STUDY ON THE EFFECT OF REPLACEMENT OF PORTLAND CEMENT BY SUGAR CANE BAGASSE ASH AND EGG SHELL POWDER ON HPC

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Abstract—Ordinary Portland Cement (OPC) an essential constituent in concrete increases drastically with the development and growth of world in terms of engineering. Production of cement as part is one of the major causes of CO_2 emission in to the atmosphere which leads to global warming and environmental pollution. So to reduce the pollution effects due to the production of cement, alternatives are to be finding as binders. Concrete made with mineral admixtures can provide adequate alternative. Sugarcane bagasse ash is the byproduct of sugar industry which is being produced above 3 millions each year. Where as egg shell powder can be easily collected from the waste egg shells.The use of egg shell powder (ESP) and sugarcane bagaasse ash (SCBA) as a replacement of cement is a fruitfull study.High performance concrete (HPC) is an engineered concrete which possess all desirable properties in fresh and hardened stages of concrete. This study tries to investigate the mechanical properties of high performance concrete made with SCBA and ESP. Different mix proportions are designed for further investigation. In all the concrete mixtures, the one with 5% ESP and 10% SCBA produced the best HPC in the experiment. Essential mechanical properties such as compressive and tensile strengths are examined.Cement is replaced partially with ESP as 2.5,5, 7.5%by weight of cementand 5, 10, 15%of SCBA respectively to find the feasibility of using these materials as an alternative to cement .A combination of SCBA and ESP were used to find the best combination which result optimum % of strength.Effects of properties of concrete was investigated.The test result showed that 5% ESP and 10%SCBA combination can be used in concrete.

Index Terms —High Performance concrete, egg shell powder, mineral additives, compressive strength, tensile strength

1 Introduction

Concrete is the most widely used construction material in India with annual consumption exceeding 100 million cubic metres. The conventional concrete designed on the basis of compressive strength does not meet many functional requirements such as impermeability, resistance to frost, thermal cracking adequately. Conventional Portland cement concrete is found deficient in respect of durability in severe environs (shorter service life and require maintenance), time of construction (longer release time of forms and slower gain of strength), energy absorption capacity (for earthquake-resistant structures), repair and retrofitting jobs [1].

Concrete is a blend of coarse aggregate, fine aggregate, cement and water. The production of Portland cement which is an essential part of concrete leads to the emission of significant amount of CO2 to the atmosphere [2]. Cement industry produces 5 to 8% of atmospheric CO2 in the world. This CO2 is largely responsible for the increases in the green house gas effect which leads to global warming [3].

HPC is an engineered concrete possessing the most desirable properties during fresh as well as hardened concrete stages. HPC is far superior to conventional cement concrete as the ingredients of HPC contribute most optimally and efficiently to the various properties. High performance concrete (HPC) is a specialized series of concrete designed to provide several benefits in the construction of concrete structures that cannot always be achieved routinely using conventional ingredients, normal mixing and curing practices.

High performance concrete is a concrete in which certain characteristics are developed for a particular application and environment, so that it will give excellent performance in the structure in which it will be placed, in the environment to which it will be exposed, and with the loads to which it will be subjected during its design life [3]. It includes concrete that provides either substantially improved resistance to environmental influences (durability in service) or substantially increased structural capacity while maintaining adequate durability [3]. It may also include concrete, which significantly reduces construction time without compromising long-term serviceability. While high strength concrete, aims at enhancing strength and consequent advantages owing improved strength, the term high-performance concrete (HPC) is used to refer to concrete of required performance for the majority of construction applications [3].

High performance concrete contains one or more of cementious materials such as fly ash, Silica fume or ground granulated blast furnace slag and usually a super plasticizer [4]. The term 'high performance' is somewhat pretentious because the essential feature of this concrete is that it's ingredients and proportions are specifically chosen so as to have particularly appropriate properties for the expected use of the structure such as high strength and low permeability.

Some studies [8, 10] reported that high performance concrete using sugarcane bagasse ash and egg shell powder showed excellent results.

This study investigates the mechanical and durability properties of high performance concrete.Essential mechanical properties such as compressive and tensile strengths are examined. Indian Standard (IS) codes are reffered for the selection of the mix design.

All the ratios are expressed in percentages of volume. The

SBCA percentage is varied from 5 – 15% and ESP percentage from 2.5-7.5 % analyze the variation in different properties of the sulfur concrete.

The existing studies on high performance concrete are adopted for reference on different experimental investigate-ons.

2 MINERAL ADDITIVES

Eggshell and protein membrane separation is a recycling process. Nearly 30% of the eggs consumed each year are broken and processed or powdered into foods such as cakes, mixes, mayonnaise, noodles and fast foods. The Indian food industry generates 150,000 tons of shell waste a year. The disposal methods for waste eggshells are 26.6% as fertilizer, 21.1% as animal feed ingredients, 26.3% discarded in municipal dumps, and 15.8% used in other ways.

Bagasse is the fibrous matter that remains after sugarcane or sorghum stalks are crushed to extract their juice. It is dry pulpy residue left after the extraction of juice from sugar cane. Bagasse is utilized as a biofuel and in the manufacture of pulp and building materials.

"Agave bagasse" is a material that consists of the tissue of the blue agave after extraction of the sap. For each 10 tonnes of sugarcane crushed, a sugar factory produces nearly 3 tonnes of wet bagasse. Since bagasse is a by-product of the cane sugar industry, the quantity of production in each country is in line with the quantity of sugarcane produced.

The high moisture content of bagasse, typically 40 to 50%, is detrimental to its use as a fuel.

3 MIX DESIGN

The major difference between conventional cement concrete and High Performance Concrete is the use of mineral admixtures in HPC. Some of the mineral admixtures included are: Fly ash, Silica fume, Carbon black, Anhydrous gypsum based mineral additives etc.

Mineral admixtures like fly ash and silica fume act as puzzolonic materials as well as fine fillers.These materials makes the microstructure of the hardened cement matrix becomes denser and stronger.

The use of silica fume fills the space between cement particles, cement particles and aggregate and cement particles. Addition of silica fume to the concrete mix does not impart any strength to it.As silica fume addition to the concrete makes it act as a rapid catalyst to gain the early age strength. Optimum dose of high range water reducing admixtures (HRWRA) is around 1.5% by weight of cement.

Several researchers designed High Performance Concrete mixes by using mix design methods of Normal Strength Concrete. It is also done by combining principles of one or more methods. Suitability of existing mix design methods such as Indian Standard Code, Department of Environment, American Concrete Institute etc. for designing High Performance Concrete mixes giving necessary modifications had not been reported so far.

Kumbhar et al. [14] suggested some of the following modifications for existing mix design methods in achieving High Performance Concretes are as follows.

- Indian Standard code method gives lesser proportion of fine to coarse aggregate ratio.Proper coarse to fine aggregate ratio should be recommended for better workability of mix. Further, Indian Standard code method incorporates use of only one mineral admixture. There should be modification in methods in the terms of addition of more than one mineral admixture with appropriate proportion of chemical admixture.
- Department of Environment method suggests higher-quantity of fine aggregate which increases water required and hence reduces the strength which is not acceptable for High Performance Concrete. Therefore proper dosage of Superplasticizer should be recommended.
- Modified American Concrete Institute method gives usage of High dosage of Superplasticizer to get high slump that reduces the strength.So proper content of SP should be recommended.

A mix design procedure for High Performance Concrete had been suggested by aminul Islam Laskar [15] which took rheological parameters into account to determine compressive strength, water cement ratio and aggregate volume to paste volume ratio. Instead of using water cement ratio and compressive strength relationship, relationship between compressive strength, paste volume-aggregate volume ratio; physical properties of aggregate and rheological parameters were used in mix design.

Correlation charts for rheological parameters and compressive strength was developed based on cube test results of several trial mixes whose rheological parameters had also been found by the rheometer. Muhammad Fauzi Mohd.Zain et al. [16] developed prototype expert system called HPCMIX according to the mix design method proposed by Aitcin that gave proportion of trial mix of High Performance Concrete and recommendations on mix adjustment.

Mehta and Aitcin [23] proposed a simplified mixture proportioning procedure that was applicable for normal weight concrete with compressive strength values between 60 and 120 MPa. This method was suitable for coarse aggregates having a maximum size of between 10 mm and 15 mm and slump values of between 200 and 250 mm.The optimum volume of aggregate was suggested to be 65% of the volume of the high performance concrete. Beyond the limit it does not significantly reduce yield stress as well as plastic viscosity.This method is used in this experimental investigation which is based on Indian Code.

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4 EXPERIMENTAL PROGRAM

Experimental investigations have been carried out on the HPC specimens to ascertain the strength related properties such as compressive strength and tensile strength.

Sugarcane bagasse ash was taken from sugar industry and Egg Shell Powder was prepared by collecting egg shells from hotels and restaurants.These were water washed and oven dried.Dried shells were powdered in mixer to prepare the raw material.

Compressive test was carried out for M50 grade concrete with 100×100×100mm cube specimens and 150×300 mm cylinder specimen .Tensile test was carried out on cylinder specimens.

5 RESULT AND DISCUSSION

Compressive strength is the capacity of a material/ structure to withstand loads. It always increases with age and curing.Compressive strength is affected by factors such as effect of material, mix proportion, curing condition, etc.

Table 1 shows the compressive strength values of control specimen of high performance concrete with weplacements of cement with sugarcane bagasse ash and egg shell powder. Cement is replaced with sugarcane bagasse ash in 5%, 10% and 15% and eggshell powder by 2.5,5 and 7.5%.

TABLE I.
COMPRESSIVE STRENGTH VALUES OF HPC WITH DIFFERNET REPLACEMENT MIXES

Mix designations	Notations	7day Compressive Strength (N/mm²)	Tensile Strength ((N/mm²)
HPC	O	41.25	58.93
HPC + 5% SBCA	A	41.61	59.45
HPC + 10% SCBA	B	42.17	60.25
HPC + 15% SCBA	C	35.87	51.25
HPC + 2.5% ESP	D	34.17	48.82
HPC + 5% ESP	E	43.52	62.14
HPC + 7.5% ESP	F	40.04	57.21
HPC +5% ESP +10%SCBA	G	41.89	59.85

From table 1 it is seen that high performance concrete with sugarcane bagasse ash attains 80% of its maximum compressive strength even within the seventh day after demolding the specimen.

From the above results it can be seen that the addition of sugarcane bagasse ash increases the strength of the normal HPC. This is likely attributed to the better particle size distribution and packing of the concrete components that resulted from the addition of SCBA.

It is seemed that both the materials increased the density of concrete by filling the pores and better packing the particles, which led to the strength improvements. The addition of 5% of SCBA increased the strength to upto 59.45 KN/mm².

But further addition of SCBA in excess of 15% results in decrease of the strength and density gradually because excess amount of ash leads to extreme moist mixture and increased amount of pore spaces in the concrete.Fig 1 shows the graphical representation of the compressive strength results.

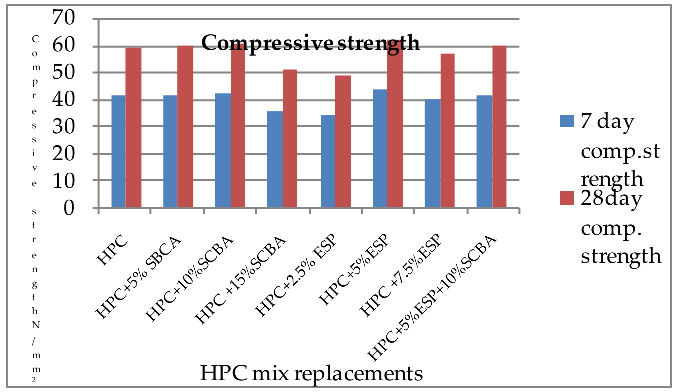

Fig 1. Graph showing variation of compressive strength with different replacement level

Hence it is found out that the optimum filler addition is 10 and 5% of SCBA and ESP .Inorder to utilise waste materials effectively in the high performance concrete the cement content is replaced by sugarcane and eggshell products.Tensile strength values of HPC with replacements are given in table II as follows.

TABLE II
TENSILE STRENGTH OF DIFFERENT REPLACEMENTS

Replacement %	Notations	28 day Tensile strength(N/mm²)
HPC	H0	4.23
HPC +5% SCBA	H1	4.46
HPC +10% SCBA	H2	4.48
HPC +15% SCBA	H3	4.51
HPC +2.5% ESP	H4	4.12
HPC +5% ESP	H5	4.25
HPC +7.5% ESP	H6	4.21
HPC+5%ESP+10 %SCBA	H7	4.32

From the table it is clear that addition of 10% SCBC to the concrete gives maximum tensile strength where as further increment cause the strength decrease.In case of ESP 5% addition gives maximum strength of 4.25 N/mm².Graph shows the H2 and H3 has the maximum gain in strength.

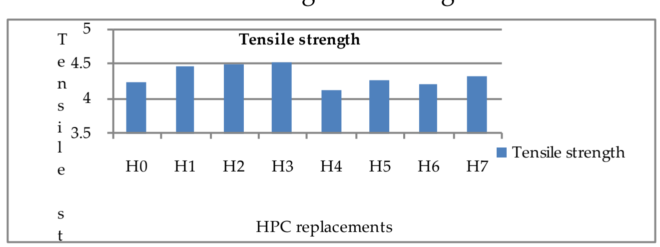

Fig 2. Graph showing variation of tensile strength with different replacement level

The results obtained from various studies showed that the addition of sugarcane bagasse ash and egg shell powder have significant effect on the compression and tensile and strength.

6 CONCLUSION

In this paper, investigations on high performance concrete with replacement of cement by SCBA and ESP is presented. From the experimental studies conducted, following conclusions can be drawn:

- Addition of sugarcane bagasse ash increases the strength of the normal HPC. This is likely attributed to the better particle size distribution and packing of the concrete components that resulted from the addition of SCBA.
- High performance concrete with sugarcane bagasse ash attains 80% of its maximum compressive strength even within the seventh day after demolding the specimen.
- The tensile strength parameters improved by the incorporation of SCBAand ESP.
- Maximum replacement level of SCBA is 10% and ESP is 5% beyond which strength parameters decrease and concrete becomes poor.

Future study can be done on HPC concentrating the durability and water absorption properties .Resistance of this concrete to severe environments could also be studied.

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