an appliance or machine for habitation [4]. Sustainable residential development necessitates a steady information between the rising housing demand and the effective utilization of materials and resources such as newly introduced waste to wealth like palm oil fuel ash and palm kernel shell are examples of agricultural and industrial waste items that can be used to lower flooring costs and lessen environmental impact [5].

A composite building material known as concrete is primarily composed of gravel, cement, and water. There are many formulas with a variety of characteristics. In the construction sector, concrete is the most common material [6]. This is produced using a combination of water, chemical admixtures, fine and coarse aggregate, and binding materials. The simplicity of concrete comes from the fact that its components are practically everywhere, making it the cheapest and most easily accessible material with strong water resistance that can be made easily when it is fresh [7]. A coarse aggregate like gravel or crushed rocks like limestone or granite and a fine aggregate like sand are the usual components of the material. The cement, usually Portland cement, as well as other cementitious components like fly ash and slag cement, hold the aggregate together.

The palm oil business produces palm kernel shell (PKS), which is utilized extensively in Africa and Asia. Earlier investigations [8-10] have thoroughly demonstrated the lignocellular properties of A substance made of living organisms (biogenic) green waste is palm kernel shell (PKS). These qualities are well-known to the material because it is used as a raw material to create other products like fly ash and lightweight concrete. Additionally, the production of palm oil results in by-products like palm oil fuel ash (POFA), empty fruit bunches (EFB), palm kernel shells (PKS), pericap, palm oil mill effluent (POME), palm kernel fibre (PKF), the oil palm tree, and palm fibre, which are primarily used as a fuel source [11]. It undoubtedly demonstrates how oil palm debris, such as unfilled fruit bunches, can be utilized as a catalyst in the transesterification process to make biodiesel [12-14].

The hard endocarp that covers the palm seed inside the palm kernel fruit is known as the shell of a palm kernel (PKS). In order to manufacture palm kernel oil, the seed must first be crushed or threshed out, it is obtained in broken pieces [15]. PKS is so light that it is the ideal substitute for coarse aggregate when building lightweight concrete. For instance, palm kernel shells can be used as reinforcement when producing concrete [16], as a fuel generating medium [17], when producing cement [18], when developing cutting tools [19], and when creating plastic polymer composites [20]. By splitting the shell to release the palm kernel nut, one can obtain the palm kernel shell by separating the fleshy fibre with the sole intent of obtaining the shell and having no interest in the palm oil.

In order to create kernelrazzo, palm kernel shell (PKS) can be utilized as a partial replacement for marble chippings (MC) in terrazzo floor finish, either entirely or to some amount [21-24]. One of the ideas at the forefront of several proposals focusing on reducing the costs of conventional building materials has been the sourcing, development, and use of alternative, non-conventional local construction materials, including the potential use of some indigenous building materials. For the rural and urban populations of Nigeria and other developing countries, there is a need for inexpensive housing solutions that use local building materials [25-31].

The unit weight of the palm kernel shell aggregate is 500–600 kg/m^3, which is almost 60% less than the weight of traditional crushed stone aggregates [21, 32, 33]. The creation and application of local building materials that are alternative and non-traditional, including the potential use of some agricultural wastes and by-products as building materials, has been one of the proposals that has been at the forefront. This is a reaction to the demand for a system of inexpensive housing for Nigeria's rural and urban populations as well as those of other emerging nations [34].

Due to their higher porosity, palm kernel shells' specific gravities range from about 1.14 to 1.37, and according to [6] the range of specific gravities was given as 1.17 to 1.37, demonstrating that palm kernel shells are among the most significant lightweight aggregates in terms of specific gravity and are around 60% lighter than typical coarse aggregates. The relationship between an object's density and a substance assigned to it is called the specific gravity of that material and [35] supplied 1.30 and 1.29, [36] reported 1.19, [37] gave same value of 1.17.

Different-sized palm kernel shells were assembled from the location where palm oil was produced and processed. The thickness of the palm kernel shell (PKS) varies depending on the species at 6, 8, or 12 mm [38], and the size of the palm kernel shell relies on how the nut is cracked or divided. These density patterns show that palm kernel shells weigh about 60% less than typical coarse materials [39-42]. The palm kernel shell's densities fall within the scope of the majority of commonly used lightweight materials [39, 41, 42]. Palm kernel shell with free and compressed bulk density differs in the scope of 500 – 600 kg/m^3 and 595 – 740 kg/m^3, correspondingly. Due to the reduced density of palm kernel shell (PKS), the density of palm kernel shell (PKS) concrete typically falls between 1600 – 1900 kg/m^3 [33, 36]. The palm kernel shells' typical moisture content ranges from 3.10 to 15%, which also meets the requirements for lightweight materials but is higher than the average moisture content of aggregates with specified weights, which is typically found between 0.5% and 1%, according to [43]. This suggests that light weight aggregates retain moisture better than standard weight materials.

PKS offers excellent abrasion resistance because to its low abrasion rate of 3.05–8.02%, which is less than the 20–25 percent for natural broken granite material [44]. This demonstrates that it has a far lower cost than typical coarse aggregates and a high level of wear and tear resistance. When compared to typical crushed stone aggregates, palm kernel shells have an aggregate impact value of 16.19% and an aggregate crushing value that is significantly low [45]**.** [46] showed that these shells can be successfully employed in brake lining compositions when correctly coupled with other supplements and briquettes since they are subjected to harsh and varying braking forces particles. Ordinary Portland Cement (OPC) Type 1, a cement that complies with the [47, 48] with a specific gravity of 3.15 g/cm³. Concrete's ability to attach is improved by cement. [49] studied the hydration/pozzolanic state and the microstructure of hardened materials reaction mechanism provided a means of unlocking the enigma around the concrete's mechanical qualities and durability. The bulk density cement content was held constant at 1362 kg/m^3 and the most often used type of cement is Portland cement type 1 as outlined in Table 1. Ordinary Portland cement (OPC) from Malaysia was used in the test as a binder since it complies with the requirements in [50] for a common cement, which details its composition, specifications, and conformity criteria.

Table 1
Properties of OPC Type 1

S/N	Chemical properties of cement		Physical properties of cement	
	Composition	%	Composition	Specifications
1.	Silicon dioxide (SiO_2)	21.28	LOI	0.64
2.	Aluminium oxide (Al_2O_3)	5.60	Specific gravity	3.14
3.	Calcium oxide (CaO)	64.68	Blaine's specific surface area (cm^2/g)	3510
4.	Potassium oxide (K_2O)	0.39	Bulk density (kg/m^3)	1362
5.	Sodium oxide (Na_2O)	0.40	-	-
6.	Iron oxide (Fe_2O_3)	3.36	-	-
7.	Magnesium oxide (MgO)	2.06	-	-
8.	Sulphur oxide	2.14	-	-

As measured by its weight per unit volume, cement's bulk density was computed using the [51] standard to determine its relative density or specific gravity. Calculating the percentage of the cement that passed through the 0.045 mm sieve in line with [52, 53] technique allowed for the determination of the cement's fineness. Due to excessive water, the damage to concrete structures occurs in strength reduction; drying shrinkage; durability reduction; dusting and scaling; loss of abrasive resistance; and rise in permeability [54]. If there is little water in the concrete mix, it will encourage rise to fragile and pervious concrete. Hence, why bother about whether the water is too much or too small when you can calculate it to avoid its adverse effects [54, 55]. Quantity of water required using 0.5 water-cement ratio [55]. Moreover, the water used to produce kernelrazzo concrete must be fit for human consumption and free of organic material, alkalis, and acids. Volumetric calculations along with an acceptable waste percentage ranging from 3 to 8% are necessary to determine concrete volumes for a construction project [56].

The main purpose of concrete's compressive strength is to carry and transmit imposed loads; the minimal compressive strength of lightweight concrete in accordance with [57] is 17Mpa at 28 days. Researchers have looked into the compressive strength of lightweight geopolymer concrete, extensively, with a variety of results reported. Compressive strengths were measured at 7 and 28 days using [58] A decrease in the amount of coarse aggregate and a constant rise in palm kernel shell in the concrete mixture also caused a drop in compressive strength because the weight of palm kernel shells is weaker than that of granite [59]. The specified cylindrical compressive (fc) strength of 17 MPa by ACI is almost closer to this value. According to [60] the compressive strength was 22 MPa. Previous researchers [61-63] employed the ACI mixed design approach for NWC; the goal strength was 28 MPa higher and the compressive strength was 13.65 MPa. [64] recorded a strength of 37 MPa, which exceeded the necessary minimum strength of 20 MPa by 85%. It was discovered that the cement matrix and PKS's link were reinforced by the suction of silica fume into the material's pores.

According to [65, 66], this must be followed while creating structural lightweight concrete, and 2.0 MPa is the minimum splitting tensile strength requirement.

Additionally, according to a number of researchers, including [60, 63, 64] the splitting tensile strength of the lightweight materials concrete after 28 days curing age generally varied from nearly 1.1 to 2.4 MPa [67]. The size distribution of the materials is one of the most major factors that hinders the water absorption, durability, mechanical strength, and workability of concrete, according to [68], one of the most important elements that impedes concrete's water absorption, durability, mechanical strength, and workability is the size distribution of the ingredients. Historically, concrete has been regarded as a sturdy substance, but this belief is no longer shared by many people. According to [69] numerous issues, including poor design, carelessness and oversight during construction, and the use of the wrong building materials, contribute to concrete's inability to achieve this requirement. In this study, the water cement ratio and aggregate size distribution are considered to assess the durability and strength of the concretes created and their value. Table 2 contains the volume of the batch-determined components of concrete which to determine the ratio that will provide adequate durability, economy, and strength, when utilized for kernelrazzo concrete production, the ratios of water, cement, quarry dust, palm kernel shell, and marble chippings were determined using absolute volume and DoE method.

Table 2
Volume of the batch-determined components of kernelrazzo concrete

Description	Beam	Cube	Cylinder
Strength Test	Flexural	Compressive	Tensile Splitting
Size, mm	40 x 40 x 160	100 x 100 x 100	100 x 200
Testing Days After Curing	3, 7, 14, 28	3, 7, 14, 28	3, 7, 14, 28
Number	3 x 4 = 12	3 x 4 = 12	3 x 4 = 12
Concrete Volume V, m^3	0.003	0.012	0.019

When calculating each component that resulted in the concrete volume in terms of 50 kg cement bags in m^3, DoE and the absolute volume approach were used. The specific gravity and bulk density of each material were considered. To establish the batching of the concrete's constituent parts as shown in Table 2, the gained volume is then converted to weight.

2. Materials and Methodology

Palm kernel shells were generated from United Palm Oil Industry, Nibong, Malaysia and it was obtained as cracked one and palm oil has been extracted from it, PKS was put inside detergent water for twenty-four hours to allow the dirt of oil on it to be cleaned off, marble chippings of 19mm size as coarse aggregates, quarry dust as fine, cement were supplied by the supplier form Penang Island, and water was sourced from the HBP concrete laboratory. Cement utilized was Ordinary Portland Cement CEM Type 1 in conformity in accordance with the European Standard, [50] Type 1 cement were kept constant. Percentages of PKS in partial replacement for marble chippings were 10, 20, 30, 40, and 50, while 100% marble chippings, 0.5 w/c ratio and quarry dust of 33% serve as control. For each percentage replacement, the following tests were carried out; Flexural strength, splitting tensile and compressive strength and slump tests to determine the fresh and mechanical properties of kernelrazzo concrete.

2.1 Mix Proportion

Six samples of the concrete mixture were examined in this investigation. 10% of the required water, 100% of the fine aggregate, 50% of the coarse aggregate, 100% cement, and the remaining 50% of the coarse aggregate were all added to the spinning mixer. 80% of the required water was added before the mixture was removed from the rotating mixer, and the minimum amount of time for mixing was 4 minutes. The remaining 10% of the water was then added and allowed to spin for 30 seconds before being poured directly on top of the already-mixed concrete on the platform. The samples were marked PKSC-11 for palm kernel shell concrete with 100% granite, PKSC-12, PKSC-13, PKSC-14, PKSC-15, and PKSC-16 for palm kernel shell concrete with 10%, 20%, 30%, 40%, and 50% marble substitution, respectively. Tables 3, 4 and 5 summarize batching and mixing with various mix compositions for compressive strength and flexural strength tests, respectively.

Table 3
Mix proportions of PKSC Compressive strength test samples

Mix Samples	Mix Proportion (%)		Cement (kg)	Fine Aggregate (kg)	Water (kg)	Coarse Aggregate (kg)		Cube
	PKS	MC				PKS	MC	
PKSC-11	0	100	6.048	8.27	3.024	0.00	16.79	12
PKSC-12	10	90	6.048	8.27	3.024	1.68	15.11	12
PKSC-13	20	80	6.048	8.27	3.024	3.36	13.43	12
PKSC-14	30	70	6.048	8.27	3.024	5.04	11.75	12
PKSC-15	40	60	6.048	8.27	3.024	6.72	10.07	12
PKSC-16	50	50	6.048	8.27	3.024	8.395	8.395	12

Table 4
Compressive strength kernelrazzo concrete mix of 100 x 100 x 100mm cubes

Water/cement	Ingredients		19 mm granite weight (kg)
0.5	Water		18.144
	Cement		36.288
	Fine aggregate		49.62
	Coarse aggregate	Palm kernel shell	25.195
		Marble chippings	75.545

Table 5
Flexural strength kernelrazzo concrete mix of 40 x 40 x 160mm cubes

Water/cement	Ingredients		19 mm Granite Weight, Kg
0.5	Water		4.92
	Cement		9.84
	Fine aggregate		13.44
	Coarse aggregate	Palm kernel shell	6.825
		Marble chippings	15.925

2.2 Workability and Slump Tests

The concrete slump test, a rudimentary gauge of a fresh batch of concrete's flexibility after curing, can be used to evaluate workability. The concrete slump test as outlined in Table 6, a rudimentary gauge of a fresh batch of concrete's plasticity following curing in line with [70, 71] test standards, can be used to evaluate workability. By adding a sample of fresh concrete to an "Abram's cone," slump is often measured. Ten minutes after the finished concrete mixture was mixed, the tests for slump and compacting factor were conducted. The slump test was conducted according to the steps given in [72, 73]. The slump test is crucial for determining new concrete's consistency as well as its high and medium workability [70]. In line with [74], the 100 mm x 100 mm x 100 mm concrete cubes were evaluated at 3, 7, 14, and 28 days after being removed from the clear water curing tank. The cubes were put through their paces in a laboratory with a calibrated compression machine, and the reading upon failure was used to calculate the concrete's maximum compressive strength. Table 6 shows the slump readings for PKSC blends with percentage replacement levels of ordinary Portland cement Type 1 with water cement to ratio of 0.5.

Table 6
Slump test of PKSC on samples

Mix Samples	Mix Proportion (%)		Slump (mm)
	PKS	MC	
PKSC-11	0	100	190
PKSC-12	10	90	180
PKSC-13	20	80	170
PKSC-14	30	70	140
PKSC-15	40	60	100
PKSC-16	50	50	80

The slump is one of the earliest and most used methods for evaluating workability tests. PKSC-11 samples recorded a higher slump with 190mm followed by PKSC-12, PKSC-13, PKSC-14, PKSC-15 and having the least slump value of 80mm due to the presence of 50% PKS.

3. Results and Discussions

This research has presented the findings of studies conducted on palm kernel shell, marble chip quarry dust, and cement. Table 1 displays the results of this study on the chemical and possible compound compositions when utilizing regular Portland cement Type 1 to produce kernelrazzo concrete. To establish the batching of the concrete's constituent parts as shown in Table 2, the gained volume is then converted to weight. Tables 3, 4 and 5 summarize batching and mixing with various mix compositions for compressive strength and flexural strength tests, respectively.

3.1 Compressive Strength

A compressive strength test is employed to evaluate the concrete's resistance to an axial force applied to its surface. Compressive strength is calculated in line with [74]. The primary factor that affects elastic modulus, flexural strength, and splitting tensile strength of concrete is its compressive strength. Six concrete batch mixes with varying percentages of palm kernel shell materials varying from 0, 10, 20, 30, 40 and 50% partially replaced with marble chippings to evaluate the impact of replacing them as coarse materials on the compressive strength of kernelrazzo concrete (PKSC). This test will reveal the cube's breaking strength, which was created specifically to measure the compressive strength of compacted concrete. The given reading is the average reading of three samples and the compressive strength of the sample is evaluated by dividing the optimum load, P carried by the sample during the investigation by the average cross-sectional area, A.

$$\text{Compressive strength}, \delta = \frac{P}{A} \quad (1)$$

where *A is a cross-sectional area cube, P is the optimum load at failure.*

3.1.1 Effect of PKS on compressive strength

Figure 1 is a graphical representation of the average compressive strength findings for all samples at 3, 7, 14, and 28 days. The most accurate way to evaluate the calibre of concrete is through its compressive strength. The compressive strengths displayed by the tested cement kernelrazzo concrete mixtures are listed in Table 7. The readings shown in Table 6 represent the average of readings from three samples. We shall go into detail about factors like PKS replacement level and sample age that promote the compressive strength of cement concrete mixtures. According to past studies, the compressive strength of concrete increased as palm kernel shell content did. The results of strength similarly dropped as the quantity of palm kernel shell (PKS) increased in the palm kernel shell concrete (PKSC) [75, 7, 76]. To increase the compressive strength of the kernelrazzo concrete, one technique is to lower the volume of palm kernel shell by lowering the volume of PKS or replacing it with another form of aggregate. Curing conditions and a decrease in water content also helped to enhance good compressive strength. The compressive strength results of palm kernel shell concrete (PKSC), reduced as the percentage content of PKS rose in the concrete [76]. The outcomes are shown in Table 6 and illustrated graphically in Figure 2. On basis of this example, the curing procedure used to create the kernelrazzo concrete floor is suggested. water supply on a regular basis while the concrete for kernelrazzo is curing.

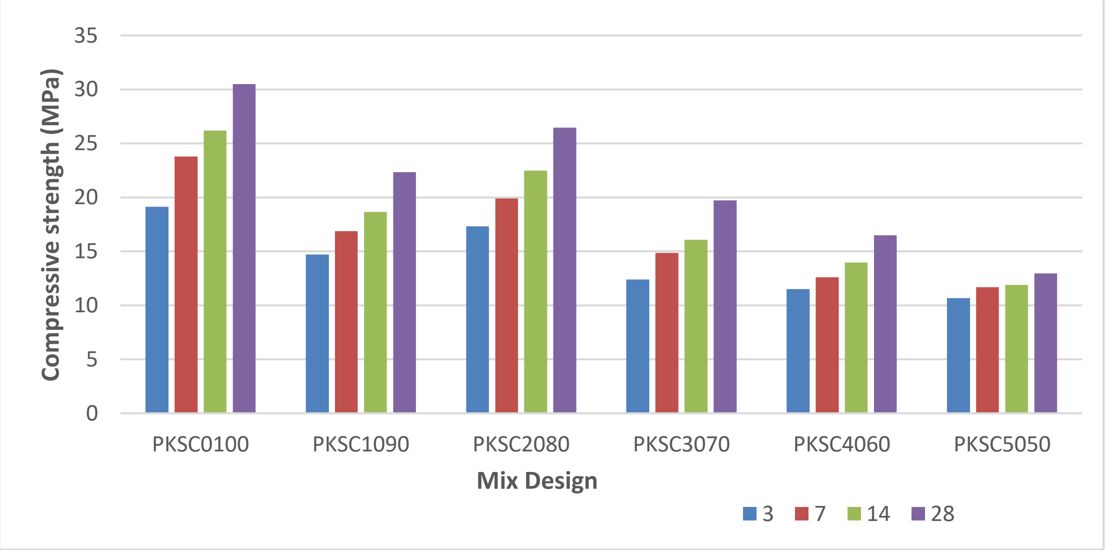

Fig. 1. Evolution of compressive strength with age for the kernelrazzo concrete

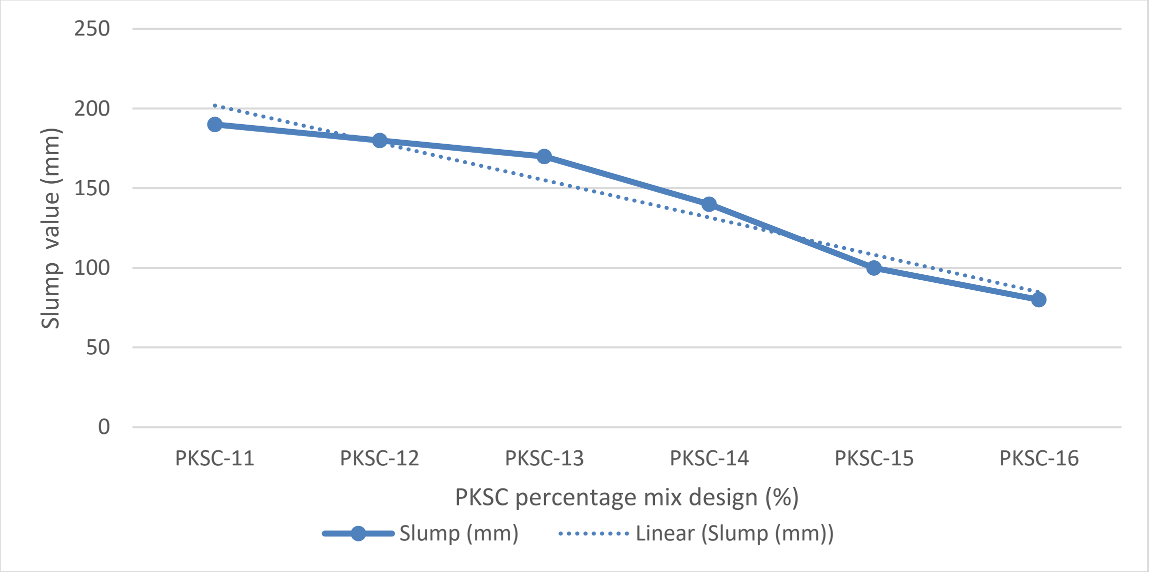

Fig. 2. Development of slump of POFA blends against percentage replacement (mm)

Table 7
Compressive strength for the cement kernelrazzo concrete mixes (N/mm^2)

Mix	Curing Age (Days)			
	3	7	14	28
PKSC-11	19.14	23.77	26.18	30.50
PKSC-12	14.71	16.86	18.66	22.32
PKSC-13	17.33	19.91	22.49	26.46
PKSC-14	12.38	14.85	16.06	19.72
PKSC-15	11.51	12.61	13.97	16.47
PKSC-16	10.66	11.67	11.88	12.96

According to Table 7, the control sample, PKSC-11, has the maximum compressive strength at 30.50 N/mm^2, followed by the sample, PKSC-13, at 26.46 N/mm^2, and the sample, PKSC-12, at 22.32 N/mm^2. At 28 curing ages of 28 days, cement kernelrazzo concrete has a minimum compressive strength of 12.96N/mm^2.

Figure 1 illustrates the compressive strength progression with age for cement kernelrazzo concrete mixes with PKSC-11, PKSC-12, PKSC-13, PKSC-14, PKSC-15, PKSC-16 design parameter respectively. The figures show that all the compressive strengths improved with age. PKSC-1 increases from 23.77 – 30.50 N/mm^2 (24.19% - 59.35%), PKSC-2 moves from 16.86 – 22.32 N/mm^2 (14.62% - 51.73%), PKSC-3 enjoying from 19.91 – 26.46 N/mm^2 (14.89% - 52.68%), PKSC-4 from 14.85 – 19.72 N/mm^2 (19.95% - 59.29%), PKSC-5 increases from 12.61 - 16.47N/mm^2 (9.56% - 43.09%), and PKSC-6 rises from 11.67 - 12.96N/mm^2 at 7 and 28 days respectively.

3.2 Flexural Strength Test

To allow for a flexural strength test in accordance with [77, 78], a third point loading with an effective span, l, of 450 mm was accomplished on the simply supported sample as indicated in Figure 1. The rupture modulus, or flexural strength, F, was determined by applying the load continuously and without shock at a rate of 200 m/s, and then using the formula below:

$$Flexural\ strength, F = \frac{PL}{bd^2} \tag{2}$$

P stands for maximum breaking load; L stands for span length; b stands for specimen breadth; and d stands for specimen depth.

3.2.1 Effect of PKS flexural strength

To assess the flexural strength of concrete, two ASTM standard tests are employed [77, 79]. Modulus of Rupture (MR) in psi is the unit of measurement for results. Flexural tests are extremely sensitive to the handling, preparation, and curing of concrete. The specimen should be moist when the test is performed. Because these figures are more trustworthy, findings from compressive strength tests are more frequently used to describe concrete's durability. The flexural strength, splitting strength and compressive strengths of kernelrazzo concrete mixes have been tested for all the kernelrazzo concrete for cement and palm oil fuel ash types in this study. The flexural strength of kernelrazzo concretes were calculated and examined at the ages of 3, 7, 14, 28 days. Table 8 which are shown in Figure 1. It will be proven that flexural strength and compressive strength are related. Cracks started when the samples were subjected to flexural load. Sincerely concrete are strong in compression but weak in tension. The compressive strength and flexural strength of concrete is decreased by PKS addition. However, replacing 25% PKS with acceptable values results in values that are as long as lightweight structural concrete is used, which is permissible. At 28 days of age, the 0%, 10%, 20%, 30%, 40% and 50% PKS acquire appropriate strength values of 5.44N/mm^2, 3.85N/mm^2, 4.56N/mm^2, 3.01N/mm^2, 2.46N/mm^2 and no result at 50% PKS respectively. Flexural strength is influenced by particle size, as evidenced by the loss of between 41.50% and 45.22% observed in specimens containing 40% PKS. About 7 and 12% of the corresponding compressive strengths were represented by the 28-day flexural strengths.

Table 8
Flexural strength for the kernelrazzo concrete mixes (N/mm^2)

Mix	Curing Age (Days)			
	3	7	14	28
PKSC-21	3.86	4.53	4.63	5.44
PKSC-22	3.23	3.55	3.69	3.85
PKSC-23	3.57	4.17	4.23	4.56
PKSC-24	2.45	2.59	2.89	3.01
PKSC-25	1.67	1.88	2.15	2.46
PKSC-26	-	-	-	-

The kernelrazzo concrete's curing time for solidification had an impact on the results of the tensile splitting strength. Flexural strengths have been evaluated for all of the kernelrazzo concrete mixes in this research at various ages, just like tensile splitting strengths. The flexural strengths were assessed at ages 3, 7, 14, and 28. The flexural strengths of the various age groups of kernelrazzo concrete mixes are shown in Table 7.

Figure 3 below illustrates the flexural strength for the mixes in samples PKSC-21, PKSC-22, PKSC-23, PKSC-24, PKSC-25 and PKSC-26, the flexural strengths reduced with increasing PKSC replacement levels beyond 20%. PKSC-21, PKSC-22 and PKSC-23 exhibited higher flexural strengths than PKSC-24 and PKSC-25, there is no result for PKSC-26 mixes at all ages because of the high volume of PKS presence. Flexural strengths at 28 days of age for PKSC-21, PKSC-22 and PKSC-23 (5.44N/mm^2, 3.85N/mm^2, 4.56 N/mm^2) are higher than those exhibited by other mixes by 40.93%, 19.20% and 27.73%. There is no flexural strength result for PKSC-26 due to the high proportion of 50% PKS.

Particle size has an impact on flexural strength since samples containing 50% of PKS showed a 100% loss in flexural strength at all days of age.

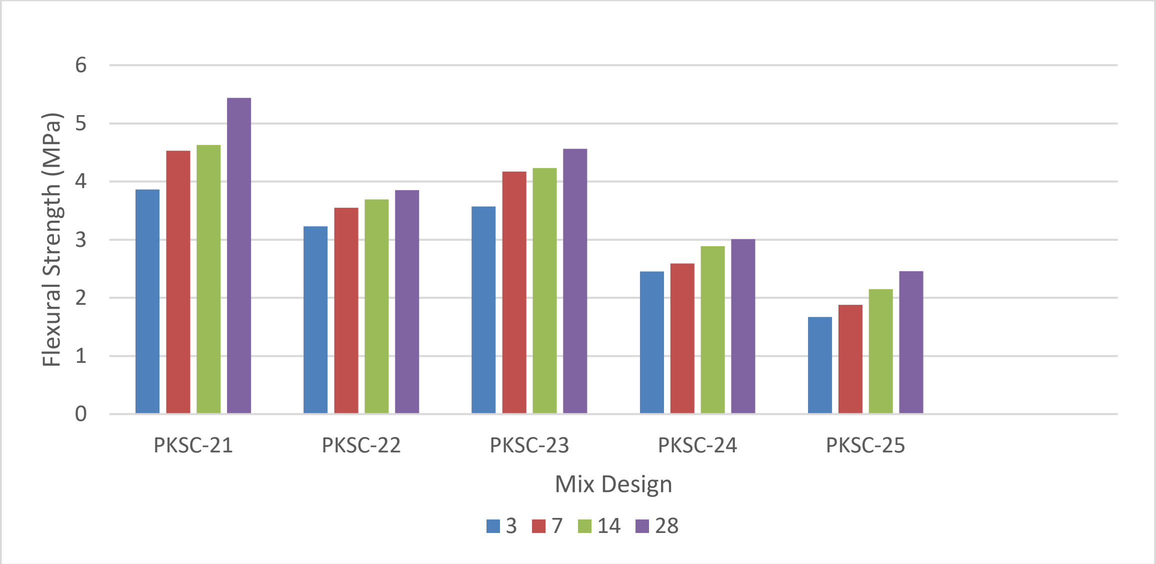

Fig. 3. Spread of flexural strength for the kernelrazzo concrete (MPa)

The impact of increasing PKS levels on flexural strength of kernelrazzo concrete has been shown in Figure 1. The kernelrazzo concrete mixes' flexural strengths displayed a similar pattern to that seen in the analysis of their tensile splitting strengths.

4. Conclusions

The waste product known as palm kernel shell (PKS) is produced by the palm oil industry, which is widely used in nations in Asia and Africa. As a result, using the palm kernel shell in applications needing low to moderate strength works well as a coarse aggregate in the production of kernelrazzo concrete and other lightweight structures. A typical Portland cement Type 1, quarry dust, palm kernel shell, and marble chips were used to create concrete specimens for testing compressive and flexural strengths. This kernelrazzo concrete production technique employs a water cement ratio of 0.5. At the curing age of 28 days, the concrete's flexural strength of the kernelrazzo concrete for the 0%, 10%, 20%, 30%, 40% and 50% replacements were 5.44 N/mm^2, 3.85N/mm^2, 4.56 N/mm^2, 3.01N/mm^2, and 2.46N/mm^2. There is no result at 50% palm kernel shells, because concrete is good in compression but week in tension. Based on the findings, it is advised to utilize palm kernel shell in place of some of the coarse aggregate (a substitute material) for kernelrazzo concrete and for creating lightweight concrete with the use of 20% PKS and 80% marble chippings.

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