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PALM KERNEL SHELL AS AGGREGATE FOR LIGHT WEIGHT CONCRETE

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ABSTRACT

In this study, the effect of replacing the conventional gravel with palm kernel shell as aggregates in making concrete was inquired into. Several volumes of palm kernel shells were used in two (4) different proportions with the other constituents and the strength of the concretes produced were tested to ascertain the effect of the replacement on the concrete produced. The palm kernel, cement, sand and gravel were mixed and cast in steel or cast iron moulds of 150mm2 cubes. The results show that the PK_1 with ratio of 1:2:3:1 of cement, sand, gravel and palm kernel shells respectively gave the highest compressive strength of 8.03N/mm^2 after 28 days of curing. Comparing the results of the tests with some standards, it was observed that 64% of the samples of the concretes produced with this partial replacement conform to the standard after 7 days of curing.

Keywords: Aggregate, Cement, Concrete, Sand, Palm Kernel Shell.

1.0 INTRODUCTION

Concrete is an artificial engineering material made from a mix of Portland cement, water, fine and coarse aggregates, and a tiny or negligible amount of air which aids the drying technique of the mixture. It is the most widely used construction material in the world. Concrete is the only major building material that can be delivered to the job site in a plastic state (Aguwa, 1998). This one-of-a-kind quality makes concrete desirable as a building material because it can be moulded to virtually any form or shape. Concrete provides a wide latitude in surface textures and colours and can be used to construct a wide range of structures, Such as highways and streets, bridges, dams, giant buildings, airport runways, irrigation structures, breakwaters, piers and docks, sidewalks, silos and farm buildings, homes, and even barges and ships. Other desirable qualities of concrete as a building material are its strength, economy, and durability. Depending on the mixture of materials used, concrete will support, in compression, 700 or more kg/cm^2. The tensile strength of concrete is much lower, but by using properly designed steel reinforcing, structural members can be made that are as strong in tension as they are in compression

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The durability of concrete is evidenced by the fact that concrete columns built by the Egyptians over 3600 years ago are still standing (Bellis, 2009). The seven major parts of concrete are a cement paste and inert materials. The cement paste consists of Portland cement, water, and some air either in the type of naturally entrapped air voids or minute, intentionally entrained air bubbles. The inert materials are usually composed of fine aggregate, which is a material such as sand, and coarse aggregate, which is a material such as gravel, crushed stone, or slag. In general, fine aggregate particles are smaller than 6.4 mm (.25in) in size, and coarse aggregate particles are larger than 6.4 mm (.25in). Depending on the thickness of the structure to be built, the size of coarse aggregate particles used can vary widely.

Palm kernel shell is a by-product of agro-processing from oil palm. They are available in very giant quantities where oil palm processing is carried out. For some time now, the Nigerian government has been clamouring for the use of local materials in the construction industry to cut down cost of construction. There has therefore been a greater call for the sourcing and development of alternative, non-conventional local construction materials. Palm kernel shells are derived from the oil palm tree (elaeis guineensis), an economically valuable tree, which is native to Western Africa and widespread throughout the tropics.

In Nigeria, the oil palm trees are grown in the rain forest region close to the coastal areas. Palm kernel shells are used mostly as a source of fuel for domestic cooking in some areas. The shells are often dumped as waste products of the oil palm industries which sometimes constitute environmental hazards, hence the necessity to find other makes use of to which they can be put (Ndoke, 2006). Because of reduced financial resources, a significant component of African rural population use local building materials for erecting houses. Soil is the basic material for this purpose because it is available in all places in rural areas. It is chiefly used for making house mud walls and house construction bricks. When some financial resources are available, homeowners sometimes mix soil with natural fibres and a certain amount of cement (Eko and Riskowski, 1996).

After processing of palm fruits to palm oil, the mesocarp is separated from the kernel and then the nut are washed dried in the sun and cracked to separate the kernel from the seed. However, the chance of using this by-product as substitute for aggregates in concrete making needs to be exploited hence the present work.

The investigations conducted by Shokry et al. (1992) shows the chance of making a lightweight masonry unit from concrete reinforced with white spruce sawdust.

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The first consisted of soaking it in chilled water for 3 days prior to use; the second scheme consisted of boiling it in water for 3 hours prior to make use of. They selected to make use of the chilled water scheme because there was no dissimilarity between the hydration products from the seven schemes. Furthermore, the chilled water treatment was less energy intensive.

Concrete Mix Design

Concrete mix design is the procedure by which under a given set of conditions the constituent materials are selected so as to produce a concrete with all the necessary properties at the maximum cost. Necessary concrete properties are durability, strength and workability (Jackson, 1991). Fast setting and strength gain are the properties that make Portland cement a desirable binder in the construction industry. These properties are so important that hydration, the process in the coursework of which they occur, and factors affecting it have been extensively studied over the years (Eko and Riskowski, 1996).

The compressive strength of high weight aggregates is usually related to cement content at a given slump than water-cement ratio. Water reducing or plasticizing admixtures are often used with high weight concrete mixtures to increased workability and facilitate placing and finishing. In some cases, compressive strength can be increased with the partial replacement of high weight fine aggregate with a good quality of natural sand (Shirley, 1975). It's discovered that the presence of air voids in concrete mix causes a reduction in the compressive strength and hence adequate workability for proper compaction in the coursework of placing is important.

Of importance in concrete mix therefore, is the aggregate grading, aggregate/cement ratio as well as the water/cement ratio because the strength of concrete depends on them. The fresh concrete ought to be workable in order to be properly placed and the hardened concrete need to be long lasting and attain a specific compressive strength. A mean strength greater than the specified strength must be the objective of mix design. Since the aggregate is vital in the design, it's desirable to inquire in to the effect of using the palm kernel shell as substitute for other conventional aggregates and see how it affects the compressive strength of the kernel.

The objective of this study is to check the strength of concrete using palm kernel shells and granite as coarse aggregate with a view to ascertain the suitability or other wise of using palm kernel shell as local building material that can effectively substitute the traditional gravel.

2.0 MATERIALS AND METHODS

The control and quality of concrete in its various forms such as fast setting, high strength reinforcement is supremely important to the design and material engineer. In this study, the preparation and testing of concrete cubes made from palm kernel shells mixed with cement, sand and granite in different proportions were carried out.

The palm kernel nuts were obtained locally with the shells separated from the seeds. The shells were washed with detergent to remove the impurities. The other materials obtained include granite, cement and sand.

The materials were mixed and cast in steel or cast iron moulds (150mm2) cubes which conformed to the cubical shape recommended (Jackson, 1991). The mould and the base were clamped together in the course of casting.

In clamping of the mould and the base, the mating surfaces and base were smeared with mineral oil to reduce the friction between the surfaces. Each layer of concrete was compacted by 25 strokes of steel bar whose dimension was the same with the cast iron mould to permit for even pressure. The mould was filled to over flow to permit compaction of the material and after the compaction; excess concrete was removed by downing motion of a steel rule. They were undisturbed for a period of 24 hours at a temperature of 18°C to 22°C and 90% relative humidity. At the end of the period the cubes were marked for identification.

The identification of the concrete cubes were: (a) 4 cubes of one part of cement to four part of sand, five parts of granite and one part of palm kernel shells-PK_1, (b) 4 cubes of one part of cement to four parts of sand to four parts of granite to four parts of palm kernel shells PK2, (c) 4 cubes of one part of cement to four parts of sand, to one part of granite to five parts of palm kernel shells PK_3 and (d) 4 cubes of one part of cement to four parts of sand and five part of palm kernel shells PK_4. After the identification mark, the cubes were immediately submerged in a curing tank until it was time for testing. They were tested at 7, 14, 21, and 28days interval.

For the compression check, cubes were placed with the cast faces in contact with the platens of testing machine i.e. the position of each cube when tested was at a right angle to the cast. The load on the cube was applied at a constant rate of stress of 15Mpa/min due to the non-linearity of the stress-strain relation of concrete at high stress. The strain was increased progressively when approaching the failure. Five concrete cubes were crushed each day, which is on the 7th, 14th, 21st and 28th days after casting.

3.0 RESULTS AND DISCUSSION

The results obtained were recorded in a typical cube check sheet and the summary is shown in Table 1. It was noticed that the concrete produced with higher ratio of normal aggregates have higher strength than those produced with higher percentage of palm kernel shell and lightweight concretes normally have densities of less than 2000kg/m^3 and the density of the oil palm shell falls within this limit, thus making it a lightweight.

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Compared to normal weight concretes of 2400kg/m^3, oil palm shells is approximately 20% lighter. This shows that oil palm shell concrete would decrease by 20% dead load when used in construction. The results also showed that the cubes produced from palm kernel shell undergo normal failure when observed physically indicating that we are well cast and cured.

Table 1: Typical cube test record sheet

Ref. Mark No. Cube	Age at test days	Size (mm)	Average weight in air (kg)	Average maximum load (kN)	Average compressive strength (N/mm^2)	Type of failure and remarks.
PK_1	7	150	6.75	126	5.63	Normal Failure
PK_2	7	150	6.36	119	5.27	Normal Failure
PK_3	7	150	6.39	108	4.81	Normal Failure
PK_4	7	150	6.00	77	3.44	Normal Failure
PK_1	14	150	6.70	140	6.23	Normal Failure
PK_2	14	150	6.52	130	5.79	Normal Failure
PK_3	14	150	6.61	124	5.51	Normal Failure
PK_4	14	150	6.09	96	4.28	Normal Failure
PK_1	21	150	6.75	169	7.54	Normal Failure
PK_2	21	150	6.67	154	6.71	Normal Failure
PK_3	21	150	6.64	132	5.97	Normal Failure
PK_4	21	150	6.52	110	4.89	Normal Failure
PK_1	28	150	6.84	180	8.03	Normal Failure
PK_2	28	150	7.00	174	7.75	Normal Failure
PK_3	28	150	6.28	149	6.64	Normal Failure
PK_4	28	150	5.75	122	5.44	Normal Failure

Table 2 shows the strength of the different concrete mix obtained using different volumes of kernel shells. The results show that the greatest compressive strength was obtained at the end of the 28th days from the PK_1 sample. It may also be observed from Table 2 that the difference in strength between PK_1 and PK_2 is not much compared to that between PK_1 and PK_4. This is because there is no sample of normal aggregate in the PK_4 mix which was purely palm kernel shell. In the other words, the results showed that as the granites are gradually reduced the concrete produced get weaker in compressive strength. Partial replacement of granite with the palm kernel shells is advisable, but complete replacement is not lovely as the concrete are weak in strength.

A comparative analysis was carried out using the British standards (BS 598:, 1995 and BS 1881-116: 1983), to ascertain the percentage of sample of the concrete that meets the standard. It was observed from these analyses that 64% of the PK_1 conforms to the BS 598 standard after 7 days of curing.

Because of the cost of granite, PK_2 with the mixed value of 1:2:2:2 for cement, sand, granite and palm kernel shell can greatly save a lot of cost as far as granite usage/replacement is concerned. Since the palm kernel shell is lighter in weight, the product from such partial replacement will also have lighter weight for the same strength. Effective utilization of these shells can greatly reduce the environmental issues posed by the indiscriminate dumping of these agricultural by-products from oil palm processing.

Usually, the compressive strength of the concrete increases with increase in age of curing. PK_1 with ratio 1:2:3:1 gave the highest compressive strength of 8.03N/mm2 after 28 days of curing.

Table 2: Summary of the comprehensive strength of concrete produced with palm kernel shells in different proportion.

Cube Numbering	Ratio of palm kernel shell				Compressive Strength in Ages			
	C	S	G	K	7days (N/mm^2)	14days (N/mm^2)	21days (N/mm^2)	28days (N/mm^2)
PK_1	1	2	3	1	5.63	6.23	7.54	8.03
PK_2	1	2	2	2	5.27	6.79	6.71	7.75
PK_3	1	2	1	3	4.81	5.51	5.97	6.64
PK_4	1	2	0	4	3.44	4.28	4.89	5.44

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4.0 CONCLUSION

The strength of such concretes meet greater percentage of the standard strength recommended for construction of columns in buildings as they are lighter in weight. The concrete obtained from the palm kernel mix increase in compressive strength with increase in curing days. The greatest strength was obtained after 28 days of curing from a concrete produced with ratio 1:2:3:1 of cement, sand, gravel and palm kernel.

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