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Experimental Study on Partial Replacement of Coarse Aggregate by Palm Kernel Shells in Concrete

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***Abstract*: The aim of the present research work is to study the possibilities of replacing the part of coarse aggregate by palm kernel shells. Because of storing issues, the waste negatively affects the environment & creating solid waste issues. To solve this problem, an attempt was made to check the effectiveness of palm kernel shells as a partial replacement of coarse aggregate. Coarse aggregate was replaced up to 25% palm kernel shells and cement was replaced 10%(constant) by silica fume and evaluating its fresh and hardened properties. The optimum gained after 7 and 28 days curing period was found to be 5% palm kernel shells +10% silica fume.**

***Keywords*: Palm kernel shells, silica fume, compressive strength, split tensile strength.**

1. 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 one of the the most widely used construction material accross the world. Concrete is the only major building material that can be delivered to the job site in a plastic state. This one-of a-kind quality makes concrete desirable as a building material because it can be moulded to virtually any form or shape.

1.1 The role of coarse aggregate in concrete

Aggregate in concrete is structural filler, but its role is more important than what that simple statement implies. Aggregate occupies most of the volume of the concrete. It is the stuff that the cement paste coats and binds together. The composition, shape, and size of the aggregate all have significant impact on the workability, durability, strength, weight and shrinkage of the concrete. Aggregate can also influence the appearance of the cast surface, which is an especially important consideration in concrete countertop mixes.

1.2 Palm Kernel Shells

Palm Kernel Shell (PKS) is one of the waste material obtained during the crushing of palm nuts in the palm oil mills for palm oil extraction. These are agricultural waste products and are available in large quantities in the tropical regions of the world. Palm kernel shells are mostly used as a source of fuel for domestic cooking in most areas where they occur.

Normally, the Palm kernel shell is obtained by breaking the palm nut. Shells are lightweight in nature, but hard and come in different shapes and sizes. Further, the shells are often dumped as waste products of the oil palm industry. In

South East Asia, Palm Kernel Shell (PKS) is one of the most quantitative waste materials produced every year. Among different countries Malaysia produces approximately 4 million tons of palm kernel shells annually. Hence, utilizing Palm Kernel Shell would impose lower construction costs compared to other waste materials like rubber crump, plastic waste etc.

Every year, palm oil industries produce large volume of Palm kernel shell as waste material after the production of palm oil. Nearly five million hectors of oil palm trees is expected by the year 2020 in Malaysia alone. This will increase the production of both palm oil and its wastes such as palm kernel shells. Palm kernel shells are not fully utilized and it has contributed to environmental pollution. This kind of waste material can be utilized to substitute the conventional coarse aggregate to produce concrete.

Fig.1 Palm kernel nuts

Fig.2 Palm kernel shells

1.3 Silica Fume

Among different admixtures, Mineral admixtures are widely used in concrete for various reasons especially for reducing the amount of cement required for making concrete & strength which shows to a reduction in construction as well as production cost. Moreover most Pozzolanic materials are by-product materials from industry. The use of these materials shows the reduction in waste, freeing up valuable land, save in energy consumption to produce cement and save the environment. Durability of Portland cement concrete is defined as its ability to resist weathering action, chemical attack, abrasion, fire or another process of deterioration etc.

Fig.3 silica fume

2. OBJECTIVES

The following are the objectives derived from the literature survey

1. To determine the optimum content of palm kernel shell as substitute for coarse aggregate in concrete.
2. To study the fresh properties of the concrete containing palm kernel shells.
3. To evaluate mechanical properties of concrete containing palm kernel shells.

3. EXPERIMENTAL METHODOLOGY

The methodology has been adopted to study the fresh and hardened properties of concrete incorporated with palm kernel shells (replacement of coarse aggregate). The study work includes the following procedure.

The M30 grade mix design was prepared by using as per IS 10262:2009 codal provisions. The concrete mixes are prepared by varying the palm kernel shells content as 0%, 5%, 10%, 15%, 20% and 25% by weight with replacement of coarse aggregate & constant replacement of cement by silica fume (10%). The prepared mixes are studied for both fresh properties as well as for hardened properties.

4. RESULTS AND DISCUSSION

4.1 Workability Test Results

Table No. 4.1: Workability Test Results

% of replacement of coarse aggregate by palm kernel Shells & cement by silica fume	Fresh properties tested		
	Slump (mm)	Compaction Factor	Vee-Bee Degree (sec)
0%PKS+0%SF	89	0.89	6
5% PKS+10% SF	87	0.88	8
10% PKS+10% SF	85	0.87	12
15% PKS+10% SF	83	0.85	20
20% PKS+10% SF	82	0.83	22
25% PKS+10% SF	80	0.82	30

4.2 Compressive Strength Results

Table No 4.2.: Overall results of Compressive Strength Test for 7 days and 28 days curing period

% of replacement of coarse aggregate by palm kernel Shells & cement by silica fume	Compressive Strength (N/mm^2) 7 Days	Compressive Strength (N/mm^2) 28 Days
0%PKS+0%SF	21.13	32.68
5% PKS+10% SF	**21.36**	**33.23**
10% PKS+10% SF	21.07	32.62
15% PKS+10% SF	20.67	31.63
20% PKS+10% SF	20.29	31.25
25% PKS+10% SF	20.07	30.89

Observation:

The Table 4.2 indicates compressive Strength of cubes of curing period 7 & 28 days. It has been observed that, the Split tensile strength produced with the palm kernel shells goes on increasing up to 5% PKS + 10% SF. After 5% PKS+ 10% SF, the Split tensile strength decreasing gradually with increasing % of palm kernel Shells & silica fume, Thus it can be concluded that, the optimum compressive Strength gained after 28- days curing period is at 5% PKS + 10% SF.

Compressive Strength Test at 7 days and 28 days

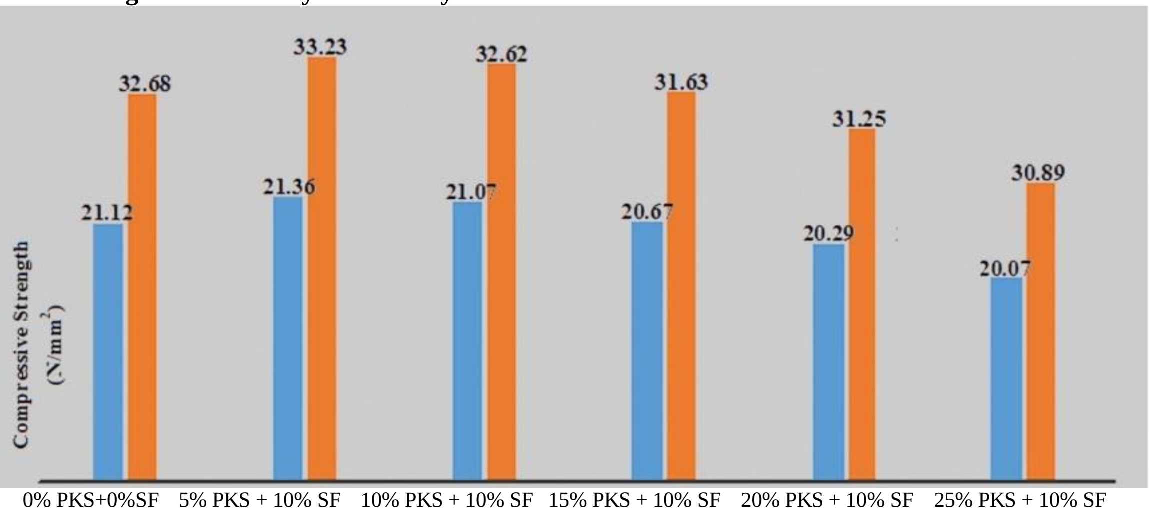


Fig No. 4.1: Compressive Strength of Cubes of curing period 7 & 28 days

4.3 Split tensile Strength Results

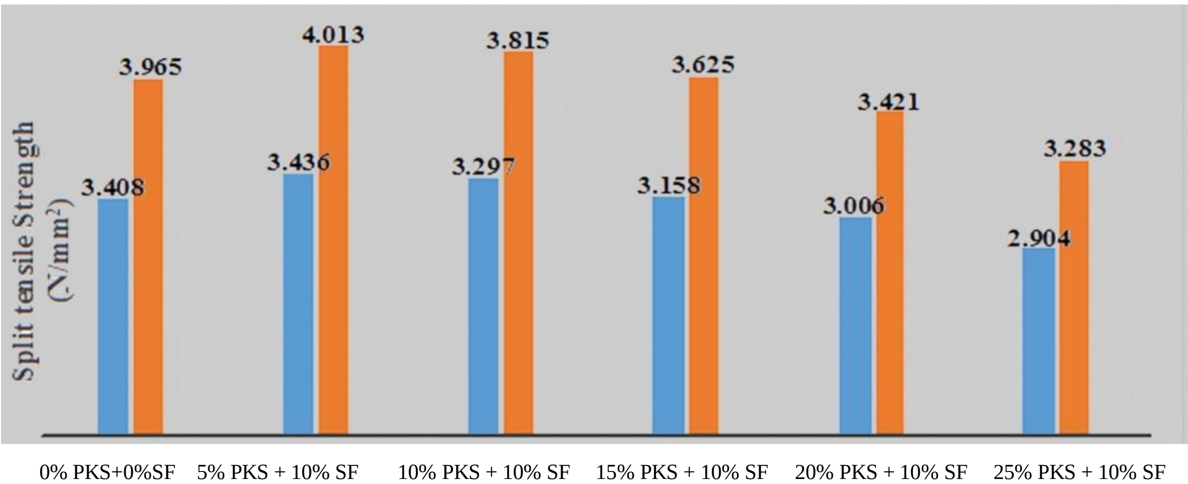
Table No 4.3: Overall results of Split tensile Strength Test for 7 days and 28 days curing period

% of replacement of coarse aggregate by palm kernel Shells & cement by silica fume	Split tensile strength (N/mm^2) 7-days	Split tensile strength (N/mm^2) 28-days
0%PKS+0%SF	3.40	3.96
5% PKS+10% SF	**3.43**	**4.01**
10% PKS+10% SF	3.29	3.81
15% PKS+10% SF	3.15	3.62
20% PKS+10% SF	3.00	3.42
25% PKS+10% SF	2.90	3.28

Observation:

The Table 4.3 indicates Split Tensile Strength of cylinders of curing period 7 & 28 days. It has been observed that, the Split tensile strength produced with the palm kernel shells goes on increasing up to 5% PKS + 10% SF. After 5% PKS+ 10% SF, the Split tensile strength decreasing gradually with increasing % of palm kernel Shells & silica fume, Thus it can be concluded that, the optimum split tensile strength gained after 28- days curing period is at 5% PKS + 10% SF.

Split Tensile Strength at 7 and 28 days



% of replacement of coarse aggregate by palm kernel Shells & cement by silica fume

Fig No. 4.2: Split Tensile Strength of cylinders of curing period 7 & 28 days

5. CONCLUSIONS

- The workability of fresh concrete with slump cone test is gradually decreasing of palm kernel shells content in concrete and the maximum slump is obtained for 0% palm kernel shells + 0% silica fume and compaction factor is gradually decreasing of palm kernel shells content in concrete and the maximum compaction is obtained for 0% PKS + 0% S.F (control mix).
- Vee-bee degree is gradually increasing of palm kernel shells content in concrete and the maximum vee-bee is obtained for 25% PKS +10% S.F.
- The specimens with palm kernel shells as replacement with coarse aggregate &silica fume as replacement with cement was found to be better in compression which has compressive strength of 1.10% and 1.70% more than that of nominal mix concrete after 7 days and 28 days curing period respectively for 5% palm kernel shells + 10% silica fume.
- Better split tensile strength was achieved with the replacement to coarse aggregate with palm kernel shells in concrete. The split tensile strength was increased up to 0.85% and 1.23% when compared to that of the nominal mix concrete after 7 days and 28 days curing period respectively for 5% palm kernel shells + 10% silica fume.
- Considering the all above points it is concluded that the optimum utilization of 5% palm kernel shells in concrete as replacement to the coarse aggregate to obtain a considerable design mix.

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