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A Study of Future Trend for Sustainable Development by Incorporation of Supplementary Cementitious Material's

Chirag J. Shah, Vyom B. Pathak, Rushabh A. Shah

Abstract- The key area of interest of present world is about the preservation of environment, cost effective and sustainable development in sector of engineering. This paper comprises of detailed study of major Supplementary Cementitious Materials (SCM) commonly used and new emerging materials as a replacement of natural resources used for construction activity in Indian context. In a general way we can define concrete as a mixture of Portland cement, sand, coarse aggregate and water. The most important cementitious material in concrete is Portland cement. Today, most concrete mixtures contain supplementary cementitious materials that make up a portion of the cementitious component in concrete. These materials are generally byproducts from other processes or natural materials. They may or may not be further processed for use in concrete. Some of these materials are called Pozzolana, which by themselves do not have any cementitious properties, but when used with Portland cement, react to form cementitious compounds. For use in concrete, supplementary cementitious materials, sometimes referred to as mineral admixtures, need to meet requirements of established standards. They may be used individually or in combination in concrete.

Keywords- Egg Shell (ES), Pozzocrete, Quartz Sand (QS), Rice Husk Ash (RHA), SCM (Supplementary Cementitious Materials), Saw Dust Ash (SDA).

I. INTRODUCTION

The use of SCM's was done from the ancient Greeks who incorporated volcanic ash with hydraulic lime to create a cementitious mortar. The Greeks passed this knowledge on to the Romans, who constructed such engineering marvels as the Roman aqueducts and the Coliseum, which still stand today. Early SCMs consisted of natural, readily available materials such as volcanic ash. Nowadays, most concrete mixture contains supplementary cementitious material that forms part of the cementitious component.

These materials are majority byproducts from other processes or natural materials. The major benefits of SCM is its ability to replace certain amount of Portland cement and still able to display cementitious property, thus reducing the cost of using Portland cement. More recently, strict air-pollution controls and regulations have produced an abundance of industrial byproducts that can be used as supplementary cementitious materials such as Pozzocrete, Saw dust ash, Rice husk ash, Sugarcane bagasse ash, etc. The use of such byproducts in concrete construction not only prevents these products from being land-filled but also enhances the properties of concrete in the fresh and hardened states.

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The SCMs can be divided into two categories based on their type of reaction: hydraulic or pozzolanic. Hydraulic materials react directly with water to form cementitious compounds, while pozzolanic materials which by themselves do not have any cementitious property but when used with Portland cement, react to form cementitious combination. It chemically reacts with calcium hydroxide (CH), a soluble reaction product, in the presence of moisture to form compounds possessing cementing properties. Types of SCM that will be discussed further in this context are Pozzocrete, Rice husk ash, Saw dust ash, Quartz sand and Egg shell.

II. DEFINITION OF SCMS

Some of the supplementary cementitious materials are called Pozzolana, which by themselves do not have any cementitious properties, but when used with Portland cement, react to form cementitious compounds whereas other materials, such as slag, do exhibit cementitious properties. Thus SCM can be defined as: "The materials that when used in conjunction with Portland or blended cement, contribute to the properties of the fresh as well as hardened concrete through hydraulic or pozzolanic activity or both."

III. TYPES OF SCMS

The most commonly used supplementary cementitious material at present stage in India is fly ash. Other supplementary cementitious materials used are Rice Husk Ash (RHA), Saw dust ash (SDA), Pozzocrete (P), Quartz Sand (QS) and Egg Shell (ES).

IV. RICE HUSK ASH

Rice husks are shells produced during the de-husking of paddy rice.1000 Kg of paddy rice can produce about 200 Kg of husk, which on combustion produces about 40 Kg of ash. Rice husk constitute about 1/5th of the 300 million metric tons of rice produced annually in the world. According to a report, the current yearly production paddy rice is approximately 500 million tons that give about 100 million tons of rice husks as a waste product from the milling. Rice husk is also not used for feeding animals since it is less nutritional properties and its irregular abrasive surface is not naturally degraded and can cause serious accumulation problems. Research in India and the United States has found that if the hulls or straw are burned at a controlled low temperature, the ash collected can be ground to produce a Pozzolana very similar to (and in some ways superior to) silica fume and heat produced during burning can beneficially use in power production, by doing so not only crop waste can effectively disposed, but also can generate electricity for the area, and provide high quality cement.

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The characteristics of the typical rice husk produce in India has organic amorphous silica (made of rice husk ash) with silica content of above 85%, in very small particle size of less than 25 microns. The production detail in India is as shown in figure3.

Fig. 1: Rice husk

Source: C. Marthong, Effect of Rice Husk Ash (RHA) as Partial Replacement of Cement on Concrete Properties.

Fig. 2: Rice Husk Ash

Source: C.Marthong, Effect of Rice Husk Ash (RHA) as Partial Replacement of Cement on Concrete Properties.

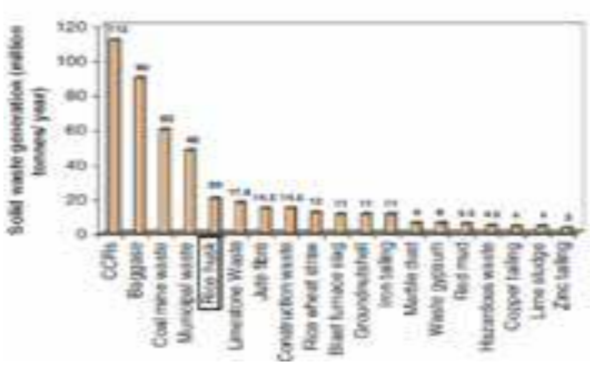

Fig. 3: Production of Rice Husk

(Source: www.elsevier.com/locate/buildenv)

A. Properties of rice husk ash

TABLE I: Chemical properties of rice husk ash

Constituents	Weight % RHA
Silicon dioxide, SiO2	87.2
Aluminum oxide, Al2O3	0.15
Ferric oxide, Fe2O3	0.16
Calcium oxide, CaO	0.55
Magnesium oxide, MgO	0.35
Sodium oxide, Na_2O	1.12
Potassium oxide, K_2O	3.68
Phosphorous oxide, P_2O_5	0.50
Titanium oxide, TiO	0.01
Sulphur Oxide, SO3	0.24
Carbon, C	5.91
Loss on Ignition	8.55

Source: http:// Building Materials and Technology Promotion Council (BMTPC)

TABLE II: Physical properties of rice husk ash

Sr. No.	Name	Physical Properties
1.	Density	2.06
2.	Average particle size	5.85 to 6.86
3.	Specific surface area	32.4 to 112.1
4.	Mineralogy	Non-crystalline
5.	Shape and texture	Irregular, Cellular

Source: http:// Building Materials and Technology Promotion Council (BMTPC)

B. Advantages of rice husk ash

- Considerable reduction in alkali-silica and sulfate expansions.
- Higher frost resistance of non-air entrained RHA concrete compared to similar mixtures of silica fume concrete.
- Higher compressive strength.
- Higher resistance to chloride ion penetration of RHA concrete with 10% cement replacement compared to normal concrete.
- Reduction in the heat of hydration,
- Higher resistance to carbonation.
- Higher abrasion compared to control mortar specimens

C. Application of rice husk ash

- Green concrete
- High performance concrete
- Insulator
- As a fibrous building panels brick acid proof cement and rice husk ash as concrete additive and as a building materials and products.
- Waterproofing chemicals
- Oil spill absorbent
- Specialty paints
- Flame retardants

V. SAW DUST ASH

Sawdust or wood dust is a by-product of cutting, grinding, drilling, sanding, or otherwise pulverizing wood with a saw or other tool; it is composed of fine particles of wood. It is also the byproduct of certain animals, birds and insects which live in wood, such as the woodpecker and carpenter. It can present a hazard in manufacturing industries, especially in terms of its flammability. Sawdust is the main component of particleboard. Saw dust is a waste material from the timber industry. It is produced as timber is sawn into planks at saw mills located in virtually all major towns in the country. This process is a daily activity causing heaps of saw dust to be generated after each day. During the last decades it has been recognized with growing sawdust ash waste are of large volume and that this is increasing year by year in the household , mills and factory's. Now a days even in rice mills they are using sawdust for burning due to shortage of rice husk. This waste storage disposals are becoming a serious environmental problem. Hence there is a need for recycling more and more waste materials.

SDA is a suitable material for use as a pozzolans, since it satisfied the requirement for such a material by having a combined ($SiO_2+Al_2O_3+Fe_2O_3$) of more than 70%.

Fig. 4: Saw Dust

Source: www.alibaba.com

Fig. 5: Saw Dust Ash

Source: M. Mageswari and b. Vidivelli, "The Use of Sawdust Ash as Fine Aggregate Replacement in Concrete"

A. Properties of saw dust ash

TABLE III: Chemical properties of saw dust ash

Constituents	Weight % RHA
Silicon dioxide, SiO2	65.3
Aluminum oxide, Al2O3	4.0
Ferric oxide, Fe2O3	2.23
Calcium oxide, CaO	9.6
Magnesium oxide, MgO	5.8
Manganese Oxide, MnO	0.01
Sodium oxide, Na_2O	0.07
Potassium oxide, K_2O	0.11
Phosphorous oxide, P_2O_5	0.43
Sulphur Oxide, SO_2	0.45

Source: M. Mageswari and b. Vidivelli, "The Use of Sawdust Ash as Fine Aggregate Replacement in Concrete"

TABLE IV: Physical properties of saw dust ash

Name	Physical Properties
Specific Gravity	2.5
Fineness Modulus	1.78
Water Absorption %	0.56
Moisture Content	0
Bulk Density (Dry Loose State) (Kg/m^3) % Voids % Porosity	1250 64 41
Bulk Density (Dry Compact State) (Kg/m^3) % Voids % Porosity	1300 55 40
Flakiness Index	----
Elongation Index	----

Source: M. Mageswari and b. Vidivelli, "The Use of Sawdust Ash as Fine Aggregate Replacement in Concrete"

B. Advantages of saw dust ash

- The compressive strength of cubes and cylinders of the concrete for all mix increases with age of curing.
- The split tensile strength of cubes and cylinders of the concrete for all mix increases with age of curing.
- The flexural strength of cubes and cylinders of the concrete for all mix increases with age of curing.

C. Dis-advantages of saw dust ash

- Adversely affects the setting and hardening of Portland cement.
- Shrinkage and moisture movement is high.
- The water requirement increases as the SDA content increases.

D. Application of saw dust ash

- Green concrete.
- As a light weight aggregate in flooring.
- Manufacture of pre-cast concrete products.
- Roofing tiles.
- Concrete blocks for holding the nail well.
- Wall panels for acoustic purpose.

VI. QUARTZ SAND

Sand is a naturally occurring granular material composed of finely divided rock and mineral particles. The composition of sand is highly variable, depending on the local rock sources and conditions many sands, especially those found extensively in Southern Europe have iron impurities within the quartz crystals of the sand, giving a deep yellow color. The most common constituent of sand, in inland continental settings and non-tropical coastal settings, is silica (silicon dioxide, or SiO_2), usually in the form of quartz, which, because of its chemical inertness and considerable hardness, is the most common mineral resistant to weathering. Silica sand is one of the most common varieties of sand found in the world. It is used for a wide range of applications, and can be purchased from various suppliers throughout the world. Silica sand is used in industrial processing, to make glass, as fill, and to create molds and castings. Silica sand is used throughout the world, and in so many different ways it is hard to imagine a world without it. From water filtration, to glass manufacture, to industrial casting, to blasting, to producing concrete, to adding texture to slick roads silica sand impacts every aspect of daily life. Many industrial suppliers carry silica sand in bulk quantities, while some smaller household stores sell it in smaller amounts for home or home construction use. Quartz silica powder or Quartz powder is natural silica having purity of more than 99.7% Sio2. This silica powder comes in a very snow white color; the whiteness in A-grade silica is more than 96%. Silica powder is available in 100 mesh, 200 mesh, 300 mesh, and 10 microns D-97.

Fig. 6: Quartz Sand
Source: zhenshengky.com

A. Properties of quartz sand

TABLE V: Chemical properties of quartz sand

Constituents	Weight % RHA
Silicon dioxide, SiO2	99.72
Aluminum oxide, Al2O3	0.05
Ferric oxide, Fe2O3	0.04
Calcium oxide, CaO	0.03
Magnesium oxide, MgO	0.01
Loss on Ignition	0.09

Source: http://en.wikipedia.org/wiki/quartz .sand

TABLE VI: Physical properties of quartz sand

Name	Physical Properties
Specific Gravity	2.55
Whiteness	95–98 %
Average Particle Size	below 5 microns
Category	Silicate materials
Tenacity	Brittle

Source: http://en.wikipedia.org/wiki/quartz .sand

B. Advantages of quartz sand

- Reduction in sulfate expansions.
- Reduce permeability
- Early strength
- Higher ultimate strength
- Reduce alkali-silica reactivity

C. Dis-advantages of quartz sand

- Increase water demand
- Increase shrinkage potential

D. Application of quartz sand

- Green concrete
- In industrial processing, to make glass, as fill, and to create molds and castings.
- Water filtration, to glass manufacture, to industrial casting, to sand blasting, to producing concrete, to adding texture to slick roads, silica sand impacts every aspect of daily life.
- The major use of silica sand in the modern world is as an ingredient in industrial concrete.

VII. POZZOCRETE

Pozzocrete is a processed quality fly ash having all the pozzolanic properties. Pozzocrete is obtained by processing fly ash produce as a by-product at coal fired electricity generation power station. Pozzocrete entails in the main controlling its fineness and unburnt carbon and thus producing a material that can be used with confidence to make concrete / mortar that is readily consistent and is of high quality. Pozzocrete replaces about 20 – 70 % Portland cement depending upon various application in the construction industry. Every single tonne of Pozzocrete used reduces the demand and production of Portland cement by one tonne.

Every tonne of Portland cement clinker produced even with the best of technologies creates 0.9 tonne of Co_2 emission in to the atmosphere, Co_2 is one of the main contributors to the greenhouse effect. Using Pozzocrete instead of Portland cement can save up to 1 million tonne of Co_2 emission per year. Pozzocrete is a high efficiency pozzolanic material, obtained by selection and processing of power station fly ashes resulting from the combustion of pulverized bituminous coal. Pozzocrete is subjected to strict quality control.

1) POZZOCRETE 40 (P40)

P40 is a high efficiency pozzolanic material, obtained by selection, processing and testing of power station fly ash resulting from combustion of coal at electricity generating power station.

Fig. 7: Pozzocrete 40

Source: Rushabh A. Shah, Jayeshkumar Pitroda "Pozzocrete: Modern Material Partially Replaced with Cement in Mortar"

PROPERTIES OF P40

TABLE VII: Chemical properties of P40

Constituents	Weight % RHA
Silicon dioxide, SiO2	50
Calcium oxide, CaO	5
Magnesium oxide, MgO	4
Sodium oxide (Na_2O)	1.5
Sulphur Oxide (SO_3)	2

Source: Rushabh A. Shah, Jayeshkumar Pitroda "Pozzocrete: Modern Material Partially Replaced with Cement in Mortar"

TABLE VII: Physical properties of P40

Name	Physical Properties
Presentation	Finely divided by powder
Colour	Light grey
Bulk Weight	1.0 tonne/m^3
Specific Density	2.3
Loss of Ignition	<2.5 %
Particle Size	<25 % Retained on 45 micron sieve
Particle Shape	Spherical
Package	1 tonne big-bags and bulk tankers

Source: Rushabh A. Shah, Jayeshkumar Pitroda "Pozzocrete: Modern Material Partially Replaced with Cement in Mortar"

2) POZZOCRETE 60 (P60)

P60 is a high efficiency pozzolanic material, used as cement component with Portland clinkers. It is obtained by selection, processing and testing of power station fly ash resulting from combustion of coal at electricity generating power station.

Fig. 8: Pozzocrete 60

Source: Rushabh A. Shah, Jayeshkumar Pitroda "Pozzocrete: Modern Material Partially Replaced with Cement in Mortar"

PROPERTIES OF P60

TABLE IX: Chemical properties of P60

Constituents	Weight % RHA
Silicon dioxide, SiO2	50
Calcium oxide, CaO	5
Magnesium oxide, MgO	4
Sodium oxide (Na_2O)	1.5
Sulphur Oxide (SO_3)	2

Source: Rushabh A. Shah, Jayeshkumar Pitroda "Pozzocrete: Modern Material Partially Replaced with Cement in Mortar"

TABLE X: Physical properties of P60

Name	Physical Properties
Presentation	Finely divided by powder
Colour	Light grey
Bulk Weight	1.0 tonne/m^3
Specific Density	2.3
Loss of Ignition	<2.5 %
Particle Size	<18 % retained on 45 micron sieve
Particle Shape	Spherical
Package	30 kg bags, 1 tonne big-bags and bulk tankers

Source: Rushabh A. Shah, Jayeshkumar Pitroda "Pozzocrete: Modern Material Partially Replaced with Cement in Mortar"

3) POZZOCRETE 100 (P100)

P100 is a high efficiency pozzolanic material, used as cement component with Portland clinkers to yield high performance concrete. It is obtained by careful selection, processing and testing of power station fly, ash resulting from combustion of coal at electricity generating power station.

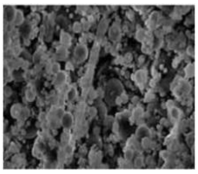

Fig. 9: Pozzocrete 100

Source: Rushabh A. Shah, Jayeshkumar Pitroda "Pozzocrete: Modern Material Partially Replaced with Cement in Mortar"

PROPERTIES OF P100

TABLE XI: Chemical properties of P100

Constituents	Weight % RHA
Silicon dioxide, SiO2	50
Calcium oxide, CaO	5.5
Magnesium oxide, MgO	4.5
Sodium oxide (Na_2O)	2
Sulphur Oxide (SO_3)	1.5

Source: Rushabh A. Shah, Jayeshkumar Pitroda "Pozzocrete: Modern Material Partially Replaced with Cement in Mortar"

TABLE XII: Physical properties of P100

Name	Physical Properties
Presentation	Finely divided dry powder
Colour	Greyish White
Bulk Weight	0.65 tonne/ m^3
Specific Density	2.3
Loss of Ignition	<2.5 %
Particle Size	Zero retention on 45 micron sieve, <0.25 % retained on 25 micron sieve
Particle Shape	Spherical
Package	30 kg bags

Source: Rushabh A. Shah, Jayeshkumar Pitroda "Pozzocrete: Modern Material Partially Replaced with Cement in Mortar"

A. Advantages of pozzocrete

- Reduced water demand, segregation and bleeding.
- Increased mix stability, pump ability and placeability.
- Increased sulphate resistance, acid resistance and sea water resistance.
- Reduced permeation, chloride ingress and ASR risk.
- Reduced thermal strain, drying shrinkage and creep.
- Increases the ultimate strength, ultimate stiffness and pore blocking.

B. Application

- Concrete
- Cement
- Mortar
- Grout

VIII. EGG SHELL

Eggshell is generally thrown away as a waste. The egg shell also creates some allergies when kept for a longer time in garbage. Disposal is a problem. It creates undesirable smell which can cause irritation. The main ingredient in eggshells is calcium carbonate (the same brittle white stuff that chalk, limestone, cave stalactites, sea shells, coral, and pearls are made of). The shell itself is about 95% $CaCO_3$ (which is also the main ingredient in sea shells).

The remaining 5% includes Magnesium, Aluminum, Phosphorous, Sodium, Potassium, Zinc, Iron, Copper, Ironic acid and Silica acid. Eggshell has a cellulosic structure and contains amino acids; thus, it is expected to be a good bio-sorbent and it was reported that large amounts of eggshells are produced in some countries, as waste products and disposed in landfills annually.

Fig. 10: Egg Shell

Source: www.elin.af.mil

TABLE XIII: India: production of eggs and poultry meat, 1980-2003 (quantity)

Year	Bird Eggs* (incl. Hen Eggs) (nos. in Billion)	Poultry (Chicken) Meat** (000 tons)
1980	10.1	179
1990	21.1	342
1995	27.2	578
2000	36.6	1,080
2004	41.0***	1,650

Note: * Data for financial year (Apr.-Mar.),
Source: Govt. of India, Department of Animal Husbandry.

A. Properties of egg shell

TABLE XIV: Chemical properties of egg shell

Constituents	Values
pH	6.59
Electrical conductance (mS)	0.1
pH ZPC	6.3

Source: R. Bhaumik, N. K. Mondal, B. Das , P. Roy, K. C. Pal, C. Das, A. Banerjee, And J. K. Datta, "Eggshell Powder As An Adsorbent For Removal Of Fluoride From Aqueous Solution: Equilibrium, Kinetic And Thermodynamic Studies"

TABLE XV: Physical properties of egg shell

Name	Physical Properties
Specific Gravity	0.846
Moisture content	1.174
Bulk Density g/m^3	0.8024
Particle Density g/m^3	1.075
Porosity (%)	25.4
BET Surface area m^2/g	21.2
Particle size	150-350 micro-meter

Source: R. Bhaumik, N. K. Mondal, B. Das , P. Roy, K. C. Pal, C. Das, A. Banerjee, And J. K. Datta, "Eggshell Powder As An Adsorbent For Removal Of Fluoride From Aqueous Solution: Equilibrium, Kinetic And Thermodynamic Studies"

B. Advantages of egg shell

- Considerable reduction in alkali-silica and sulfate expansions.
- Meets the most stringent environmental regulations nationwide.
- Ideal for painting in occupied spaces.
- Excellent durability and washable finish.
- Resist mold and mildew on the paint film.
- Saves money; less material required.
- Safe waterborne formula.
- Meets strict performance and aesthetic requirements.

C. Application of egg shell

- Concrete/Masonry Block.
- Plaster.
- Ferrous Metal.
- Wood.
- Gypsum Wallboard-Drywall.
- Road Pavements.

IX. CASE STUDY

"Study of the Properties of Concrete by Partial Replacement of Ordinary Portland Cement by Rice Husk Ash",

By: Abhilash Shukla, C. K. Singh and Arbind Kumar Sharma, International Journal of Earth Sciences and Engineering ISSN 0974-5904, Volume 04, No 06 SPL, October 2011, pp. 965-968.

This research work was experimentally carried out to investigate the effects of partially replacing Ordinary Portland cement (OPC) with our local additive Rice Husk Ash (RHA) which is known to be super pozzolanic in concrete at optimum replacement percentage which will help to reduce the cost of housing. Among the different existing residues and by products, the possibility of using rice husk ash in the production of structural concrete is very important for India. The commercially available rice husk procured from M/S Prakash Rice mill Danapur, Bihar with specific gravity of 2.06. Controlled burning of rice husk between 500 and 600 ^{o}C for short duration of about 2hrs yields ash with low un-burnt carbon and amorphous silica. When rice husk is burnt in an uncontrolled manner, the ash, which is essentially silica, is converted to crystalline forms and is less reactive. Both the crystalline and amorphous rice husk ash is used to manufacture a lime- rice husk ash mix or a Portland rice husk ash cement or the rice husk ash can be used as a Portland cement replacement in concrete.

TABLE XVI: Mix proportions used in research work

Sr. No.	Grade	Description	% Cement	% RHA
1	M30	BC	100	0
2	M30	BC1	95	5
3	M30	BC2	90	10
4	M30	BC3	85	15
5	M30	BC4	80	20
6	M60	CC	100	0
7	M60	CC1	95	5
8	M60	CC2	90	10
9	M60	CC3	85	15
10	M60	CC4	80	20

TABLE XVII: Physical and Chemical analysis of Rice husk ash used

Parameters	Values
Fineness passing 45 micron	96%
Specific gravity Bulk Density Silicon Dioxide (SiO2)	2.06 718 Kg/m3 87.20%
Aluminum oxide, Al2O3	0.15
Ferric oxide, Fe2O3	0.16
Calcium oxide, CaO	0.55
Magnesium oxide, MgO	0.35
Sodium oxide (Na_2O)	1.12
Potassium oxide (K_2O)	3.68
Phosphorous oxide (P_2O_5)	0.50
Titanium oxide (TiO)	0.01
Sulphur Oxide (SO_3)	0.24
Carbon (C)	5.91
Loss on Ignition	8.55

TABLE XVIII: Workability results for different mixes

Mix	C.F	Mix	C.F
BC	0.92	CC	0.82
BC1	0.83	CC1	0.73
BC2	0.82	CC2	0.68
BC3	0.80	CC3	0.60
BC4	0.77	CC4	0.56

TABLE XIX: % change in compressive strength of M30 & M60 grade concrete at 7 days

Mix	7 days	Mix	7 days
BC	----	CC	-----
BC1	4.68	CC1	2.88
BC2	10.93	CC2	4.23
BC3	-6.25	CC3	-4.80
BC4	-14.06	CC4	-8.65

TABLE XX: % change in compressive strength of M30 & M60 grade concrete at 28 days

Mix	28 days	Mix	28 days
BC	----	CC	-----
BC1	3.37	CC1	4.87
BC2	6.74	CC2	6.50
BC3	13.48	CC3	0.80
BC4	-17.97	CC4	-5.69

TABLE XXI: % change in flexural strength of M30 & M60 grade concrete at 28 days

Mix	28 days	Mix	28 days
BC	----	CC	-----
BC1	6.06	CC1	0.60
BC2	8.88	CC2	1.85
BC3	0.60	CC3	0.30
BC4	-0.40	CC4	-1.01

TABLE XXII: % change in split tensile strength of M30 & M60 grade concrete at 28 days

Mix	28 days	Mix	28 days
BC	----	CC	-----
BC1	-6.62	CC1	-9.7
BC2	-16.40	CC2	-11.60
BC3	-21.20	CC3	-22.93
BC4	-26.90	CC4	-26.60

There was a significant improvement in Compressive strength, Flexural strength of the Concrete with rice husk ash content of 10% for different grades namely M30 and M60 and at different ages i.e. 7 days and 28 days. The increase in Compressive strength was of the order of 4.23% to 10.93% for different grades and at different ages. There increase in Flexural strength was of the order of 1.85% to 8.88% for different grades and at the age of 28 days. There was reduction in Split tensile strength for 28 days at every rice husk content. As the concrete is a brittle material and cannot handle tensile stress as per IS: 456-2000 proved to be right and that is why as the percentage of rice husk ash increased strength decreased. So it can be concluded that Split tensile strength test has a little importance for design aspects.

X. CONCLUSIONS

The use of RHA in civil construction works will reduce environmental pollution, improve the quality of concrete, and reduce its cost of production as well as solving the problem of agro-waste management by putting into use this locally found additive (RHA). Adding RHA to concrete resulted in increased water demand, increase in workability and enhanced strength compared to the control sample. This results show that an addition of RHA from 5-10% will increase the strength and a further addition up to 15-25% RHA will have a slight reduction in strength of 15% and a decreasing in strength values is pointed out when the levels of RHA are increasing. So, we can say that up to 20% RHA utilized for economical and sustainable development of concrete. Uses of RHA in concrete can save the agro-waste disposal costs and produce a 'greener' concrete for construction. An innovative supplementary Construction Material is formed through this study.
Authors must convince both peer reviewers and the editors of the scientific and technical merit of a paper; the standards of proof are higher when extraordinary or unexpected results are reported.

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