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Utilization of Sugarcane Bagasse Ash and Rice Husk Ash on Flexural Strength and durability of sustainable Pavement Quality Concrete

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Abstract
There is growing interest in the construction of concrete pavements, due to its high strength, durability, better service ability and overall economy in the long run. The thrust nowadays is to produce thinner and green pavement sections of better quality, which can carry the heavy loads. The high strength is a concrete having strength, made of hydraulic cements and containing fine and coarse aggregates; the present study aims at, developing pavement quality concrete mixtures incorporating sugar cane bagasse ash and rice husk ash partial replacement of cement. The aim is to the design of slab thickness of PQC pavement using the achieved flexural strength of the concrete mixtures. In this study, flexural strength for pavement quality concrete mixtures for different percentage replacement of cement are reported. It is found that it is possible to achieve savings in cement by replacing it with sugar cane bagasse ash and rice husk ash. This study also shows that in view of the high flexural strength, high values of strength the 20% replacement of cement with sugar cane bagasse ash is ideal for design of Pavement Quality Concrete (PQC).

Keywords: Pavement Quality Concrete, Flexura strength, Slump value, Rice Husk Ash, Sugar Cane bagasse Ash.

INTRODUCTION

Concrete is basically a mixture of two components: Aggregates and paste. The paste comprises cement, supplementary cementing or supplementary cementitious materials and water. It binds the aggregates (sand and gravel or crushed stone) into a rock-like mass. The purpose is to fill up the voids and come with dense and strong materials. The fine aggregates fill up the voids formed by the coarse aggregates; and cement fills up the voids of the fine aggregates. Lesser the voids more would be the strength of concrete. The chemical reaction of the cementitious materials and water is called hydration. It is the process by which paste hardens and binds the aggregates. The high modulus of elasticity and rigidity of concrete compared to other road making materials provides a concrete pavement with a reasonable degree of flexural or beam strength. This property leads to a wider distribution of externally applied wheel loads. This in turn limits the pressures applied to the sub-grade. The major portion of the load carrying capacity of a concrete pavement is therefore provided by the concrete layer alone. Its thickness is primarily determined by the flexural strength of the concrete and by the magnitude of the wheel or axle loads. Sub-bases do not make a significant structural contribution to concrete pavements. By contrast, a flexible pavement is a structure comprising a number of layers of bound or unbound materials which can have a variety of surface treatments and in which the intensity of stresses from traffic loads requires a lot more depth to diminish. Both the base and sub-base layers in flexible pavements contribute significantly to the structural properties of the pavement.

Concrete acts more like a bridge over the sub-grade. Much less pressure is placed on the material below the concrete, than bituminous pavements. Since the first strip of concrete pavement was completed in 1893, concrete has been now extensively used for paving the highways and airports as well as business and residential streets. It is determined that in the normal third-point bending test, the flexural strength of SFRC is about 50 to 70 percent more than that of the plain concrete mix. So with the inclusion of steel fibers the slab thick gets reduced and hence is very economical. The most significant influence of the incorporation of steel fibers in concrete is to delay and control the tensile cracking of the composite material. This positively influences mechanical properties of concrete. These improved properties resulting SFRC being a feasible material for concrete road pavements. The work shall consist of construction of un-reinforced, dowel jointed, plain cement concrete pavement in accordance with the requirements of these Specifications and in conformity with the lines, grades and cross sections shown on the drawings. The work shall include furnishing of all plant and equipment, materials and labour and performing all operations in connection with the work, as approved by the Engineer.

2. LITERATURE REVIEW

Nagrale et al. (2019) in their paper "Utilization of Rice Husk Ash" studied various properties like workability of the concrete mix when we replace cement by 15% RHA compared to our normal ordinary Portland cement concrete mix. The fine aggregate used is natural sand conforming to Zone II & standard sand of Grade 2. The coarse aggregate used are of sizes 20 mm and 12.5mm. Cement used is of 43 grade. The mix proportion used is M20. Three w/c ratios were used i.e. 0.45, 0.5, 0.6. The Concrete Slump values decreases with the addition of RHA. This means that a less workable (stiff) mix is obtained when RHA is used as a cement blender. More water is therefore required to make a workable mix. The increased fines in the concrete due to excess RHA is partly responsible for this increased demand of water. Water Absorption tests reveal that higher substitution amounts results in lower water absorption values which is due to RHA being finer than cement. The use of RHA considerably reduces the water absorption of concrete. Thus, concrete containing RHA can be effectively used in places where the concrete can come in contact with water or moisture.

Dilip Shrivastava, et.al (2018) Black Cotton Soils exhibit high swelling and shrinking when exposed to changes in moisture content and hence have been found to be most troublesome from engineering considerations. This behavior is attributed to the presence of a mineral montmorillonit. The wide spread of the black cotton soil has posed challenges and problems to the construction activities. To encounter with it, innovative and nontraditional research on waste utilization is gaining importance now a days. Soil improvement using te waste material like Slags, Rice husk ash, Silica fume etc., in geotechnical engineering has been in practice from environmental point of view. The main objective of this study is to evaluate the feasibility of using Rice Husk Ash with lime as soil stabilization material. A series of laboratory experiment has been conducted on5%lime mixed black cotton soil blended with Rice Husk Ash in 5%, 10% 15% and 20% by weight of dry soil. The experimental results showed a significant increase in CBR and UCS strength. The CBR values increases by 287.62% and UCS improved by30%.The Differential free swell of the black cotton soil is reduced by 86.92% with increase in Rise Husk Ash content from 0% to 20% respectively. From this investigation it can be concluded that the Rice Husk Ash has a potential to improve the characteristics of black cotton soil.

Kishore et al. (2018) in their paper "Study on Strength Characteristics of High Strength Rice Husk Ash Concrete" has investigated the compressive strength, splitting tensile and flexural strength of high strength concrete with different replacement levels of ordinary Portland cement by Rice Husk Ash. . The standard cubes (150mmX150mmX150mm) and the standard cylinders (150mm diaX300mm height) were caste. In all specimens with M40 and M50 grade mix cases were caste and tested. The strength effect of High-strength concrete of various amounts of replacement of cement viz., 0%, 5%, 10%, 15% with Rice Husk Ash of both the grades were compared with that of the high- strength concrete without Rice Husk Ash. As the replacement level increases there is decrease in splitting tensile strength at 28 days age of curing for both M40 and M50 grades of concrete by 5 to 10%. The splitting tensile strength for both M40 and M50 grade of concrete was 3.98MPa and 4.19MPa respectively at 15% replacement.

Uduweriya et al. (2017) in their paper “Investigation of Compressive Strength of Concrete Containing Rice-Husk-Ash " investigated the results of three different replacement percentages of RHA in concrete (10%, 20% and 30% by mass of cement) were compared with the concrete that does not contain RHA. Concrete cylinders of 150 mm diameter and 300 mm height were casted by using concrete with W/C ratio of 0.75. Mechanical vibrator was used to compact the concrete during casting. The average value of tensile strength was obtained by testing of three specimens. There is significant increment in the tensile strength in concrete containing RHA. The maximum tensile strength is resulted with 20% replacement. Therefore tendency of cracking of concrete containing RHA can be considered as low compared to the normal concrete.

3. MATERIAL

3.1 Cement

The OPC is classified into three grades, namely 33 Grade, 43 Grade, 53 Grade depending upon the strength of 28 days. It has been possible to upgrade the qualities of cement by using high quality limestone, modern equipments, maintaining better particle size distribution, finer grinding and better packing. Generally use of high grade cement offers many advantages for making stronger concrete. Although they are little costlier than low grade cement, they offer 10-20% saving in cement consumption and also they offer many hidden benefits. One of the most important benefits is the faster rate of development of strength. Ordinary Portland Cement (OPC) of 43 Grade from a single lot was used throughout the course of the investigation. It was fresh and without any lumps. The physical properties of the cement as determined from various tests conforming to Indian Standard IS: 8112. Cement was carefully stored to prevent deterioration in its properties due to contact with the moisture.

3.2 Coarse Aggregates

Aggregates constitute the bulk of a concrete mixture and give dimensional stability to concrete. To increase the density of resulting mix, the aggregates are frequently used in two or more sizes. The most important function of the fine aggregate is to assist in producing workability and uniformity in mixture. The fine aggregate assist the cement paste to hold the coarse aggregate particles in suspension.

This action promotes plasticity in the mixture and prevents the possible segregation of paste and coarse aggregate, particularly when it is necessary to transport the concrete some distance from the mixing plant to placement. The aggregates provide about 75% of the body of the concrete and hence its influence is extremely important. They should therefore meet certain requirements if the concrete is to be workable, strong, durable and economical. The aggregates must be proper shape, clean, hard, strong and well graded.

3.3 Fine Aggregates

The aggregates most of which pass through 4.75 mm IS sieve are termed as fine aggregates.
The fine aggregate may be of following types:

- Natural sand, i.e. fine aggregate resulting from natural disintegration of rocks.
- Crushed stone sand, i.e. fine aggregate produced by crushing hard stone.
- Crushed gravel sand, i.e. fine aggregate produced by crushing natural gravel

According to size, the fine aggregate may be described as coarse, medium and fine sands.
Depending upon the particle size distribution IS: 383-1970 has divided the fine aggregate into four grading zones (Grade I to IV). The grading zones become progressively finer from grading zone I to IV. In this experimental program**,** fine aggregates (stone dust) were collected from Jhelum Stone Crusher, Mirthal, Pathankot and conforming to grading zone II. It was coarse sand light grey in colour. The sand was sieved through 4.75 mm sieve to remove particles greater than 4.75 mm size. Physical properties and sieve analysis of fine aggregate are tested as per Indian Standards

3.4 Sugarcane Bagasse Ash (SCBA)

The bagasse is an important by-product of the sugar cane industry and most of it is used to produce steam and electricity in a sugarcane factory. After the bagasse combustion, a new by-product is the Sugar Cane Bagasse Ash (SCBA). It consists mainly of silica (SiO2), which indicates its potential as mineral admixture for use in concrete. The results of this research program indicated that SCBA can be used as a pozzolan and substitute cement. Since durability is a very important issue for implementing new construction materials, in this Thesis, the results of tests of sulphate attack on concrete cubes made with SCBA. These tests indicated that SCBA improves the durability of a concrete. Comparison of the results from the 7, 14, 28 and 50 days samples shows that the compressive strength, tensile strength and also flexure increases with SCBA up to 6.0% replacement and then it decreases, although the results of 10.0% replacement is still higher than those of the plain cement concrete.

Figure 1: Sugarcane Bagasse Ash Sample.

3.5 Rice husk ash (RHA)

Rice husk ash (RHA) is a by-product from the burning of rice husk. Rice husk is extremely prevalent in East and South-East Asia because of the rice production in this area. The rich land and tropical climate make for perfect conditions to cultivate rice and is taken advantage by these Asian countries. The husk of the rice is removed in the farming process before it is sold and consumed. It has been found beneficial to burn this rice husk in kilns to make various things. The rice husk ash is then used as a substitute or admixture in cement. Therefore the entire rice product is used in an efficient and environmentally friendly approach. In this article we will be exploring the common processes of burning rice husk and the advantages of using the burnt ash in cement to facilitate structural development primarily in the East and South-East Asian regions. We will be investigating prior research from various sources, as well as prepare specimens of our own to perform a range of strength tests.

Rice husk is the outer cover of paddy and accounts for 20-25 % of its weight. It is removed during rice milling and is used mainly as fuel for heating in Indian homes and industries. Its heating value of 13-15 MJ/kg is lower than most woody biomass fuels. However, it is extensively used in rural India because of its widespread availability and relatively low cost. The annual generation of rice husk in India is 18-22 million tons and this corresponds to a power generation potential of 1200 MW.

Rice is a heavy staple in the world market as far as food is concerned. It is the second largest amount of any grain produced in the world. The first largest is corn, but is produced for alternative reasons as opposed to rice which is produced primarily for consumption. Therefore, rice can be considered the leading crop produced for human consumption in the world. The leading region of the world which produces rice is Asia, especially South-East and East Asia. Rice can easily be grown in tropical regions on any type of terrain. It is well-suited to countries and regions with low labor costs and high rainfall, as it is very labor-intensive to cultivate and requires plenty of water for cultivation (Wikipedia, Rice). The plains in South-East Asia provide the perfect accommodations. Completely burnt rice husk ash was brought from rice mills from Mandideep Bhopal.

Figure 2: Rice Husk Ash Sample.

4. METHODOLOGY

4.1 Preparation of Materials

All materials were brought to room temperature, (270° - 300° C) before commencing the results. The cement samples, on arrival at the laboratory, were thoroughly mixed dry either by hand in such a manner as to ensure the greatest possible blending and uniformity in the material, care is being taken to avoid the intrusion of foreign matter. The cement was stored in a dry place.

4.2 Casting of Concrete Beams

First of all, lubricating oil is applied to all the moulds so that during opening time after 24 hrs will open mould easily without damaging the concrete cube and before pouring ensures that all the bolts of cubes are tight, this prevents the leakage of concrete mix and help in setting of perfect flexural. The concrete Mix proportions (C: FA: CA-I : CA-II**)** with W/C Ratio 0.40, 0.35 and 0.30 was designed to. All the concrete mixes were mixed in Institute laboratory. Slump test and flow table tests were conducted on fresh concrete to determine slump and flow table, compaction factor test for Workability. From each mix three, 100 mm×100 mm×700 mm 90 beams were cast for the determination of flexural strength. The beams were compacted by means of standard vibration machine. After casting the strength of different concrete is determined at the age of 7 and 28 days

Figure 3: Casting of Concrete Cubes and Beams.

4.3 Curing of Cubes

After opening the cubes and beams, cubes and beams will be named for their specification by the help of water resistant paint & paint brush taken to the curing tank and rested there for 7 days and 28 days with the cover of fresh and clean water. Specification denotes the cube specimen name; type of reinforcement shape used, and date of casting. During time period of curing of cubes, always watch the curing tank that water level does not reaches below the cubes and beams due to concrete heat releasing property and then fill the tank to cover the cubes. The water for curing should be tested every seven days and the temperature of water must be at 27°C.

4.4 Flexural Strength Test

The flexural strength test was run in accordance with Universal Testing Machine (UTM) on 150×150×700 mm beam specimen at each age and the average strength was computed. Before testing, the two loading surfaces were ground evenly by using a grinding stone to ensure that the applied load was uniform. The flexural strength was calculated according to the type of fracture in the beam as follows:

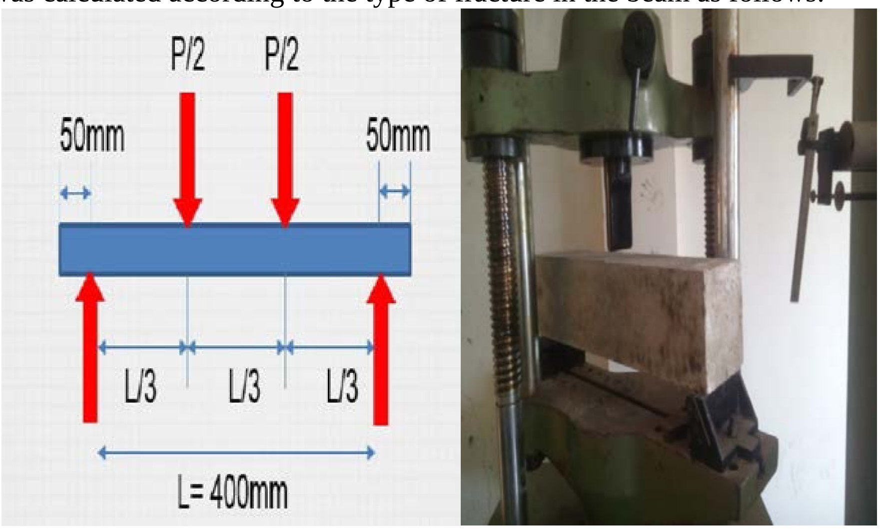

Figure 4: Flexural test setup.

5.1FLEXURAL STRENGTH

The most common concrete structure subjected to flexure is a highway or airway pavement and strength of concrete for pavements is commonly evaluated by means of bending tests. When concrete is subjected to bending, then tensile and compressive stresses and in many cases direct shear stresses are developed.

Test specimens of beam size 150 mm× 150 mm× 700 mm were prepared for testing the flexural strength of unreinforced beams. The beam moulds containing the test specimens were placed in moist air for at least 90% relative humidity and a temperature of 27°C for 24 hours from the time of addition of water to the dry ingredients. After this the specimens were removed from the moulds and placed in clean fresh water at a temperature of 27° C for 28 days curing. After 28 days of curing the specimens were tested in flexure on a Universal Testing Machine. Loads were applied at the one third points at a constant rate of 30 kg/minute. The distance between the centres of two rollers was kept 20 cm. If the fracture occurred within the central one-third of the beam, the flexural strength was calculated on the basis of ordinary elastic theory using the following equations:

When 'a' is greater than 20 cm for 15 cm specimen

When 'a' is less than 20 cm but greater than 17 cm for 15 cm specimen

Where,

Flexural Strength of the specimen in N/mm^2

B = Width of the specimen (= 150 mm)

D = Depth of the specimen (= 150 mm), L = Span of the specimen (= 700 mm)

P = Maximum load in Newton (N) applied to the specimen

A = Distance between the line of fracture and nearer support, measured on the centre line of the tensile side of the specimen in cm, shall be calculated to the nearest 0.5 kg/cm^2. If 'a' is less than 17 cm the results of a test shall be discarded. Test results of flexural test at the age of 28 days curing are given in table 1. The flexural strength results of concrete mix are also shown graphically.

W/C = 0.30	Avg Load (KN)	F.S. (MPa)	F.S.(kg/cm^2)
Controlled (FR00)	35.3475	6.284	62.84
10% SCBA (FR10)	34.0575	6.055	60.55
20% SCBA (FR20)	32.0775	5.703	57.03
30% SCBA (FR30)	29.67	5.275	52.75
10%RHA (FR01)	27.6525	4.916	49.16
20%RHA (FR02)	22.2275	3.952	39.52
30%RHA (FR03)	19.6075	3.486	34.86
10%SCBA,10%RHA (FR11)	22.5025	4.001	40.01
20%ASBA, 10%RHA (FR21)	21.0125	3.735	37.35
10% SCBA, 20% RHA (FR12)	19.70275	3.502	35.02

Table 1: Flexural Strength (F.S.) of 5.5 MPa flexure design.(w/c =0.30).

W/C = 0.35	Avg Load (KN)	F. S. (MPa)	F.S.(kg/cm^2)
Controlled (FR00)	32.8575	5.842	58.42
10% SCBA (FR10)	32.0825	5.704	57.04
20% SCBA (FR20)	30.7375	5.465	54.65
30% SCBA (FR30)	27.9325	4.966	49.66
10%RHA (FR01)	26.2825	4.673	46.73
20%RHA (FR02)	21.4175	3.808	38.08
30%RHA (FR03)	17.99	3.199	31.99
10%SCBA,10%RHA (FR11)	21.7625	3.868	38.68
20%ASBA, 10%RHA (FR21)	19.6675	3.496	34.96
10% SCBA, 20% RHA (FR12)	18.0875	3.215	32.15

Table 2: Flexural Strength (F.S.) of 5.0 MPa flexure design (w/c = 0.35).

W/C = 0.40	Avg Load (KN)	F.S. (Mpa)	F.S.(kg/cm^2)
Controlled (FR00)	29.4825	5.242	52.42
10% SCBA (FR10)	28.4525	5.059	50.59
20% SCBA (FR20)	27.955	4.977	49.77
30% SCBA (FR30)	25.045	4.452	44.52
10%RHA (FR01)	24.535	4.361	43.61
20%RHA (FR02)	18.9375	3.367	33.67
30%RHA (FR03)	16.29	2.896	28.96
10%SCBA,10%RHA (FR11)	19.3575	3.442	34.42
20%ASBA, 10%RHA (FR21)	18.8075	3.343	33.43
10% SCBA, 20% RHA (FR12)	16.38	2.912	29.12

Table 3: Flexural Strength (F.S.) of 4.5 MPa flexure design.(w/c = 0.40).

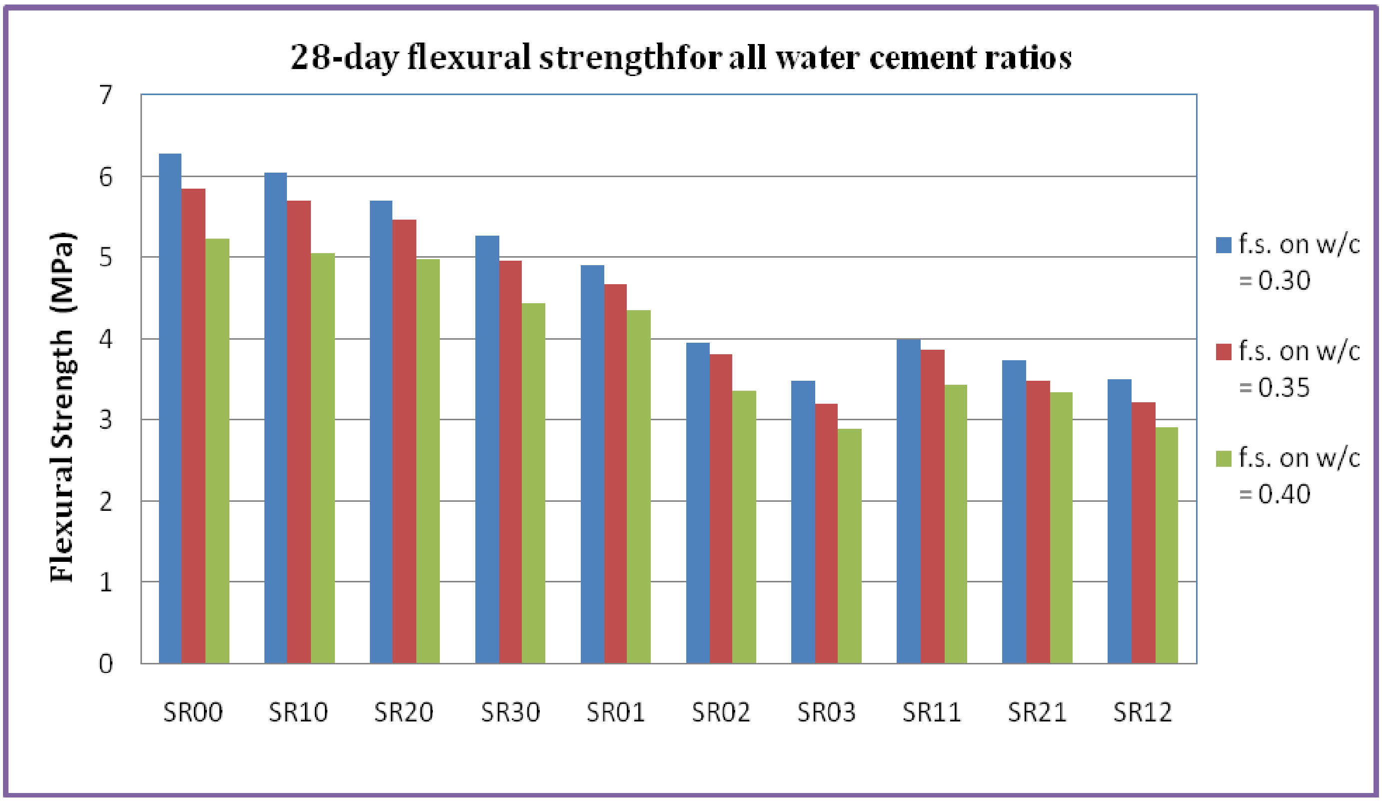

Figure 5: 28-day flexural strength for all water cement ratios.

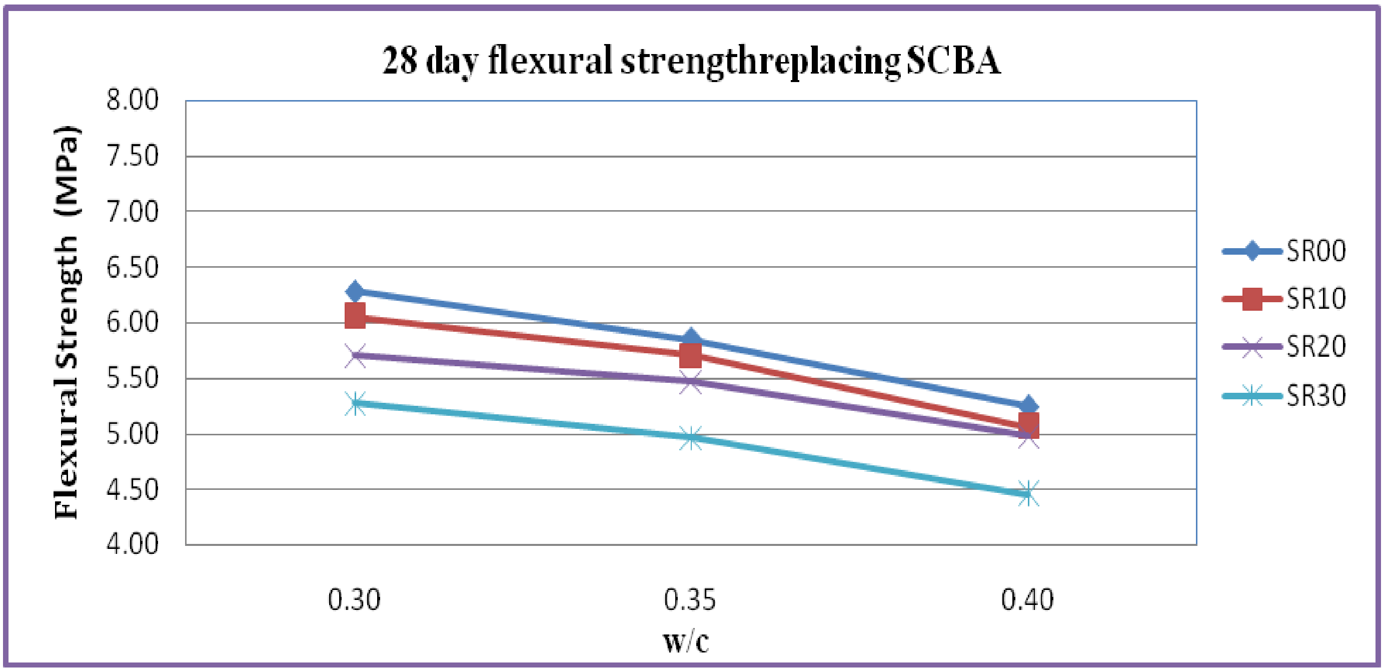

Figure 6: 28 day flexural strength replacing SCBA.

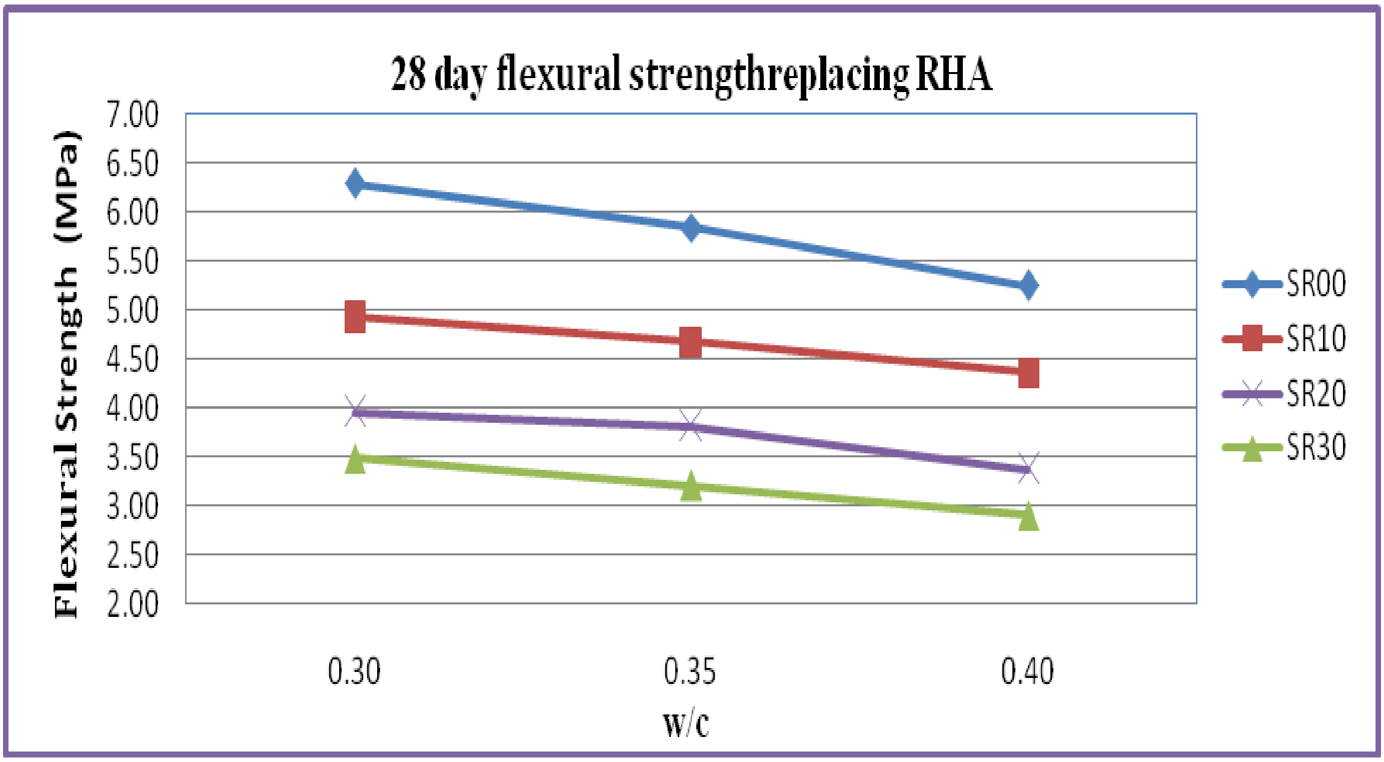

Figure 7: 28 day flexural strength replacing RHA.

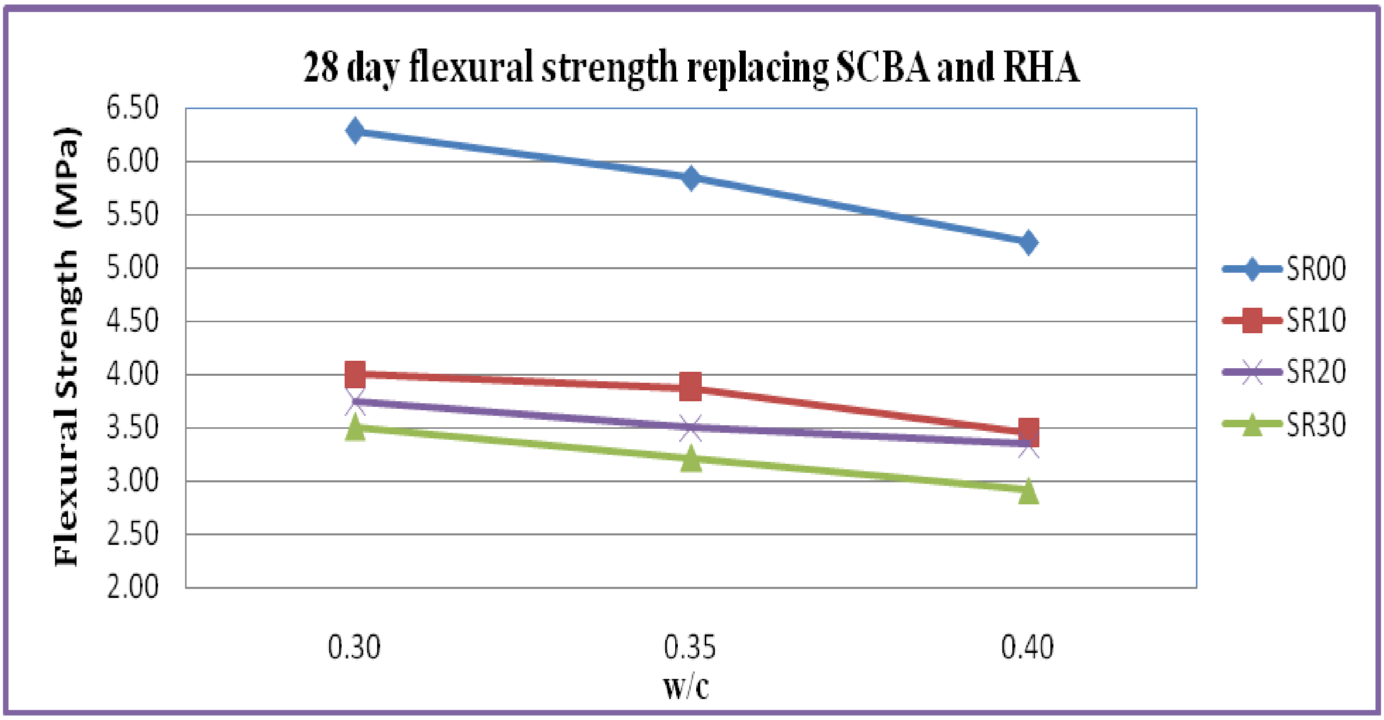

Figure 8: 28 day flexural strength replacing SCBA and RHA.

CONCLUSIONS

The present study was undertaken to investigate the effect of partial replacement of cement with SCBA and rice husk ash on flexural strength of concrete mix. Cement was partially replaced by SCBA at three different levels of replacement i.e. 10%, 20% and 30% and same with rice husk ash as well as with combined replacements of SCBA and rice husk ash. Tests were performed after 28 days of curing of concrete.

1. Beams were prepared for determining flexural strength of concrete with different water-cement ratio as 0.30, 0.35 and 0.40 for min required flexural strengths 5.5 N/mm^2 5 N/mm^2 4.5N/mm^2 respectively. Super-plasticizer was used in all the mixes at 1% level by weight of cementitious material.
2. SCBA up to 20% replacement for all the water-cement ratios showed higher flexural strengths than minimum required flexural strengths as per PQC design standards. Thus, 20% cement replacement by SCBA can be used in designing pavement quality concrete mixes with significant saving in cost.
3. Partial replacement of cement along with rice husk ash does not significantly contribute to gain in flexural strengths for all the replacement levels and for all water to cement ratios.
4. Mixes with combination of SCBA and rice husk ash were unable to achieve desired flexural strengths.
5. A 10 to 30 mm saving in the thickness of the quality concrete pavement containing 10 to 20% SCBA as cement replacement is achieved.
6. The most economic pavement design was achieved by replacing 20% fly ash in minimum required 4.5MPa flexural strength design using w/c of 0.40.

REFERENCES

[1] Al-Khalaf, M.N. and Yousif, H.A. (1984). Use of Rice Husk Ash in Concrete. The Inter. J. Cement Composites Lightweight Concrete, 6(4): 241-248.

[2] Amarnath Yerramala et al., Properties of Concrete with Coconut Shells as Aggregate Replacement, International Journal of Engineering Inventions ISSN: 2278-7461,www.ijeijournal.com Volume 1, Issue 6 (October 2012) PP: 21-31

[3] Anwar, M., Miyagawa, T. and Gaweesh, M. (2000). Using Rice Husk Ash as Cement Replacement Meterial in Concrete, Waste Mangt Series, 1: 671- 684.

[4] Building Materials in India: 50 years, A Commemorative Volume, Edited by T. N. Gupta, 1998.

[5] Concrete Technology, by M.S. Shetty.

[6] D. Maruthachalam., “Studies of Durability Aspects of Fibre Reinforced Concrete”, International Journal of Engineering Science and Technology, 2012, Vol. 4, No.02.

[7] Dhir RK, Paine KA, Dyer TD, Tang MC. Value-added recycling of domestic, industrial and construction arisings as concrete aggregate. Concrete Engineering International 2004; 8 (1): 43–48

[8] Dilip Shrivastava, et.al (2018).- Experimental Study on Strength of Concrete by Using Artificial Fibers with Rice Husk Ash, ISSN: 2248-9622 www.ijera.com Vol. 1, Issue 3, pp.571-581

[9] Ephraim etal, (2012): Compressive Strength of Concrete with RHA as partial replacement of ordinary Portland Cement Scholarly Journal of Engineering Research Vol.1 pp32-36.

[10] Ganesan, K., Rajagopal, K., &Thangavel, K. (2008) "Rice husk ash blended cement: assessment of optimal level of replacement for strength and permeability properties of concrete", Construction and Building Materials, 22(8), 1675-1683.

[11] Givi, A.N., Rashid, S.A., Aziz, F.N.A. and Salleh, M.A.M. (2010) "Assessment of the effects of rice husk ash particle size on strength, water permeability and workability of binary blended concrete", Construction and Building Materials 24 pp. 2145–2150.

[12] Habeeb, G.A. and Mahmud, H.B. (2012) "Study on Properties of Rice Husk Ash and Its Use as Cement Replacement Material", Materials Research 13 pp. 185-190.

[13] International Conference, Waste and Byproducts as Secondary Resources for Building Materials, 13-16 April, 1999, New Delhi, India.

[14] International Institute of Concrete Technology Journal, Uk, N0.55 Autumn 2004. ASTM Standard C311 Standard Test Methods for Sampling and testing Fly Ash or Natural Pozzolans for use in Portland cement concrete. West Conshohocken, Pennsylvania.

[15] K. Gunasekaran, "Utilization of Coconut Shell as Coarse Aggregate in the Development of Light Concrete", Thesis- SRM University, 2011.