EXPERIMENTAL STUDY OF SCC BY ADDING POLYPROPYLENE FIBER WITH CASHEW NUT SHELL ASH AS PARTIAL REPLACEMENT OF CEMENT

Swetha Chandran[1], Er. Rajeev V. S.[2]

[1]PG Student, Dept. of Civil Engineering, Universal Engineering College, Vallivattom, Kerala, India
[2]Assistant Professor, Dept. of Civil Engineering, Universal Engineering College, Vallivattom, Kerala, India

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Abstract - *In the present day, for the purpose of replacing the cement there is much research is being globally to identify a suitable cementitous material to take the role of cement. In this paper, the main aim of the project is to study the mechanical properties of the self-compacting concrete (SCC) by adding polypropylene fiber with cashew nut shell ash (CNSA) as partial replacement of cement with different proportions. The fresh and hardened properties of the SCC with this materials with different proportions and control one were investigated. The cashew nut shell ash is an excellent cementitious material used as partial replacement of cement and which have similar properties compared to cement. Polypropylene fiber (PPF) was added to concrete at 1% and replacement of cement with CNSA at 5%, 10%, 15% and 20%. The mould used for casting SCC are cube (150mmx150mmx150mm), cylinder (150mmx300mm). The compressive strength and split tensile strength of casted SCC are noted along with the curing period of 7 and 28 days. The results showed that 10% mix have the optimum value more than control mix.*

***Key Words*: Cashew nut shell ash, Polypropylene fiber, Compressive strength, Split tensile strength, Self-compacting concrete**

1. INTRODUCTION

Self-compacting concrete is cutting edge method that does not require vibration for placing and compaction. The serious durability issues arises in place like the marine environment, underground etc. due to sulphate attack chloride attack and carbonation can be eliminated by using SCC. Which make quick concrete placement compared to normal concrete, homogeneity, which does not use vibrating equipment for placing, which have higher productivity, which need fewer air spaces, which reduce the noise, and also enhance the strength and durability.

The industrial by-products like fly ash, silica fume, metakaolin etc., provide excellent binding properties to concrete and which used as a replacing material of cement. These substances are generally termed as supplementary cementitious materials. Self-compacting concrete is a mix of cement as binding material, water, sand and coarse aggregate. The expanding need for the use of cement could be increased day by day. There for the need of substitutive binder or replacement materials to cement is increased and which make to find the possibilities of utilizing industrial waste products as cementitious material.

Some of the reports shows that the construction industry is responsible for 23% of the total CO_2 released in global economic activities because the demand for concrete in the construction sector is ever-growing today, that also increases the production of cement, which causes the emission of CO_2. The substitution of supplementary cementitious material (SCM) reduces the clinker production, which in help to reduce the energy demand. Considering the chemical and physical properties of the agro-waste ashes (AWAs) which can be used as the replacing material. In this way, we can reduce the environmental impact by reducing the clinker production, and the open field burning of agro-based wastes. In his project we can used as the SCM as cashew nut shell ash. Which reduces the amount of cement and attain the strength more than control mix.

The Polypropylene Fiber is a kind of linear polymer synthetic fiber having lightweight, high strength, high toughness and corrosion resistance. The main role of polypropylene fiber is to overcome shrinkage and limit the formation of cracks in the concrete. Which is used in self-compacting concrete to reduce shrinkage and formation of cracks.

2. MATERIALS USED

2.1 Cement

Portland Pozzolona Cement, (Ultratech) is used for this study. Tests were conducted as per IS: 4031-1988 and the results were as per IS Standards. Unlike Ordinary Portland Cement, Portland Pozzolana cement (PPC) is manufactured by combination of pozzolanic materials. Pozzolana is an artificial or natural available material. Silica in the cement is in a reactive form. The pozzolanic materials in specific proportions, the PPC also contains OPC clinker and gypsum. These pozzolanic materials include volcanic ash, calcinated clay or silica fumes and fly ash which make around 15 percent to 35 percent of cement weight.

Table 1 Properties of Cement

SI. No.	Test Conducted	Result
1	Fineness	6.33 %
2	Standard Consistency	34 %
3	Specific Gravity	3.06
4	Initial setting time	80 min

2.2 Fine Aggregate

M – Sand was used as fine aggregate. Availability of river sand is less there for artificial sand has been employed as an alternative for construction. Which is made by crushing hard granite stone. It is commonly used because of readily available and cost less to transport. Laboratory test were conducted on fine aggregate to determine the different physical properties as per IS 2386 (Part I and III) and IS: 383-1970

Table 2 Properties of Fine Aggregate

Sl. No.	Tests Conducted	Result
1	Sieve Analysis (%)	3.84
2	Zone of aggregate	II
3	Specific Gravity	2.60

2.3 Coarse Aggregate

Crushed rock of 12.5 mm size is used as coarse aggregates. Concrete benefits from coarse aggregate's strength, hardened quality and toughness various tests on coarse aggregate were conducted based on IS: 2386 (Part I and Part III) – 1963 and IS: 383 – 1970.

Table 3 Properties of Coarse Aggregate

Sl. No.	Tests Conducted	Result
1	Sieve Analysis (%)	5.73
2	Specific Gravity	3.04

2.4 Water

Water is required to wet the surface of aggregate to develop adhesive quality as the cement paste where it binds quickly and satisfy to the wet surface of the aggregates than dry surface. It is commonly accepted view that any portable water is suitable to be used in concrete making. It should have inorganic solid less than 1000 ppm and should be free from injurious quantities of alkalies , acids ,oils, salts, sugars, organic materials, vegetable growth or other substance that may be damage to bricks, stones, concrete or steel.

2.5 Admixture

In ACI 116R the admixtures are defined as "a material other than water, aggregates, hydraulic cement, and fiber reinforcement, used as an ingredient of concrete or mortar, and added to the batch immediately before or during its mixing". The chemical admixtures are used in concrete to enhance the quality of concrete especially SCC during mixing, transporting, placement and curing. They fall into the following categories.

1. Air entrainers
2. Water reducers
3. Set retarders
4. Set accelerators
5. Superplasticizers
6. Special admixtures (corrosion inhibitors, shrinkage control, alkali-silica reactivity inhibitors, and coloring)

A new generation of admixture called MASTER RHEOBUILD 1126ND is based on modified poly-carboxylic ether. The product has been developed primarily for high performance concrete applications where the maximum durability and performance are required. Low alkali content and chloride-free MASTER RHEOBUILD 1126ND. All kind of cements can be used with it.

Table 4 Items Details [13]

Item	Specifications
Aspect	Light brown liquid
Relative density	1.08 ± 0.01 at 25° c
Chloride iron content	< 0.2 %

In comparison to the conventional super plasticizers, MASTER RHEOBUILD 1126ND has a different chemical structure. It is made up of a polymer carboxylic ether with lengthy side chains. The side chains connected to the polymer backbone create a steric barrier that significantly stabilizes the cement particles' capacity to split and disperse. It starts the same electrostatic dispersion mechanism as the conventional super plasticizers at the beginning of the mixing phase. Along with the electrostatic barrier, steric hindrance creates a physical barrier between the cement grains. This method yields flowable concrete with a significantly lower water content.

2.6 Cashew Nut Shell Ash

The cashew tree, which belongs to the Anacardiaceae family, genus Anacardium L., and species Anacardiumoccidentale L. The cashew tree have an important position among the tropical fructiferous trees on account of the growing commercialization of its main products like the cashew nut shell.

Fig. 3 Cashew Nut Shell Ash

Most of the production of the cashew nut is destined for exportation. The CNSA is the waste collected from by-product of combusted cashew nut shell.

Table 5 Properties of CNSA

Sl. No.	Properties	Magnitude
1	Fineness (%)	1.96
2	Specific gravity	3.11
3	Specific Surface Area	594

2.7 Polypropylene Fiber

Polypropylene fiber have been applied for concrete for many years. Main role is to overcome shrinkage and limit the formation of cracks in the concrete. The use of this fiber increase the durability and which also prolong the life of the element. Polypropylene fiber is a kind of polymer material with light weight, high strength, and corrosion resistance.

Fig. 4 Polypropylene Fiber

Properties of polypropylene fiber are;

1. Length (L) = 12 mm
2. Diameter (D) = 20 micron
3. Aspect Ratio (L/D) = 600
4. Density = 1000 kg/m^3

3. MIX DESIGN

In the present study M_{30} grade concrete mix design as per IS: 10262 -2019was carried out. The concrete mix proportion was 1:2.21:3.4. Water cement ratio was 0.45. For 1m3 concrete, 358.00 kg of cement, 794.00 kg of fine aggregate and 1231.00 kg of coarse aggregate were used. To improve the workability, super plasticizer were used and water content was reduced to 143.00 l/m^3. The proportioned mix for M_{30} grade of concrete is shown in Table 6.

CNSA and PPF was added as a partial replacement of cement. CNSA was replaced by 5%, 10%, 15%, and 20% [1] and PPF was 1%.

Table 6 Mix Proportion

Materials	Composition / M^3	Composition For First Trial Mix
Cement	358.00 kg	23.44 kg
Water	143.00 kg	9.374 kg
Fine Aggregate	794.00 kg	31.95 kg
Coarse Aggregate	1231.00 kg	49.53 kg

4. SPECIMEN DETAILS

The mould used for casting SCC are cube of size 150mmx150mmx150mm, and cylinder of size 150mmx300mm. 6 numbers of cube of each mix and 2 numbers of cylinder of each mix casted. After testing the optimum value is obtained at 10% cashew nut shell ash and 1% polypropylene fiber.

5. PREPARATION OF SPECIMENS

For casting the specimens, required quantities of the cement, fine aggregate, coarse aggregate, super plasticizer, cashew nut shell ash and polypropylene fiber were weighed and kept ready for mixing. For easy removal of the specimens, the oil was applied to the inner surfaces of the moulds. The mixing machine was used to mixing materials. The amount of super plasticizer to be used to the SCC mix was measured and is also kept ready for mixing. Before mixing the super plasticizer was mixed with the quantity of water. At first, all the ingredients are mixed well in dry condition and after that calculated amount of water with super plasticizer were added to the dry mix. All there were mixed thoroughly. After mixing, slump test was conducted. Finally, concrete was placed into the moulds and filled.

Fig. 3 Casting of SCC Specimens

6. TESTS ON HARDENED SCC

The hardened concrete after curing must be strong enough to withstand the structural and service loads applied on it and must be durable enough to withstand the environmental exposure for which it has been designed. If the concrete is properly proportioned, mixed, handled, placed and finished with high-quality materials, it will be the strongest and one of the most durable building materials.

The properties of hardened concrete, such as compressive strength, split tensile strength and flexural strength of concrete mixes were determined by casting cube specimens of size 150 mm x 150 mm x 150 mm, cylinder specimens of 150 mm x 300 mm as per IS specifications. The results are tabulated in Table 6.

Table 6 Test Results on Hardened SCC with PPF

Mix	Average CompressiveStrength (N/mm2)	Average Split TensileStrength (N/mm2)
0.5% PPF	24.25	2.30
1% PPF	30.33	2.82
1.5 % PPF	9.24	2.06

From the above test result, the mix with 1 % PPF shows maximum strength. So this proportion is used to make the mix with different proportion of CNSA

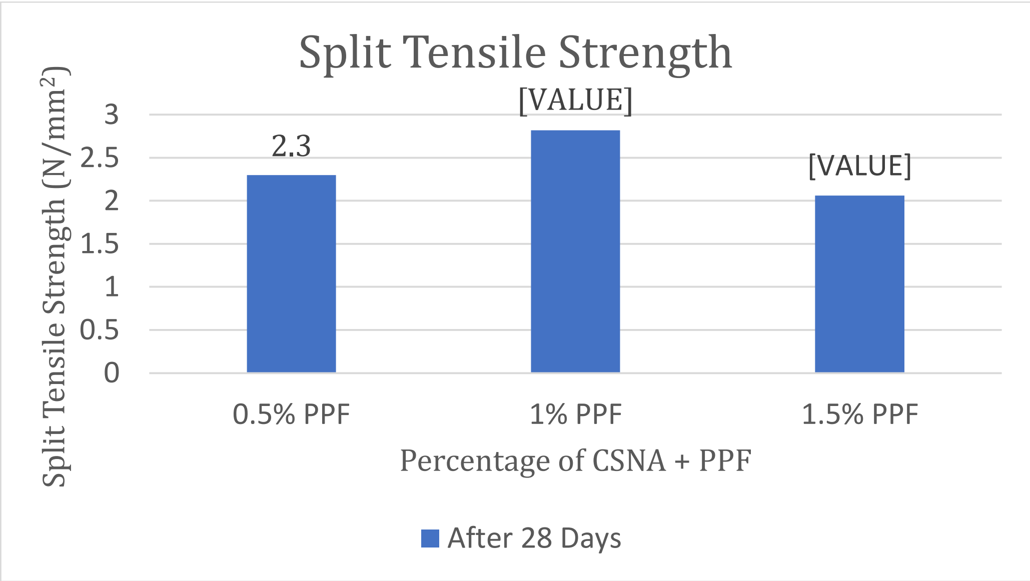

Chart 1 Results of Split Tensile Strength Tests

Table 7 Test Results on Hardened SCC with CNSA and PPF

Mix	Average Compressive Strength (N/mm2)	Average Split Tensile Strength (N/mm2)
Control Specimen	36.20	2.5
5% CNSA+ 1% PPF	35.90	2.40
10% CNSA+ 1% PPF	41.66	3.10
15% CNSA+ 1% PPF	32.93	2.35
20% CNSA+ 1% PPF	26.60	2.02

The following graph shows the test results

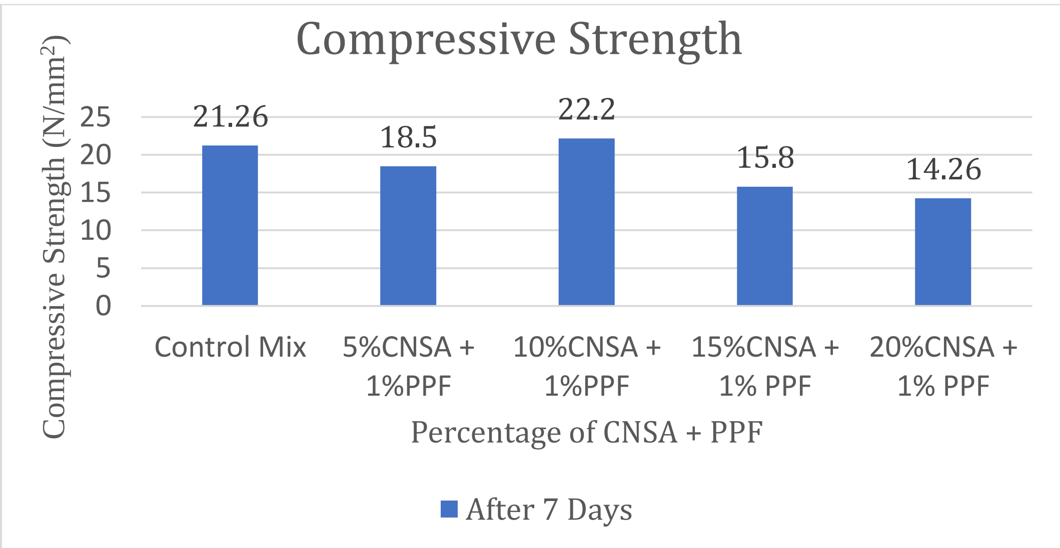

Chart 2 Results of Compressive Strength Tests

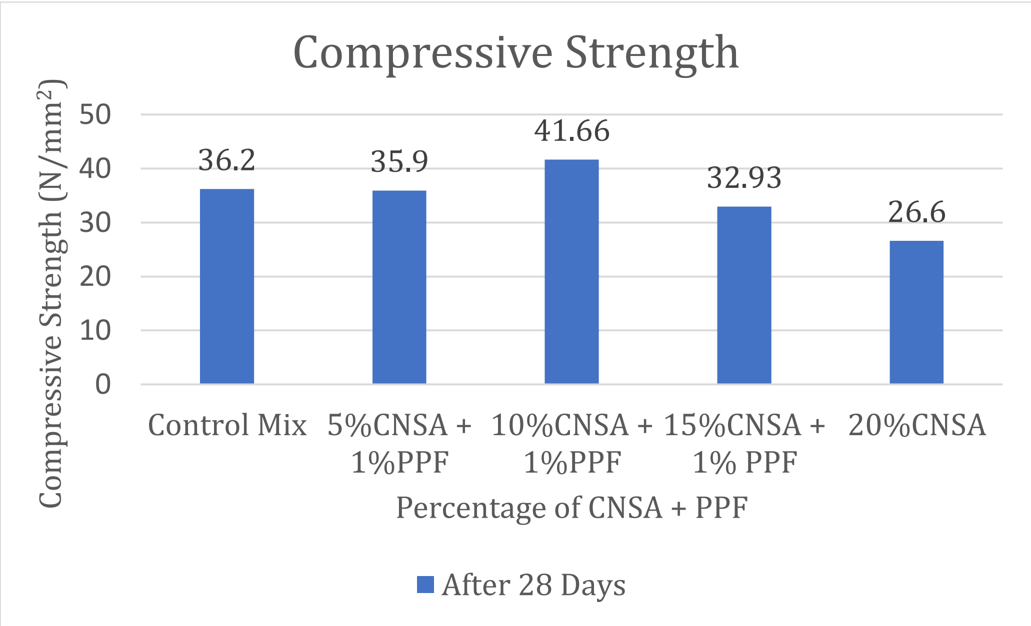

Chart 3 Results of Compressive Strength Tests

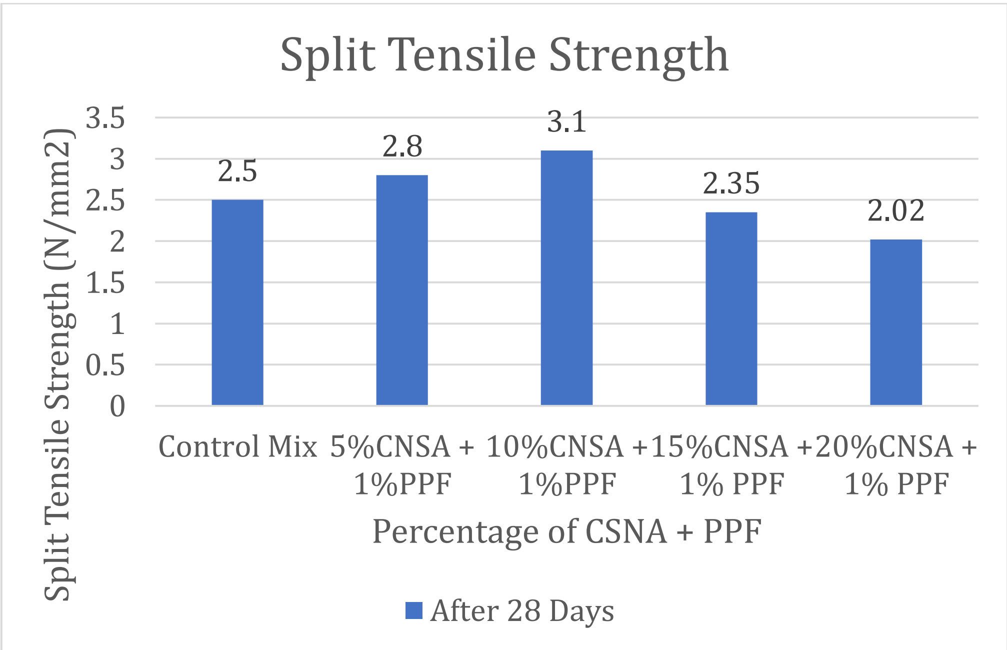

Chart 4 Results of Split Tensile Strength Tests

From the above graphs the optimum value is obtained at 10% CNSA + 1% PPF mix.

7. CONCLUSIONS

The main findings of this investigation are described below;

1. SCC with 1 % PPF shows the maximum compressive strength and split tensile strength more than the control mix.
2. More than 1% PPF used in mix which increases the volume of voids and which makes the reduction strength.
3. The optimum value is obtained at the mix made with 10% CNSA and 1 % PPF

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REFERENCES

[1] Adithya Tantri et. al. (2022). "Implementation assessment of calcined and uncalcined cashew nut-shell ash with total recycled concrete aggregate in self-compacting concrete employing Bailey grading technique." *Springer*, doi.org/10.1007/s41062-022-00907-8M.

[2] Arun Kumar et al. (2022) "Laboratory study on mechanical properties of self compacting concrete using marble waste and polypropylene fiber" *Science direct,* doi.org/10.1016/j.clema.2022.100156.

[3] Peihuan Ye t al. (2022) " Mechanical properties of fully recycled coarse aggregate concrete with polypropylene fiber" *Science* direct, doi.org/10.1016/j.cscm.2022.e01352.

[4] Jugal Kishore Mendu and Rama Mohan Rao Pannem (2021). "Assessment of mechanical properties of cashew nut shell ash blended concrete." *Springer*, doi.org/10.1007/s41062-021-00586-x.

[5] Julia Blazy and Rafal Blazy (2021) "Polypropylene fiber RC and its application in creating architectural forms of public spaces" *Science direct* doi.org/10.1016/j.cscm.2021.e00549.

[6] C. Pavithra et al. (2020) "Behaviour of concrete adding chicken feather as fiber with partial replacement of cement with Cashew nut shell powder" *Science direct*, doi.org/10.1016/j.matpr.2020.08.731.

[7] Solomon Oyebisi et al.(2019) "Performance evaluation of cashew nutshell as a binder in concrete production" *Science direct*, doi.org/10.1016/j.cscm.2019.e00293.

[8] Indian Standard Code of Practice for PPC- Specifications (First Revision), IS: 12269-2013, Bureau of Indian Standards, New Delhi.

[9] Indian Standard Code of Specification for Coarse and Fine Aggregate, IS: 383-1970, Bureau of Indian Standards, New Delhi.

[10] Indian Standard Code of Methods of Test for Aggregate for Concrete Particle Size and Shape, IS: 2386 (Part 1)-1963, Bureau of Indian Standards, New Delhi.

[11] Indian Standard Code of Methods of Test for Aggregate for Specific Gravity,Density, Voids, Absorption and Bulking, IS: 2386 (Part 3)-1963, Bureau of Indian Standards, New Delhi.

[12] Indian Standard Code of Recommended Guide Lines for Concrete Mix Design, IS:10262-2019, Bureau of Indian Standards, New Delhi.

[13] MasterRheo-build 1126ND catalogue.