Study On The Durability Properties of Coconut Shell Concrete with Granite Powder

Dilip Yadav, K. Gunasekaran

Abstract— ***An experimental investigation was done to study the durability properties of granite powder (GP) as partial replacement for ordinary Portland cement (OPC) in conventional concrete (CC) and coconut shell concrete (CSC). Optimized percentage of GP is done to derive the maximum benefits out of it. For the optimized percentage of partial replacement of granite powder for OPC, its durability properties are water absorption, sorptivity, rapid chloride penetration test (RCPT) and volume of permeable voids (VPV) tests were conducted after curing for 3, 7, 28 days. The experimental results outcomes demonstrated that the durability properties of granite powder dust used as cement replacement in concrete, performed like traditional one and coconut shell concrete are comparable to that of other conventional lightweight concretes. It was found that 10% of granite powder can be replaced for OPC as an optimum of producing better concrete properties both in CC and CSC.***

Index Terms— ***granite powder; replacement; coconut shell; durability properties.***

I. INTRODUCTION

Sustainable development is a considerable threat that civil engineers need to look at. Sustainable solution for concrete production in future is important to look for. Sustainable concrete can be formed by utilizing materials with less energy consumption capacity and which could be replenished and recycled. As concrete production, consumes a great quantity of natural resources. So, it is compulsory to come up with an engineering solution that can focus on the utilization of non-renewable resources for concrete production. Researchers have been figuring an advanced technique that offer a sustainable methodology in the construction industry. As huge amounts of industrial, domestic and agricultural wastes are recycled and utilized as replacement for aggregate or cement in concrete [1]. Coconut shell (CS) is one of the popular agricultural solid wastes which can be utilized as an alternative for conventional coarse aggregate in concrete production [2]. Coconut shell (CS) is considered as one of the best light weight aggregates and many research works were already been carried out on coconut shell concrete (CSC) as light weight concrete (LWC) [3]-[5].

In these researches, conventional coarse aggregate (CCA) was replaced by coconut shell aggregate (CSA) and found better outcomes for LWC production. But in those research works, OPC was utilised as a binding material. Therefore, to diminish the use of OPC and to decrease CO_2 emission, granite powder (GP) which is an industrial waste product can be replaced for OPC so that the landfill of GP can be minimised to some extent and environmental pollution can be lessened too [6]-[8]. GP waste can be minimized by utilizing it as a partial replacement of OPC in conventional concrete. (CC) and CSC also. Hence, in this investigation the effect of GP in CC and CSC were studied on durability properties in particular water absorption, sorptivity, VPV and RCPT.

II. MATERIALS USED

As recommended by IS: 12269 (1987) [9], OPC 53 grade having specific gravity of 3.15 was used for both CC and CSC. As per IS 383:2016 [10], river sand (Zone II) passing 4.75 mm sieve with specific gravity 2.62 was utilized as fine aggregate for both CC and CSC. Coarse aggregate of maximum size 12.5 mm with specific gravity 2.66 was taken in use. As per IS: 456-2000 [11], water was used for casting and curing of concrete specimen.

Coconut shell aggregate

Raw coconut shell collected from local sources as shown Figure 1(a) is crushed in coconut shell crusher. CS is a flaky material in irrespective of shape and size, so it was confined to maximum size of 12.5 mm in any direction. CS has the ability of absorbing water due to wood-based property when it meets water. Therefore, CS were allowed to absorb water for 24 hours before CSC production so that CSs will be saturated. The day before concreting, CSs are taken out from the water and allowed to surface dry so it will not disturb the water–cement ratio originally desired. Then, before batching, CSs were made to surface dry and in this saturated surface dry (SSD) condition as shown in Figure 1(b) were used in manufacturing of CSC.

Fig. 1 (a) Raw CS (b) CSs in SSD

Granite powder

Granite is one of the igneous rock which is broadly utilized as construction material in various forms. GP waste is obtained as a by-product during sawing, cutting and

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shaping of granite and it was characterized from a chemical and physical point of view in order to use in concrete. Since GP is abundantly available as waste in granite industries, it can be considered to replace cement due to its chemical composition listed in Table 1, referred from the literature [12].

Table 1 Chemical composition of GP [12]

Constituent	% in GP
Silica (SiO_2)	72.040
Alumina (Al_2O_3)	14.420
Potassium oxide (K_2O)	04.120
Calcium oxide (CaO)	01.820
Sodium oxide (Na_2O)	03.690
Iron oxide (Fe_2O_3)	01.220
Magnesium oxide (MgO)	00.710

In order to minimize the land fill and environmental pollution, GP waste can be well used for making concrete as partial replacement of cement [13]. GP waste collected from local granite polishing unit are dried and sieved on 90 micron having specific gravity of 2.72 as shown in Figure 2 used in CC and CSC production.

Fig. 2 Granite Powder

III. METHODOLOGY

The selected and established mix ratio 1:2.22:3.66:0.55 with cement content 320 kg/m^3 for CC was adopted and that of CSC was 1:1.47:0.65:0.42 with cement 510 kg/m^3, for the target strength M25 [5]. The percentage of GP replaced for cement by weight were 0%, 5%, 10%, 15%, 20% and 25% in order to find the optimum percentage use of GP in both CC and CSC. From these trial mixes, percentage optimization of GP to be used for the replacement of OPC in CC and CSC was fixed from compressive strength test as per IS 516:1959 [14] presented in Table 2 and Table 3. From the results of compressive strength, suggest that the optimized percentage of GP in CC and CSC was found to be 10%. Further studies were carried out to find the durability properties of CC and CSC with the optimized 10% of GP.

Table 2 Optimization of CC in GP

% replacement of GP	Compressive strength (N/mm^2)		
	3 days	7 days	28 days
0%	13.73	19.17	28.51
5%	16.77	20.53	29.30
10%	**18.86**	**21.70**	**31.30**
15%	17.90	20.36	30.61
20%	17.23	20.14	29.12
25%	16.43	19.97	28.23

Table 3 Optimization of CSC in GP

% replacement of GP	Compressive strength (N/mm^2)		
	3 days	7 days	28 days
0%	12.10	18.13	28.32
5%	13.43	18.44	29.20
10%	**16.80**	**19.97**	**30.10**
15%	16.57	19.36	29.92
20%	16.44	19.12	28.36
25%	15.73	18.79	27.32

IV. STUDY SIGNIFICANCE

The term durability of any materials defines its useful life at certain environmental situations. Durability of concrete can be understood as resistance to deteriorating effect through ignorance or which may through ignorance or oversight reside inside the concrete them self, or which are implicit in the environment to which the concrete is disclosed. Concrete is generally durable under normal condition. Complication emerge when concrete containing ingredients which were unknown, when it is exposed to adverse environmental condition which are not foreseen earlier. This study proposed for detail investigate the durability characteristics of CC and CSC which are water absorption, sorptivity, RCPT and VPV. 3, 7 and 28 days test were conducted respectively in this study.

V. EXPERIMENTAL PROGRAM & RESULTS

To determine the durability properties of both CC and CSC, as per IS 516: 1959 [14], cylinder specimen of 200 mm height and 100 mm diameter were cast and cured for required days. The standard size of specimen and standards used for testing are listed in Table 4.

Table 4 Specimen size and standards

Tests	Specimen size	Standard
Water absorption and VPV	100 mm height 100 mm diameter (cut from centre of cylinder of 200 mm height and 100 mm diameter)	**ASTM C 642-97 [15]**
Sorptivity	50 mm height 100 mm diameter (cut from centre of cylinder of 100 mm diameter and 200 mm height)	**ASTM C 1585-04 [16]**
RCPT	**50 mm height 100 mm diameter (cut from centre of cylinder of 100 mm diameter and 200 mm height)**	**ASTM C 1202-97 [17]**

Test on durability properties

Since a lot of discussion on the testing procedures, standards and significance of water absorption, RCPT, VPV and sorptivity were elaborated well in literature (Gunasekaran et al., 2013) [18]. So, here in this paper detailed explanation is not mentioned. However, standards references are tabulated in Table 4 for any difficulty of the readers. Sample of specimens tested for water absorption, VPV, RCPT and sorptivity are illustrated in Figure 3, 4, 5 and 6 respectively.

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Fig. 3 Specimen under water absorption

Fig. 4 Specimen under VPV test

Fig. 5 Specimen under RCPT

Fig. 6 Specimen under sorptivity test

VI. RESULTS AND DISCUSSIONS

Water absorption

The percentage of water absorptions at 3, 7 and 28 days was determined and shown in Figure 7 for both CC and CSC. For CC, water absorption from 3 to 28 days is reduced from 4.31% to 3.69%. Similarly, CSC water absorption from 3 to 28 days is reduced from 10.61% to 9.85%. Water absorption capacity of CC and CSC get reduced as the time of curing increases, can be noticed.

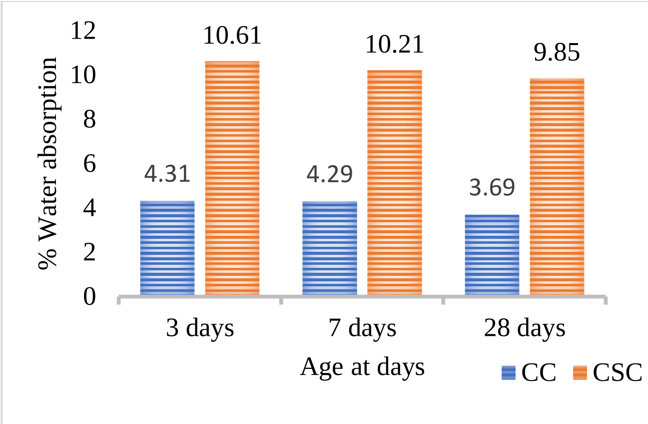

Fig. 7 Water absorption of CC and CSC

Volume of permeable voids (VPV)

VPV of CC and CSC with different age of curing is shown in Figure 8. For CC, VPV is reduced from 14.99% to 8.94% from 3 to 28 days. Similarly, CSC mix VPV is decreased from 19.90% to 13.36% from 3 to 28 days. This result shows that VPV values decreases as the age of curing increases. This is due to water absorption by CS during the time of socking. Similar range value for LWC is noted in which VPV ranges from around 8.6-22.5% [19]-[20].

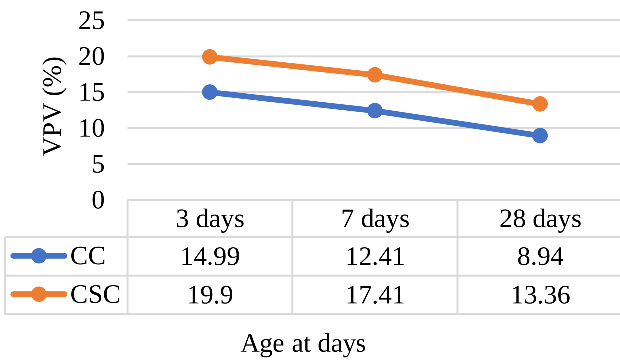

Fig. 8 VPV of CC and CSC at different age of curing

Sorptivity

A feasible warning of the pores of a concrete is given by sorptivity [19]. Lower the sorptivity values, higher will be resistance of concrete towards water absorption. Generally, concrete with high quality have sorptivity values <0.1 mm/min$^{0.5}$[21]. Sorptivity values for CC mix reduced from 0.163 to 0.065 mm/min$^{0.5}$ from 3 to 28 days. Similarly, for CSC mix sorptivity measures from 0.196 to 0.098 mm/min$^{0.5}$ from 3 to 28 days. Sorptivity reading of CC and CSC for 3, 7 and 28 days is shown in Figure 9. Similar value was observed in literature [20].

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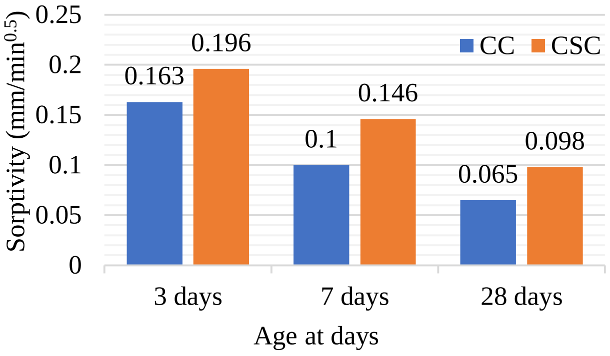

Fig. 9 Sorptivity of CC and CSC different age of curing

Rapid chloride penetration test (RCPT)

RCPT results of CC and CSC at different age of curing is shown in Figure 10. RCPT values of CC and CSC at 28 days are 2345 coulombs and 3110 coulombs respectively. For LWC made from expanded clay, the RCPT values lies between 2115 to 3336 coulombs [21]. Moderate chloride penetrability values show that; the decrease in the charge passed with age, there is progress of pore structure in CC and CSC due to the continual process of hydration of cement products.

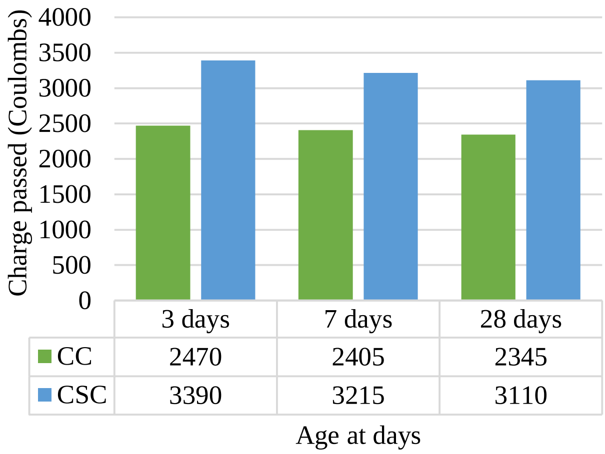

Fig. 10 RCPT results of CC and CSC

CONCLUSION

It can be concluded that, GP can be utilised as partial replacement of cement augmented the properties of both CC and CSC as well. The water absorbed by the CSA pore structures are serving as internal curing of CSC specimen and the hydration is boosted during the early stage of CSC specimen. Use of GP as partial replacement for OPC also show that there is an enhancement of durability properties. As in general, the durability properties of CC and CSC, namely water absorption, sorptivity, VPV and RCPT gives reasonably better result compared with other LWCs. This experimental investigation demonstrates that, GP can be used as a sustainable alternative material for cement for concrete production.

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REFERENCES

1 Kumar MP, Paulo JM Monteiro, "Concrete microstructure, properties, and materials", Indian edition, Ind Concr Ins, Chennai, 2005
2 Jayaprithika, A., and Sekar, S. K., "Mechanical and fracture characteristics of eco-friendly concrete produced using coconut shell, ground granulated blast furnace slag and manufactured sand", Construction and Building Materials, vol. 103, pp. 1–7, May 2016
3 Gunasekaran K., Pennarasi G., Soumya S. and Shruti L., "All-in-one about a Momentous Review Study on Coconut Shell as Coarse Aggregate in Concrete", International Journal of Civil Engineering and Technology, vol. 8, pp. 1049–1060, March 2017
4 ApekshaKanojia, Sarvesh K. Jain., "Performance of coconut shell concrete as coarse aggregate in concrete", Construction and Building Materials, vol. 140, pp 150-156, 2017
5 Mohamed Barveen M. and Gunasekaran K., "Study on the Effect of Rice Husk Ash in Coconut Shell Concrete", International Journal of Civil Engineering and Technology, vol. 9, pp. 264–273, May 2018
6 Abukersh S.A., Fairfield C.A., "Recycled aggregate concrete produced with red granite dust as a partial cement replacement", Construction and Building Materials, vol. 25, pp 4088–4094, May 2011
7 Baboo Rai, Khan Naushad H., Abhishek Kr., Tabin Rushad S. and Duggal S.K., "Influence of Marble powder/granules in Concrete mix", International Journal of Civil and Structural Engineering, vol 1, pp. 827-834, March 2011
8 Felixkala T. and Partheeban P., "Granite Powder Concrete", Indian Journal of Science and Technology, vol 3, pp. 311-317, March 2010
9 IS 12269:1987, Indian Standard Ordinary Portland Cement, 53 grade-specifications. (Reaffirmed January 1999). Bureau of Indian Standard, New Delhi.
10 IS 383:2016, Indian Standard specification for coarse and fine aggregates for concrete –Specification. Third revision. January 2016, Bureau of Indian Standard, New Delhi.
11 IS 456: 2000, Indian Standard for plain and reinforced concrete - Code of practice, BIS 2000; New Delhi.
12 Prince Arulraj G., Adin A., and Kannan T.S., "Granite Powder Concrete", IRACST-Engineering Science and Technology: An International Journal (ESTIJ), vol.3, pp. 193-198, May 2013
13 FelixKala T., "Effect of Granite Powder on Strength Properties of Concrete", International Journal of Engineering and Science, vol.2, pp 36-50, May 2013
14 IS 516:1959, Indian Standard methods of tests for strength of concrete, Reaffirmed 2004 (1991-07), Bureau of Indian Standard, New Delhi

15 ASTM C642-97, Standard test method for density, absorption, and voids in hardened concrete. West Conshohocken, PA: ASTM International, 2013, Retrieved from http://www.astm.org
16 ASTM C1585-04, Standard test method for measurement of rate of absorption of water by hydraulic-cement concretes. West Conshohocken, PA: ASTM International, 2013, Retrieved from http://www.astm.org
17 ASTM C1202-97, Standard test method for electrical indication of concrete's ability to resist chloride ion penetration. West Conshohocken, PA: ASTM International, 2017, Retrieved from http://www.astm.org
18 Gunasekaran K., Annadurai R. and Kumar P. S., "A study on some durability properties of coconut shell aggregate concrete", Material and structure, vol. 48, pp. 1253–1264, December 2013
19 Khatib JM, Mangat PS., "Absorption characteristics of concrete as a function of location relative to casting position", Cem Concr Res 25(5):999–1010, 1995
20 Teo DCL, Mannan MA, Kurian VJ., "Durability of lightweight OPS concrete under different curing conditions, Mater Struct 43(1–2):1–13, 2010
21 EuroLightCon, Properties of LWC Containing Lytag and Liapor, European Union-BriteEuRamIII, 2000, Document- BE96-3942/R8. www.sintef.no/static/BM/projects/EuroLight Con/BE3942R08.pdf. Accessed 25 Jan 2013
22 Chia KS, Zhang MH (2002) Water permeability and chloride penetrability of high-strength LWA concrete. Cem Concr Res 32(4):639–645