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Mechanical and Durability Properties of Kernelrazzo Floor Finish: A Review

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Abstract: ***This writes up analyse earlier investigation on the major benefits and problems associated with the utilization of palm kernel shell as limited substitute of marble chippings as a local material in the production of kernelrazzo floor finish tiles. Although papers on kernelrazzo floor finish are few and one hundred and one (101) current related papers on palm kernel shell concrete were used to produce lightweight concretes and former literatures was assessed on the durability and strength of kernelrazzo floor finish. Rarely work has been done on incorporating palm kernel shell as incomplete substitute of marble in the production of kernelrazzo floor finish tiles. Palm kernel shell is one of the waste agricultural products obtained from production palm oil which is originating from the palm oil industry which common in Africa and Asia. Properties and characteristics of palm kernel shell (PKS) and marble chippings are summarized as specific gravity to include shape, thickness and texture include bulk density, water absorption and moisture content. Mechanical properties tests on palm kernel shell also include abrasion property and impact resistivity. Lightweight properties of concrete produced with palm kernel shell (PKS) have a limited substitute of coarse aggregate which include chemical and physical properties of granite dust were appraised. Mechanical properties of kernelrazzo floor finish tiles that were reviewed include compressive strength; curing and minimum requirement for Terrazzo floor finish and final for the area covered on this review is the consequence of acids, bases, and salts on the durability and strength of kernelrazzo floor finish.***

Keywords: ***Mechanical Properties, Durability, Palm Kernel Shell, Kernelrazzo, Marble Chippings, Granite Dust***

I. INTRODUCTION

Housing has always been identified and classified as one of the most cogent and fundamental human needs. The term 'housing' has a broader use and definition beyond mere shelter. It involves not just structure, but also the infrastructural facilities provided within the surroundings, the good works rendered and other welfare work that contribute immensely for a good living. Housing is indeed one of the primary needs of human [1]. Provision of protection and shelter for the citizens is an important agenda for nations all over the world, thus, the right to housing as a basic need cannot be overemphasized.

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Housing is a process and product same as housing as a machine for living, housing is an enclosure for the provision of shelter, living and protection for the comfort of the occupant(s), for the purpose of sheltering people, the planning or provision delivered by an authority, with related meanings [2].

A residential home is the second indispensable need for every human being after food [3-6]. The physical survival of mankind depends on housing, besides food and clothing [7-8]. Sufficient and pleasant home encourages the wellbeing, and leads to the mental stability, efficiency, and development in works places [9].

Palm kernel shell (PKS) is an agricultural by-product originating from the palm oil industry which common in Africa and Asia. The lignocellular characteristics of palm kernel shell (PKS), as a material produced by living organism (biogenic) green waste has been well established in the literature [10-11]. These properties have familiar to the material for being used as a raw material to produce other materials such as fly ash, lightweight concrete production as well as, the production of palm oil result on by-products such as Empty Fruits Bunches (EFB), Palm Kernel Shells, pericap, Palm Oil Mill Effluent (POME), Palm Kernel Fibre (PKF), the oil palm tree, and palm fibre are used mostly as a source of fuel for domestic cooking in most areas where they occur [12-13].

Palm kernel shell PKS is the hard endocarp of palm kernel fruit that encloses the palm seed. It is obtained as broken pieces after threshing or crushing to remove the seed which is used in the production of palm kernel oil [14]. PKS is very light and therefore ideal for replacement as coarse aggregate in the production of light weight concrete. For example, palm kernel shell may be used in the manufacturing of concrete as reinforcement [15]; fuel generation medium [16]; cement production [17]; cutting tool development [18] and plastic polymer composite development [19]. Palm kernel shell can be obtained by removing the fleshy fibre with the sole aim of reaching the shell without interest in the palm oil by cracking the shell to get palm kernel nut, the shell is thus obtained. Palm kernel shell (PKS) can be used as a partial replacement to marble chippings (MC) either fully or to some extent in terrazzo floor finish to produced kernelrazzo [20].

The palm kernel shells aggregate has a unit weight of 500 - 600 kg/m^3 and this is approximately 60% lighter than the conventional crushed stone aggregates [21, 22].

With the quest for affordable housing system on the use local building material for both the rural and urban population of Nigeria and other developing countries in housing production, various proposals focusing on cutting down conventional building material costs have been put forward and one of the suggestions in the forefront has been the sourcing, development and use of alternative, non-conventional local construction materials including the possibility of using some agricultural wastes such rice husk, coconut shells, periwinkle and residues as construction materials [23].

Palm kernel shell is an agricultural by-product to use as lightweight aggregate which originated from the palm oil industry, which is approximately 50% lighter than conventional aggregate [24]. Malaysian country is currently account for 51% of world palm oil production and 62% of world exports [25]. It was received that almost 80% of the volume from the transforming of the fresh fruit bunch is removed as waste [26] and it was also obtained that over 4.56 million tonnes of waste palm kernel shell are generated annually [27]. A by-product of the extraction of palm oil from palm fruits (Pressed fibre) and shell are commonly utilised as rigid fuels for steam boilers to roll turbines for the electricity production of a palm oil mill. However, the issues connected with the burning of these two solid fuels are the emission of dark smoke and the carryover of partially carbonized fibrous powdered due to incomplete combustion of the fuels [28].

Palm kernel shell is an absorbent aggregate with a permeability of about 37% [12]. Permeability was detected as one of the factors influencing the heat transfer of lightweight concrete [29]. So, the body (cellular) structure of palm kernel shell gives thermal insulation characteristics to palm kernel shell concrete. The thickness of the shell is within the scope of most typical lightweight aggregates [30] and the specific gravity of the shells vary from between 1.14 and 1.37. Research over the years shows that palm kernel shell can be used as a lightweight aggregate (LWA) for producing structural lightweight aggregate concrete (LWAC) with a density 20–25% lower than normal weight concrete [31]. A cost analysis in Nigeria [23] indicated cost reduction of 42% for concrete produced from palm kernel shell is visible. The use of palm kernel shell as a lightweight aggregate (LWA) in producing LWC was re-searched as early as 1984 by [32] in Malaysia. It was shown that, generally, the engineering properties of palm kernel shell (PKS) concrete are satisfactory [33, 34, 35, 36]; however, there is still some hesitation regarding the use of palm kernel shell lightweight concrete. This may be because the mechanical properties of palm kernel shell concretes are slightly lower than other types of lightweight aggregate concrete. The utilization of palm kernel shells as an alternative to conventional materials for construction is desirable to promote sustainable development [37].

Researchers [13, 20, 23, 34, 38-43, 45-46] have appraised the properties of palm kernel shells as acceptable for use as a lightweight aggregate material to produce lightweight aggregate concrete. Also, research has been carried out and discovered that it is useful as granular filter for water treatment. It is also ascertained that palm kernel shell is suitable as an aggregate in production of plain, light, and dense concretes. It also used as materials for road and building constructions [32].

The maximum size of PKS is found about 15 mm. Though the sizes of PKS may vary depending upon the type of machine used to break the palm nuts but normally the size of the shells are in the scope of 2 and 15 mm. The shells characteristics are flaky, parabolic, angular, and possess smooth concave and convex surfaces. The thicknesses of PKS vary in the range of 1.5 and 3 mm. Previous investigations carried out on palm kernel shell concentrated on using the shells of different sizes above 3 mm after removing smaller particles less than 3 mm. The results showed that using palm kernel shell as lightweight aggregate, structural grade concrete of compressive strength of about 15 to 25 MPa could be generated [46].

The ground husk exhibited a bulk density of 560kg/m3 and a specific gravity of 1.26, indicating a porosity of 56% [47]. This shows that the pulverized PKS holds a good promise of high compressibility, which is desirable in constituents of fuel briquettes [48]. It is additionally demonstrated that palm oil by-products can be used as the briquette from the blend of biochar and bio-oil which are important, and desirable for use for heat generation. The briquette produced can replace coal in a few uses [49].

II. MATERIALS

The available kernelrazzo floor finish tiles experimental results used for the review were compiled mostly from papers presented at different published articles and conferences. The main materials used for this review and research works are cement, marble chippings, granite dust and palm kernel shells (as substitute for marble) and water. The published articles used include google scholar, science direct, Scopus and web of sciences databases

2.1 Properties and features of palm kernel shell (PKS) and marble chippings

The mechanical properties of palm kernel shell (PKS) depend on the physical properties of palm kernel shell. The physical properties used are specific gravity, loose bulk density, compacted bulk density, moisture content, water absorption and porosity for this review as shown in Table 1.

2.1.1 Specific gravity

Palm kernel shells specific gravity, because of its higher porosity, range from about 1.14 - 1.37, and [50] gave the scope of specific gravity as from 1.17 to 1.37 which also show that palm kernel shells are about 60% lighter than standard coarse aggregates.

The specific gravity of the shell is within the scope of most important lightweight aggregates [30]. The specific gravity of a material is the ratio between the density of an object, and a attribution material [51]. Normally, our material is water which always has a density of 1 gram per millilitre or 1 gram per cubic centimetre. Specific gravity of palm kernel shell varies but not exceeds 2.0 as reported in Table 1. The array of specific gravity for palm kernel shell (PKS) is between 1.62 and 1.14.

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The maximum value of specific gravity of palm kernel shell (PKS) from Table A.1 was reported to be 1.62 by [52] when palm kernel shell (PKS) was used for soil stabilization followed by [53] reported 1.42, [34] gave 1.37, [54] reported 1.30 and 1.29, [33, 45, 51, 55] reported the same value of 1.27, [47] gave 1.26,
[31] reported 1.22, [56] gave 1.19, [36, 46, 57, 58, 59] reported same value of 1.17. [12] reported the least value of specific gravity of 1.14.

2.1.2 Shape, thickness and texture

Figure 2 shows the palm kernel shell of different sizes as obtained from the palm oil processing and production site. The size of palm kernel shell relies on the separation method or cracking of the nut [12, 30, 57]. The thickness of palm kernel shell (PKS) varies in sizes 6, 8, 10, 12 mm depending on Species [37]

Figure 1: Thickness palm kernel shell

Figure 2: Unbroken palm kernel shell

Figure 3: Waste palm kernel shell

Figure 4: Palm kernel shell of different sizes

2.1.3 Bulk density

Bulk density is a characteristic of powders, granules, and other divided solids, especially used in relation to mineral components, chemical substances, ingredients, foodstuff, or any other masses of corpuscular or particulate matter. Higher porosity of palm kernel shells than standard aggregates make the loose and compacted bulk densities varies from about 500 - 550kg/rn3 and 590 - 620kg/m^3 respectively. These arrays of densities show that Palm kernel shells are nearly 60% lighter than standard coarse aggregates. The densities of the shell are within the scope of most typical lightweight aggregates [12, 30]. Loose and compacted bulk density of palm kernel shell varies in the range of 500 – 600 kgm^{-3} and 595 – 740 kgm^{-3} respectively [27, 36] of 500, [30] of 512, [12] of 545, [34] of 566 and [27, 36] of 600, [47, 30] 589, [58] 590, [59] 590, [12] 595, [57] 592, [46] 592, [53] 610, [56] 610, [51] 620, [45] 620, [34] 620, [32] 620, [60] 634, [31] 683 and [52] 740. Due to lower density of palm kernel shell (PKS), the density of concrete made of palm kernel shell (PKS) normally occurs within the scope of 1600 – 1900 kgm$^{-3.}$

2.1.4 Water absorption

Palm kernel shells have a 24hour water absorption capacity range of 10.20 – 33% as seen in Table 1. Palm kernel shell rising rate of water penetration and retention is high because of many holes in it. It was discovered by [30] that palm kernel shell has high water absorption of 33% based on different species and matured age of palm tree species and having the least value of 10.20% as reported by [31]] compared to standard gravel aggregates that normally have water absorption of less than 2% [61]. This high-water absorption could be due to the high pore content because the permeability of the shell is 37% [12]. [62] reported an improvement in the quality of palm kernel shell (PKS) by using pre-treatment methods such as 20% poly vinyl alcohol as a solution for treatment. Water absorption of palm kernel shell (PKS) seriously decrease from 23.3 to 4.2% due to the application of poly viny alcohol pre-treatment application.

2.1.5 Moisture content

The average moisture content of moisture content obtained from the palm kernel shells varies from 3.10% to 15% from Table 1 which also fall within the specification for light weight aggregates but greater compared to the standard weight aggregates which is normally found between 0.5%-1% as reported by [63] and is an indication that light weight aggregates retain moisture than normal weight aggregate.

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Table 1: Physical properties of palm kernel shell (PKS) as reported in literature

References	Specific gravity	Loose bulk density (kgm^{-3})	Compacted bulk density (kgm^{-3})	Moisture content (%)	Water absorption 24h (1hr) (%)	Porosity (%)
Abdullah [32]	-	-	620	-	-	-
Okafor [30]	1.37	512	589	-	27.3	-
Okpala [12]	1.14	545	595	-	21.3	37
Basri et al. [57]	1.17	-	592	-	23.32	-
Mannan and Ganapathy [44]	1.17	-	592	-	23.32	-
Teo et al. [36]	1.17	500-600	-	-	33	-
Ndoke [52]	1.62	-	740	9	14	28
Jumaat et al [34]	1.37	566	620	8-15	23.8	-
Mahmud et al. [45]	1.27	-	620	-	24.5 (10-12)	-
Alengaram et al. [51]	1.27	-	620	-	25 (10-12)	-
Gunasekaran et al. [58]	1.17	-	590	-	23.32	-
Olusola and Babafemi [53]	1.42	-	610	3.10	22.30	-
Aslam et al. [56]	1.19	-	610	-	20.5	-
Shafigh et al. [31]	1.22	-	683	-	10.20 and 18.73	-
Khankhajea et al. [54]	1.29 and 1.30	-	-	-	24.73 and 25.62	
Alengaram et al. [51]	1.27	-	620	-	25	-
Huda et al. [59]	1.17	-	590	-	23.30	-
Fono-Tamo and Koya [47]	1.26	-	560	-	13.40	56
Oti et al. [60]	1.30	-	634	-	21.50	-
Yew et al. [64]	1.33		628		23.50	
Danso and Appiah-Agyei [37]	1.29+_0.22	-	634+_42	-	11.64+_2.35	-
Eziefula et al. [65]	1.30	530	600	-	19.60	-

2.1.6 Uses of Palm Oil Fruits/Fibre/Kernel Shell

i. The oil palm tree, and palm fibre are used mostly as a source of fuel for domestic cooking in most areas where they occur [12-13].

ii. Palm kernel shell PKS is the hard endocarp of palm kernel fruit that encloses the palm seed. It is obtained as broken pieces after threshing or crushing to remove the seed which is used in the production of palm kernel oil [14].

iii. PKS is very light and therefore ideal for replacement as coarse aggregate in the production of light weight concrete.

iv. Palm kernel shell may be used in the manufacturing of concrete as reinforcement [15];

v. Used in fuel generation medium [16].

vi. Palm trees used in cement production such as palm oil fibre ash, POFA [17];

vii. It is used in cutting tool development [18] and

viii. Palm oil products are useful in plastic polymer composite development [19].

III. MECHANICAL CHARACTERISTICS OF PALM KERNEL SHELL

Researchers have reported the mechanical characteristics of palm kernel shell (PKS) with the use of Los Angeles Abrasion (LAA) equipment to test hardness properties of aggregates, aggregate impact resistance (AIR) and aggregate crushing values (ACV) as showing in Table 2 and.3.

3.1 Abrasion property

The Los Angeles abrasion value of the palm kernel shells, and crushed stone was reported as 8.02% by [34] 10% by [30]. This shows that it is much lower than standard coarse aggregates and has a good resistance to wear and tear.

3.2 Impact resistivity

Palm kernel shells have aggregate impact value of 16.19%, the aggregate impact value and aggregate crushing value were much lower compared to normal crushed stone aggregates. This shows that the aggregate has a good ability to resist sudden shock or impact [46, 59] of 7.86% respectively. [47] demonstrated that because these shells are subjected to hard and variable braking forces particles, they can be effectively used in brake lining formulations when properly combined with other additives and briquettes.

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Table 2: Mechanical properties of palm kernel shell

REFERENCES	Abrasion value (Los Angeles) %	Aggregate impact value (AIV) %	Aggregate crushing value (ACV) %
Okafor [30]	-	6.00	10.00
Okpala [12]	3.05	-	4.67
Basri et al. [57]	4.80	-	-
Mannan and Ganapathy; Mannan and Ganapathy [44, 46]	4.80	7.86	-
Olanipekun et al. [23]	3.60	-	-
Mannan et al. [62]	-	1.04 - 7.86	-
Ndoke [52]	-	4.50	-
Teo et al.; Neville [36, 63]	4.90	7.51	8.00
Jumaat et al. [34]	8.02	3.91	-
Mahmud et al. [45]	-	3.91	-
Alengaram et al. [51]		3.91	-
Arowojolu et al. [66]		6.00 - 7.51	-
Huda et al. [59]	4.80	7.86	-
Yew et al. [64]	-	2.35	-
Eziefula et al. [65]	4.20	4.80	-

It identified Los Angeles abrasion, aggregate impact value and aggregate crushing values as the mechanical characteristics of palm kernel shell

IV. FRESH LIGHTWEIGHT PROPERTIES OF CONCRETE WITH PALM KERNEL SHELL AS A PARTIAL SUBSTITUTE COARSE AGGREGATE

4.1 Materials used by researchers

The kernelrazzo materials include cement, palm kernel shell, marble chippings, granite dust and water which were obtained locally. Physical and mechanical characteristics of palm kernel shell, marble chippings and granite dust are explained in Table 3 as described by [46, 53, 64] respectively.

Table 3: Physical characteristics of dried palm kernel shell PKS^D, heat treated palm kernel shell (PKS^H) and crushed granite normal weight aggregate (NWA)

Physical property	Physical property	PKS dry	PKS heat	NWA
Yew et al. [64]	Maximum size (mm)	9.5	9.5	-
	Specific gravity (saturated surface dry)	1.33	1.30	-
	Compacted bulk density (kg/m^3)	628	625	-
	Water absorption (24 h) (%)	23.50	20.80	-
	Aggregate impact value (%)	2.35	2.37	-
Mannan and Ganapathy [44]	Specific gravity	1.17	-	2.61
	Water absorption (24 h) (%)	23.30	-	0.76
	Bulk density (kg/m^3)	590	-	1470
	Finess modulus (FM)	6.24	-	6.33
	Flakiness index (%)	65.17	-	24.94
	Elongation index (%)	12.36	-	33.38
REFERENCE	**PROPERTIES**	**PKS**	**MC**	**GD**
Olusola and Babafemi [53]	Maximum size (mm)	10	14	2.36
	Shell thickness (mm)	0.5-3.05	-	-
	Finess modulus (FM)	6.34	6.45	2.94
	Initial moisture content (%)	3.10	1.05	4.02
	Bulk density (kg/m^3)	610	1520	1700
	Specific gravity (SG)	1.42	2.58	2.54
	Water absorption-24h (%)	22.3	1.10	4.25
	Aggregate impact value (AIV) (%)	6.75	15.92	-
REFERENCE	**CHARACTERISTIC**	**PKS (LWA)**	**NWA**	**Fine AGG**
Philips et al. [67]	Maximum aggregate	10	14	10
	Specific Gravity	1.40	2.58	2.44
	24hrs water absorption (%)	30.44	2.92	6.53
	Bulk density (kg/m^3)	582.982	1.366.23	1,665.00
	Loose Density (kg/m^3)	514.389	1,255.40	1,523.58
	Aggregate Crushing Value, ACV (%)	2.15	17.42	-
	Aggregate Impact Value, AIV (%)	4.63	7.635	-
	Fineness modulus	-	-	-

It shows the physical properties of the dried palm kernel shell (PKS^D), heat treated palm kernel shell (PKS^H), marble chipping and granite dust used for normal weight aggregate used.

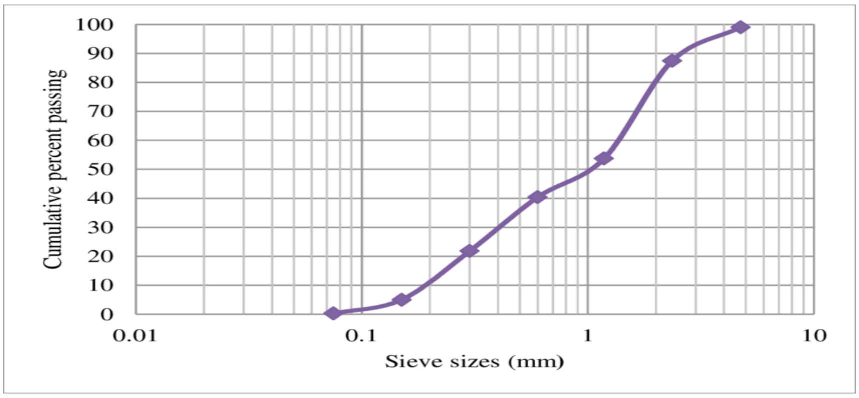

Figure 5: Particle size distribution of palm kernel shell [52]

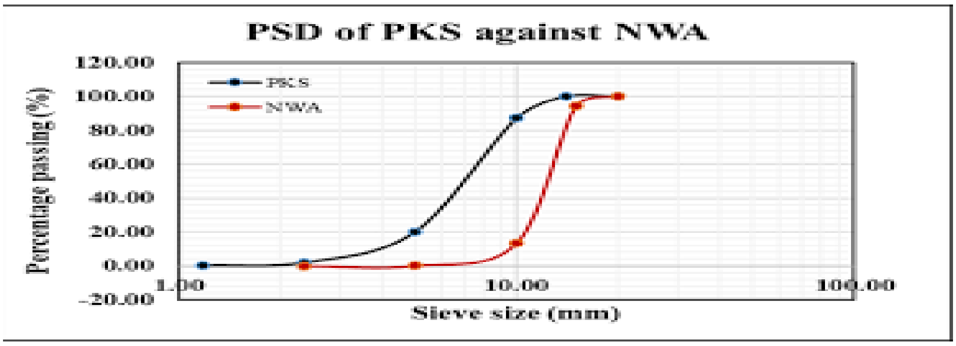

Figure 6: Particle size distribution of PKS and NWA aggregates [67]

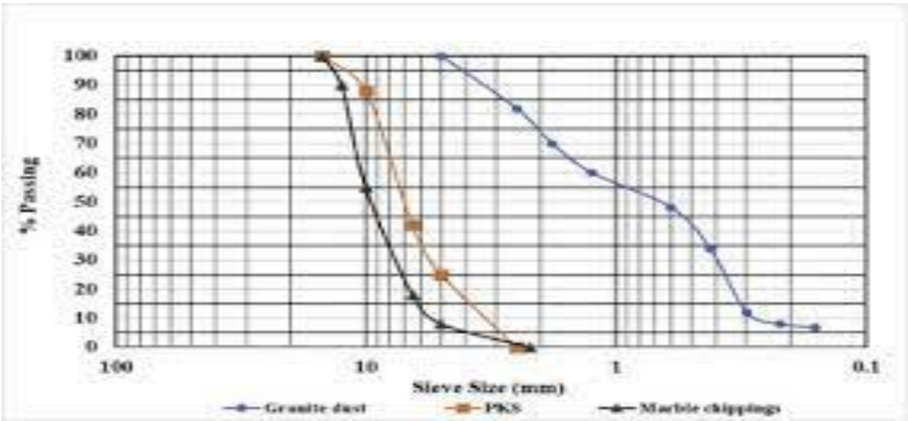

Figure 7: Particle size distribution of PKS, MC and GD aggregates [53, 66]

Fig. 5 shows the particle size distribution of palm kernel shell **[52].** Fig. 6 indicate PSD of palm kernel shell and normal aggregates **[67]** and Fig. 7 shows particle size distribution of palm kernel shell, marble chippings and granite dust **[53, 66]** with their grading curves, respectively.

4.2 Properties of granite Dust (GD)

Granite dust is a product of disintegration of rocks into small sizes or particles and primarily used as fine sand to produce plain, light and mass concrete. The particles generated as a waste from Quarry industry were in the form of non-biodegradable fine powder, the utilisation of this waste in concrete will help in sustainable and greener development [68].

4.2.1 Chemical characteristics of granite dust

Granite dust is basically comprised of silica, alumina and potassium with small quantities of calcium and magnesium. The origin of the stone checks the chemical composition of dust. Table 1 shows the similarity among chemical composition of granite dust obtained from different sources of granite stone.

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Table 4: Chemical properties of granite dust (%)

REFEREE	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	N_2O	K_2O	TiO_2	SO_3	LOI
Vieira et al. [69]	67.14	14.92	4.40	1.91	0.73	2.93	5.18	0.73	-	0.50
Hojamberdiev et al. [70]	65.10	14.00	4.34	6.04	1.12	3.51	2.75	-	-	3.14
Abukersh and Fairfield [71]	61.40	16.30	3.66	3.69	1.70	3.62	3.75	-	0.05	5.01
Vijayalakshmi et al. [72]	72.14	17.13	-	-	-	-	-	-	-	-
Li et al. [73]	57.58	10.42	2.06	1.89	-	3.29	3.42	-	-	-
Elmoaty [74]	85.50	2.10	0.40	4.90	2.50	-	-	-	1.80	1.10
Ramos et al. [75]	63.22	15.66	4.47	3.26	1.82	2.68	5.02	-	-	2.04
Medina et al. [76]	69.60	14.99	2.52	2.36	1.60	3.59	4.04	0.51	0.00	0.52

It showed chemical properties of granite dust

4.2.2. Physical characteristics of granite dust

The grains of granite dust are irregular, angular, and porous and have rough and crystalline surface texture. The grain size is almost like fine sand. Granite dust particles have integrating characteristics. The specific gravity of granite dust ranges from 2.36 to 2.72 depending upon its origin stone. Table 5 shows the specific gravity, water absorption and fineness modulus of various granite dusts reported.

Table 5: Physical characteristics of granite dust.

REFERENCES	Bulk density (kg/m^3)	Specific Gravity	Water Absorption (%)	Fineness Modulus
Donza et al. [77]		2.69	-	3.15
Arulraj et al. [78]		2.61	-	-
Arivumangai and Felixkala [79]	2500-2650	2.6-2.8	0.5-1.5	-
Felix Kala [80]		2.58	-	2.43
Williams et al. [81]		2.6-2.8	0.5-1.5	-
Adigun [82]		2.72	-	3.69
Felixkala, and Sethuraman [83]		2.5	-	2.43
Prokopski et al. [84]	920-970	2.2-2.5	-	0.2-0.5
Olusola and Babafemi [53]	1700	2.54	4.25	2.94
Mujedu et al. [85]		2.56		6.3

It was observed that bulk density of granite dust varies from 2500-2650 as reported by [79] and 920 to 1700Kg/m^3 as reported by [53, 84] respectively. The specific gravity of GD with least value of 2.2-2.5 [84] and highest specific gravity of 2.8 [79, 81]. Water absorption in 24 h is 4.25% [53] and least value is between 0.5 – 1.5 [79, 81]. Fineness modulus varies from 0.20–6.3 as reported by [53, 77, 80, 82-85].

V. MECHANICAL PROPERTIES OF KERNELRAZZO FLOOR FINISH

There are many different types of flooring which make it difficult to know just what type we can select for floor finishing and how to maintain and care for each type of floor. The density of palm kernel shell concrete (PKSC) is approximately 20%–25% less than that of NWC as reported by [30, 33, 43-44, 57] which will make palm kernel shell suitable as partial substitute marble chipping for the production kernelrazzo floor finish tiles, while the compressive strength usually ranges between 20 MPa and 35 MPa as reported by [86] . However, some researchers have secured high compressive strength of virtually 53 MPa at 28 days by using OPS as coarse aggregate in the concrete blend [87, 88]. There are different advantages that was associated with palm kernel shell in lightweight aggregate concrete (LWAC) and it was reported by [44] that it is reducing beam and column sizes, increasing the building height same as reducing the depletion of natural coarse aggregates and to diminish pollution caused by OPS [89]. It serves as the best heat insulation, fire and frost resistance, sound absorption, superior anti-condensation properties and increased seismic damping [31]. Palm kernel shells in depletion of CO_2 emission, preservation of minerals and cost-savings, and upgrading the environmental conditions and enhance green concrete production [90-91]. Tiles provide one of the most economical and worthwhile flooring choices. Its production does not require the use of substantial chemicals or other dangerous materials used to produce other floor covering types in forms of ceramic, porcelain, quarry, agglomerate, terrazzo and kernelrazzo tiles.

5.1 Compressive strength

The strength of concrete is the capacity of concrete to withstand great force that may impose on it without failure and its other characteristics include reliability, soundness, toughness, solidity, stability, and firmness. It was observed that the strength of concrete increases, and its other characteristics usually enhanced [92]. Strength is also important because it is related to several other useful properties, which are more difficult to measure directly. A simple strength test can give an indication of these other properties e.g., modulus of elasticity and durability [21]. It was observed and reviewed by many authors and concluded that the reliability of the concrete increases with the less quantities of palm kernel shell in the lightweight concrete production and vice versa [12, 23, 43]. [30] concluded that the compressive strength depended on the firmness of palm kernel shell presence. [44] showed that at the earlier ages, the non-performance of palm kernel shell concrete was governed by the non-fulfilment of palm kernel shell.

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5.2 Curing

Concrete specimens subjected to different curing regimes had been observed to possess varying strength. Strength increases with age generally. The rate of gain in strength of concrete produced with ordinary Portland Cement (OPC) expanded with increase in concrete temperature at inception, although at later ages the concrete produced and cured at moderate temperatures showed a bit toughness [92].

5.3 Minimum standards for Terrazzo floor finish

Right now, terrazzo basically is a product of marble, granite, quartz or glass chips in a binding agent. It gives constant design variations and soften in application, keeping its original quality. Terrazzo is not just ordinarily used for indoor covering, but also for wall surfaces, gardens, facades, finishing panels etc. When it comes to selecting terrazzo, it is important to get used with the methods and policy of producing the material to get the most out of the prospects the material provides [93]. Table 6 below shows the minimum requirement for Terrazzo floor finish as was reported by [94-95].

Table 6: Minimum standard for Terrazzo floor finish

S/N	Technical Properties	Testing Method	Requirement
1	Compressive strength	BS EN ISO 13,748-1: 2004	25 - 45 N/mm^2
2	Water absorption	BS EN ISO 13,748-1: 2004	Less than 5%
3	Impact resistance	BS EN 12504-2: BSI: 2012	20 - 45 N/mm^2

VI. RESULT OF ACID, BASE AND SALT ON THE DURABILITY OF KERNELRAZZO FLOOR FINISH TILES

6.1 Result of sulphate on the durability of kernelrazzo floor finish tiles

Salt is a neutral substance whose aqueous solution does not affect durability of kernelrazzo floor finish tiles at inception, but expansion was noticed at higher concentrations after longer days of uncover to the salt level of Magnesium sulphate. The ability of the kernelrazzo floor finish tile to add firmness was due to the hydration of cement product [96-97]. Low level in strength was assigned to the reaction of the sulphate ions with the hydration products to form gypsum and ettringite [96-97]. The adverse severe effect of Magnesium sulphate only notices after a prolonged testing period [96].

6.2 Result of acid on the durability of kernelrazzo floor finish tiles

The result of acid on the durability of kernelrazzo floor finish tiles for absorption curing tanks are large, the higher the concentration of the sulphate, the higher its result on the durability of the kernelrazzo floor finish tiles. [53] revealed that the result of H_2SO_4 is most dangerous on specimens having 50% palm kernel shell content. The grievous effect of tetraoxosulphate (vi) acid on the kernelrazzo samples is due to the combined action of its sulphate ions on the aluminate phase and acid attack on $Ca(OH)_2$ and C-S-H forming gypsum which usually can be eroded [96-97].

6.3 Result of basic oxides on the durability of kernelrazzo floor finish tiles

It was found that the presence of alkaline oxides from ordinary Portland cement made the strength of the kernelrazzo to increase and its water absorption to decrease. Also, the alkaline condition behaves with silica in the combined to form alkali-silica gel [98]. With an expansion of the alkali-silica gel, failures of cracking were identified in the kernelrazzo tile which leads to loss of strength of kernelrazzo floor finish tile [53].

6.4 Physical degradation of samples exposed to hostile conditions

High salts concentration on kernelrazzo floor finish tiles caused extensive fading, fretting, rough and crumbling of the surface part of the specimen, also had the greatest impact on the compressive strength reduction of kernelrazzo floor finish tiles. Acid rain increases the rate of decay of unpolished, untreated and uncoated kernelrazzo floor tiles and high acid concentration will tend to produce more surface damaging and thus form a weaker kernelrazzo floor finish tile. Furthermore, to absorption, the surface failure of the samples was noticed and visibly rated according to ranking outlined in Table 7 as proposed by [99] for concrete immersed in acidic aqueous solutions.

Table 7: Scale of visual deterioration level of kernelrazzo cubes [100]

Scale	Decline level
0	No attack
1	Very slight attack
2	Slight attack
3	Moderate attack
4	Severe attack
5	Very severe attack
6	Partial disintegration

The higher chloride concentration on kernelrazzo floor finish tiles has higher negative influence on the durability of the samples. [66] observed that durability of Kernelrazzo floor finish tiles depend on the exposure duration, combine ingredient and the concentration of the situation materials used for curing. Nevertheless, the case of samples controlled in chloride condition revealed decrease in impact resistance with increase in curing age [101].

VII. CONCLUSION

Although papers on kernelrazzo floor finish are few and one hundred and one (101) recent papers on palm kernel shell were used,

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few papers are on kernelrazzo floor finish tiles and past literatures were reviewed on the durability of kernelrazzo tiles floor finish. Rarely research was completed on incorporating palm kernel shell as partial substitute of marble, in the production of kernelrazzo floor finish tiles. The current research is exploring the possibility of incorporating palm kernel shell from oil palm production to produce kernelrazzo floor finish tiles. From economic point of view, cement, granite dust and marble contribute a bigger portion of costs in the production of conventional tiles.

With the consultations of research journals, textbooks, web and libraries, many conclusions can be deduced as follows:

i. Palm kernel shell is the hard endocarp of palm kernel fruit that surrounds the palm seed and has a unit weight of 500-600 kg/m^3 and this is approximately 60% lighter than the conventional crushed stone aggregate. It is a lightweight aggregate originating from the waste of palm oil industry, which is approximately 50% lighter than conventional aggregate and it was estimated that over 4.56 million tonnes of waste palm kernel shell are produced annually.
ii. Okpala [12] reported that PKS is a porous aggregate with a porosity of about 37% and its porosity is one of the factors affecting the thermal conductivity of concrete and enclosed pores reduce the conductivity due to low thermal conductivity of air.
iii. The use of palm kernel shells as lightweight aggregate is suitable to produce lightweight aggregate concrete, suitable as granular filter for water treatment, useful aggregate in road building material. The results showed that using PKS as LWA, structural grade concrete of compressive strength of about 15 to 25 MPa could be produced, its ground shell exhibited a bulk density of 560kg/m^3 and a specific gravity of 1.26, indicating a porosity of 56% and its thickness of palm kernel shell varies in sizes 6, 8, 10, 12 mm depending on Species.
iv. The shells are flaky, parabolic, angular, and poses smooth concave and convex surface and its performance in acidic condition depends on the concentration of the chloride concentration.
v. Ability to avoid failure (Impact resistance) reduced, while water absorption rises with expansion in concentration of curing materials which open on to the evolution of Friedel's salt ($3CaO.Al_2O_3.CaCl_2.10H_2O$) chloride reacts with hardened cement paste and appeared to be weaker and softer in activities of curing [53, 60, 99].

A. Declaration of Competing Interest

The Authors declared that they have no competing financial interests or personal relationships that could have hampered the success of this review report.

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