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Experimental study on structural behaviour of reinforced palm kernel shell concrete beams

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ABSTRACT

This project gives an account of the study conducted on the substitution of Palm Kernel Shell (PKS) for coarse aggregate in concrete works. It is aimed at determining the properties of PKS that makes it suitable as a replacement for natural aggregate in concrete works and the effects of mixing ratios of Palm Kernel Shell Concrete (PKSC). A number of tests were conducted on the PKS and concrete produced with palm PKS. Tests conducted on PKS were specific gravity and water absorption capacity. The results obtained gave the specific gravity and water absorption capacity of PKS as 1.37 and 10% respectively, thickness ranging from 1.0–3.0 mm, size ranging from 2–15 mm. While the tests conducted on PKSC include, density, compressive strength test, splitting tensile strength test and flexural strength, concrete mixes of 1: 2.48: 1.68 were used to produce cubes, cylinders and beams which were cured for 28 days before testing. Normal coarse aggregates was replaced in concrete in such gradation 0%, 10%, 20%, 30% and % 40%. The density of the PKSC is lower which characterize PKSC as a Light Weight Concrete (LWC). The compressive strength and split tensile strength test results showed that 30% of PKS replacement is optimum. The flexural strength of PKS reinforced concrete beam was closer to conventional reinforced concrete beams. 1% of hooked end steel fibre was added to 30% of PKS replacement concrete to improve the split tensile strength and flexural strength. The density test, compressive strength test, split tensile strength and flexural strength were conducted for PKSC with steel fibre. The test results show that steel fibre increases the compressive strength, split tensile strength and flexural strength of PKSC.

INTRODUCTION

Concrete is a artificial stone-like material utilized for different basic purposes. It is made by mixing a binding material and various aggregates such fine aggregates and coarse aggregates, water and allowing the mixture to harden by hydration. Concrete has more advantages such economical, long life, low maintenance requirements etc.. But Concrete has a relatively low tensile strength, low ductility, low strength-to-weight ratio, and concrete is susceptible to cracking. The above characteristics are considered as disadvantages of concrete [1-3]. The drawbacks of concrete are overcome with use of some special material in the concrete like admixture, steel fibre and special type of aggregate [4-6].

There is a high demand for construction materials which are used to make concrete due to rapid decrease of natural materials such as coarse aggregates (CA) and fine aggregates (FA). Environmental problems arise due to the excessive usage of natural aggregates and thereby causing ecological imbalance. This leads to find and explore an alternative material that could be used as a replacement to the conventional aggregates to save the natural aggregates and to prevent the ecological imbalance. In concrete structures, the concrete imposes a huge amount of the total load

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of the structure which increases the total cost of construction. So the present scenario needs the importance of Light Weight Concrete (LWC) for the construction to reduce the self-weight of the structures and to reduce the construction cost. LWC offers design flexibility and substantial cost savings by provide less dead load, low heat conductivity and lower foundations costs when applied to the high-rise buildings [7-10].

At the Same time the solid waste from agro industries creates the disposal problem. It affects the nature of environment. Palm Kernel Shell (PKS) is a Light Weight Aggregates (LWA) from the agricultural sector and is one of several types of waste resulting from the palm oil industry Palm Kernel Shell disposal creates the environment pollution.

Palm kernel shell

Palm Kernel Shell (PKS) is an agricultural solid waste originating from the palm oil industry. The prerequisite of vegetable oil is always expanding and more development of palm oil is figure sooner rather than later. At the same time, the production of palm oil result in by products such as empty fruit bunches, palm kernel shells (PKS) or oil palm shells, fibres and palm oil mill effluent. The major problem of with solid wastes of palm oil mill is due to surplus, despite the use of palm pressed fibre as boiler feed. But Palm Kernel Shell is not suitable for boiler feed; because of it give block smoke and its high heating value.

PROPERTIES OF MATERIALS

Discuss about the properties of the materials which are used for the experimental investigation of this project.

Materials used

- Cement
- Fine aggregates
- Coarse aggregate
- Water
- Steel Fibres
- Palm Kernel Shell

Palm kernel shell

Palm kernel shells (PKS) are organic waste materials obtained from crude palm oil producing factories. PKS is used as Light Weight Aggregate (LWA) to produce Light Weight Aggregate Concrete (LWAC). The properties of PKS were found.

Table 2.1 Properties of Palm Kernel Shell

Size (mm)	2–15 mm
Thickness (mm)	1.0–3.0 mm
Specfic Gravity	1.37
Water absorption capacity %	10

MIX PROPORTIONING

General

The concrete mix was done for M_{20} grade as per IS 10262-2009. Extent of cement ought to be chosen to make the most prudent utilization of accessible materials to deliver cement of required quality. The mix ratio for casting the specimen used was 1:1.68:2.48 and water cement ratio is 0.45 In this concrete mix CA is replaced by PKS in proportion of 0%,10%,20%,30% and 40%. 1% of steel fibre was added to optimum PKS replacement concrete.

RESULT AND DISCUSSION

Compressive strength

Compressive strength of concrete is the most desirable property for any new material used in concrete technology. All other mechanical parameters such as flexural strength, splitting tensile strength and modulus of elasticity directly depend on the compressive strength of the concrete. Three cubes were made and tested for each gradation ie 0%, 10%, 20%, 30% and 40% of CA was replaced by PKS. Compressive strength of M_{20} grade of concrete should not fall below the 20 N/mm^2. Compressive strength of PKS concrete was within limit upto 30 % replacement of PKS after that considerable strength reduction is noticeable. The test results is shown in Table 6.2.The test result clearly shows that 30 % of PKS replacement is optimum.

Table 4.1 Compressive strength results of NWC and PKSC

Specimen	Compressive strength in N/mm^2
NWC	26
PKS 10%	24.44
PKS 20%	22.22
PKS 30%	21.33
PKS 40%	19
PKS 30%+1% SF	22.66

Split tensile strength

Three cylinder were made tested for each gradation ie 10%, 20%,30% and 40% of CA was replaced by PKS. Split tensile of concrete is lower than compressive strength of concrete. Split tensile strength should be 12% to 15% of compressive strength of concrete. Split tensile strength of PKS concrete was within limit upto 30 % replacement of PKS after that considerable strength reduction is noticeable. The both test result clearly shows that 30 % of PKS replacement is optimum. 1 % of steel fibres added to concrete which containing 30% of PKS instead of CA.

Table 4.2 Split tensile strength results of NWC and PKSC

Specimen	Ultimate load (kN)	Deflection (mm)
NWC	52	22
PKS 10%	50	23
PKS 20%	45	27
PKS 30%	40	35
PKS 40%	35	52
PKS 30%+1% SF	54	21

Flexural Behaviour

Load Vs deflection curve for all beams 0%,10%,20%,30% and 40% of PKS replacement concrete beams and 30% of PKS replacement with 1%SF concrete beams were drawn and comparisons of load deflection behaviour for all the beams. All the curves were linear up to the formation of first crack and then they become nonlinear due to the formation of multiple cracks and generate of the same up to ultimate load. The deflection of PKSC beams was higher than NWC beams at ultimate load due to ductility properties of PKS and lower stiffness. The behaviour of fibre as crack bridging made fibre reinforced concrete capable to carry the load well after the development of cracks on the concrete. The load deflection curve for the PKSC with SF gave the better behavior as compared to all other PKSC beams. The reason for this is when the structure were subjected to flexural loading, the SF bridge the micro cracks and prevent the expansion of the structure.

Table 4.3 Ultimate load and corresponding deflection of NWC and PKSC beams

specimen	Split tensile strength of concrete in N/mm^2
NWC	3.32
PKS 10%	3.11
PKS 20%	2.81
PKS 30%	2.47
PKS 40%	2.12
PKS 30%+1% SF	2.90

Ultimate load and moment capacity

The ultimate load and moment capacity of the PKSC and NWC beams tested under two-point loading. The hypothetical extreme minutes were determined utilizing a definitive quality of the support. The test results showed that the PKSC beams had slightly lesser moment capacities than the NWC beams. The ultimate load and moment capacity decrease with increase of % of PKS in the concrete. The ultimate load and moment capacity of PKSC beams with SF was higher than NWC beams due to high tensile strength of SF. Moment capacity of PKSC beams was higher.

Table 4.4 Ultimate load and moment capacity of NWC and PKSC beams

Specimen	Ultimate load in kN	Moment capacity in kNm
NWC	52	8.7
PKS 10%	50	8.3
PKS 20%	45	7.3
PKS 30%	40	6.7
PKS 40%	35	5.8
PKS 30%+1% SF	54	9

Table 4.5 First crack load of NWC and PKSC beams

Specimen	First crack load in kN
NWC	23
PKS 10%	21.5
PKS 20%	20
PKS 30%	19.4
PKS 40%	18
PKS 30%+1% SF	26

CONCLUSION

The experimental results of six beams are presented in this report. The comparison of mechanical properties and structural behavior of the NWC, PKSC and PKS with SF beams are discussed. The crack width, deflection, ultimate load of all the beams are compared.

Summary and concluding remarks

- The PKSC produced a density reduction concrete compared to that of the NWC.
- Compressive strength of concrete decreases with increases the proportion of Palm Kernel Shell in concrete. But Compressive strength of concrete is within the limit up to 30 % of PKS replacement in concrete.
- The compressive strengths obtained for the 30 % PKS replacement PKSC was 21.33 N/mm^2 which was higher than the target strength of 20 N/mm^2 and hence PKSC can be produced as structural grade concrete of grade 20.

- Split tensile strength of concrete decreases with increases the proportion of Palm Kernel Shell in concrete. But split tensile strength of concrete was within the limit up to 30 % of PKS replacement in concrete.
- The both compressive strength and split tensile strength results clearly showed 30 % of PKS replacement is optimum.
- Lower modulus of break and modulus of flexibility of PKSC brought about early splits in PKSC pillar. Be that as it may, the nearby dispersing and enormous number of breaks in PKSC shafts brought about lesser split widths than the NWC pillars.
- The redirection of the PKSC shafts was higher than the diversion of the NWC pillars. In any case, the enormous avoidances at close to most extreme heap of the PKSC shafts displayed high bendable conduct that gave plentiful admonition before all out breakdown.
- The extreme burden and extreme minute limit of the PKSC shafts was lower to that of the NWC pillars because of lower firmness and lower modulus of versatility of PKSC.
- The PKSC pillars had adequate flexibility and the disappointment zone was unmistakably bigger than the NWC bars.

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