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Experimental Investigation On Development Of Binder And Mortar By Partial Replacement Of Cement Using Sugarcane Bagasse Ash, Copper Slag And Egg Shell Powder

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Abstract: The research presented herein studies the effect of ESP, SCBA and CS as a partial replacement of cement in concrete. The experiment was done by replacing cement with materials specified above and tested for compressive strength at time intervals of 7 and 28 days. To understand chemical composition of these materials,X-ray fluorescence (XRF) were performed.The new and creative ways to create cement has led various type of cement being created. But various components required for the creation of cement are not readily available in most localities, hence a substitute is required which will fill the role of cement, without affecting the overall strength of the structure or being susceptible to weathering attacks. In this research paper, ESP, SCBA, CS are used on the Compressive strength of binder and mortar. This paper summarizes the research work on the properties of Copper Slag, Sugarcane Bagasse Ash, and egg shell powder when castoff as a partial replacement for Ordinary Portland Cement. The necessary lab tests were conducted for all the materials to know their chemical and physical properties. OPC was replaced with ESP, SCBA, CS by weight at 5,10,20. Consequently, the use of slag and ash in concrete lessens environmental pollution, enhances the properties of concrete and also reduces the cost.

Key Words: - ESP. SCBA, CS, XRF.

1. INTRODUCTION

In the present scenario the concrete has become the most widely used construction material throughout the world because of its versatility and efficiency of cost. Cement(OPC/PPC) is one the major constituents of concrete. But 5% of CO2 is produced by the production of cement and that's why it becomes major environmental problem throughout the world. Hence the construction industry is also in search of finding out the alternative of cement. The partial replacement of cement by supplementary cementious material(SCM) has give the benefits such as decrease in waste disposal problem, reduce the amount of cement without affecting the properties.

1.1 Eggshell Powder:

Eggshell is the outer covering provided to cover and protect the inner contents of an Egg, when a bird is born, it cracks the shell from within and when we eat eggs, we tend to break it off. In any case, the egg shell is a wasted material which eventually is thrown out. Since it is biodegradable in nature, disposing it in careless manner does not cause any pollution. But the process of decomposition creates nuisance in form of foul smell and flies. So rather than throwing it away, the egg shell can be powdered and used as partial replacement for cement in a concrete mix. It's a well-known fact that cement when used in concrete gives out large quantities of carbon monoxide and carbon dioxide in the atmosphere. For example, 1.1 tons of OPC release 1 tones ofCO_2 in the atmosphere. In an environment where the pollution is ever growing, we need to take any and all measures to reduce the pollution. Since as stated earlier eggshell is a waste material it can obtained rather easily and also since there are very uses of the eggshell aside from compost, people will more than happy to get rid of the shells. Once it is obtained it should be dried and then crushed finely to convert it into powdered form. It requires no further treatment or addition of the chemicals in order to make it usable. It was seen from various previous experiments that when eggshell powder is added in 5%, 10%, 15%, 20% weight of the cement, various properties of cement such as compressive strength, flexural strength, soundness were improved when compared to normal OPC concrete mix. Usage of eggshell is beneficial in multiple ways i.e. since a percentage of cement is replaced with eggshell, overall cost of cement is reduced. The improved properties that are obtained due to eggshell render any admixture such as plasticizer useless and most importantly its eco-friendly and reduces pollution.

1.2 Sugarcane Bagasse Ash:

Nowadays the reuse of waste material for concrete production is a worldwide adopted. These various types of waste for producing cement concrete include coconut pit, sawdust, cork granule, etc. one of these waste materials is sugar cane bagasse ash which is obtained from sugarcane. This sugarcane that is industrial waste, which can be used as fuel in the same industry. sugarcane bagasse ash is currently used as biofuel in paper and sugar manufacturing. The sugar cane bagasse ash is the agro waste, or by-product of sugar cane factories found obtain burning sugar cane. The SCBA is used as a partial replacement of cement in concrete reduced the problem associated with their disposal as well as decrease the ignition of greenhouse gases it also reduced the production of cement. The sugar cane bagasse ash is a cementitious material that can act as a partial replacement for Portland cement without signification compromising that compressive Strength. In sugar cane bagasse ash, the amount of silica present in bagasse reacts with a compound of cement and not only reduces the environmental pollution but also increases / Developed the property of cement. The sugar cane bagasse ash by using improve the mechanical property, durability and improve the Pozzolanic activity of cement. This bagasse ash has a valuable pozzolanic material that has the potential to reduce cost conserve energy and minimize waste emission.

1.3 Copper Slag:

Copper slag is an industrial by-product material produced from the process of manufacturing copper. It has been estimated that approximately 24.6 million tons of slag are generated from the world copper industry. Although copper slag is widely used in the sand blasting industry and in the manufacturing of abrasive tools, the remainder is disposed of without any further reuse or reclamation. Copper slag possesses mechanical and chemical characteristics that qualify the material to be used in concrete as a partial replacement for Portland cement or as a substitute for aggregates. For example, copper slag has a number of favorable mechanical properties for aggregate use such as excellent soundness characteristics, good abrasion resistance and good stability. Production of Portland cement includes the grinding of raw materials, the calcinations of them at 1500 ◦C and the grinding of cement clinker with gypsum. The average energy input required to produce one ton of cement is approximately 4.8 million Btu. As seen, it is an energy intensive process which releases significant amount of pollution such as CO2. Consequently, the production of Portland cement has many environmental problems as well as economic considerations. By using copper slag as a partial replacement of cement, substantial amounts of energy required for production of cement will be saved because its use needs only grinding. Furthermore, it will be possible to reuse a waste by-product material beneficially. Also, more amounts of copper slag will be utilized by using it as fine and coarse aggregates in concrete because more than 75% volume of concrete is occupied by aggregates. Many researchers have investigated the use of copper slag in cement clinker production, and the effects of copper slag on the properties of Portland cement mortar and concrete in the form of cement replacement, coarse and fine aggregate. The use of copper slag in cement and concrete provides potential environmental as well as economic benefits for all related industries particularly in areas where a considerable amount of copper slag is produced. This paper reviews the characteristics of copper slag and its effects on the properties of cement, mortars and concrete.

2. NEED OF RESEARCH

Nowadays as we can see that, some materials in the field of concrete production are largely impact on the environment which is becoming the major problem to the mankind; that's why if we can reduce or reuse some materials, it will help us to give pollution free and soothing surrounding. Thus, as we concluded from the literature review that we can research furthermore in the direction of partially replacing the cement by various industry waste materials, which can gives us up to the mark results in various properties of concrete. The objective or Principle for using this industry waste materials is not just providing cost effectiveness but also to improve the properties of concrete specially strength and durability.

Nowadays as we can see that the cost of concrete is getting so high and due to unavailability of material which can replace the concrete, we just have an option to partially replaced the cement or concrete ingredients with this industry waste materials. As this industry waste dumping to sites which spoil the land and atmosphere, so use of this waste material is cost effective and environment friendly. So, this research includes investigation done on various properties of cement with the help of industry waste materials.

3. SCOPE OF RESEARCH

(1) The aim of this experimental work is to investigate the effect of supplementary cementitious material on cement and mortar properties.
(2) To find out an optimal mix design pertaining to the amount of waste materials, water and sand required.

4. LITERATURE STUDY

4.1 "An Experimental Study on Partial Replacement of Cement with Egg Shell Powder in Concrete"Bandhavya G.B, Sandeep K, Bindhushree G.B (2017) studied the Properties of concrete with eggshell powder as cement replacement. They replaced ESP 0%, 5%, 10%, 15% by weight of cement. It was seen that compressive strength of concrete was maximum at 5-10%. On the other hand, split tensile strength went increasing up to 15%. The results showed that irrespective of presence of ESP, there was a good relationship between, compressive strength and split tensile strength of concrete. Mix proportion used to conduct this study was 1:1.74:2.93.[1]

4.2 "Eggshell powder as partial cement replacement and its effect on theworkability and compressive strength of concrete"Ashfaque Ahmed Jhatial , Samiullah Sohu , Muhammad Jaffar Memon , Nadeem-ul-Karim Bhatti , Darya Memon(2019) studied effects of ESP when mixed with concrete and replaced with cement. concrete. ESP was grounded into two fineness (50 um and 100 um) and for three percentages (5%, 10% and 15% by weight of cement) of ESP. This grounded ESP was then replaced with cement. From various tests and observations, it was seen that Eggshells when grounded into fine powder can be used as supplementary cementious materials (SCAs). ESP was more effective when grounded more finely as it can link up with fine cement particles. Although the strength was on increase, the workability was seen to be reduced due to water absorbing nature of ESP. Hence from various tests it was seen that 10% replacement was optimum with particle size being 50um.[2]

4.3 "Sugar cane bagasse ash from a high efficiency co-generation boiler as filler in concrete" ElisabethArif, Malcolm W.Clark, Neal Lake (2017) they found that, As the Ash content increases workability reduces. By adding 20% ash content, concrete was not uniform not workable. Also found that 10% ash content it gives high strength (13% more than ordinary concrete) at 56 days. Flexural strength at 15% SCBA was found to be more than 90 days of controlled concrete. From the result it is found that drying shrinkage of 10% used SBCA, concrete is get reduced from 1600 microstrain to 900 microstrains at 56 days by comparing with ordinary concrete. From the chloride penetration test result, it is found that controlled concrete has very low penetrability class and concrete by using a 10% ash content moderator penetrability class.[3]

4.4 "Utilization of bagasse ash as a pozzolanic material in concrete". NuntachaiChusilp, Chai Jaturapitakkul, KraiwoodKiattikomol (2009) They found that the development of compressive strength of mortar containing ground bagasse ash with high LOI slower than that of mortar containing ground bagasse ash with low LOI, at the later age, Both types of ground ash mortars displayed similar compressive strength. Mortar containing high LOI (20%) of ground bagasse ash at 20% and 30% by weight of binder Could produce higher compressive strength than control mortar after 28 and 90 days respectively. The greater effect on the compressive strength of mortar then did the LOI value (5-20 %) of ground bagasse ash.[4]

4.5 "Experimental Study on Partial Replacement of Cementand Fine Aggregate by Silicafume and Copper Slag inConcrete"M. Kiruthika(2018)has done experimental study on the partial replacement of cement and fine aggregate by silica fume and copper Slag in Concrete. This paper study presents the results of an experimental investigation on the properties of concrete using silica fume and copper slag as partial replacement for cement and fine aggregate. In this research work, M20 grade concrete was used and tests were conducted. We have study that workability increases when replacing cement by 10% silica fume. Self weight of the concrete increases while sand is replaced by copper slag due to the density of copper slag. Compressive strength increased by 20% and Tensile strength increased by 15 % by replacing the cement by 10 % silica fume and fine aggregate by 30 % copper slag when comparing to control specimen.[5]

4.6 "Utilization of Copper Slag to Enhance the Impact Strength ofconcrete"John J Lawrence, M. Jemimah Carmichael(2017) has done experimental study on the utilization of copper Slag to enhance the impact strength of concrete. The study it was noted that disposal of these waste material has been a major problem and has created many environmental issues. One of such material is copper slag which has 42% to 65% of silica content. Since availability of river sand is decreasing day by day, copper slag can be used as a partial replacement of fine aggregate. The percentage increase of first crack and failure crack of impact strength for 10% replacement of copper slag with fine aggregate was found to be higher than that of M30 grade of concrete of Normal Cement Concrete for 28 days.[6]

5. HYPOTHESIS

1) Uses of agricultural waste can be used as a partial replacement for cement
2) Research is carried out on use of above material shows that they offer a cost effective replacement for cements without compromising strength.
3) Copper slag having close knit composition which reduce pores and hence can resist weathering action to a higher degree.

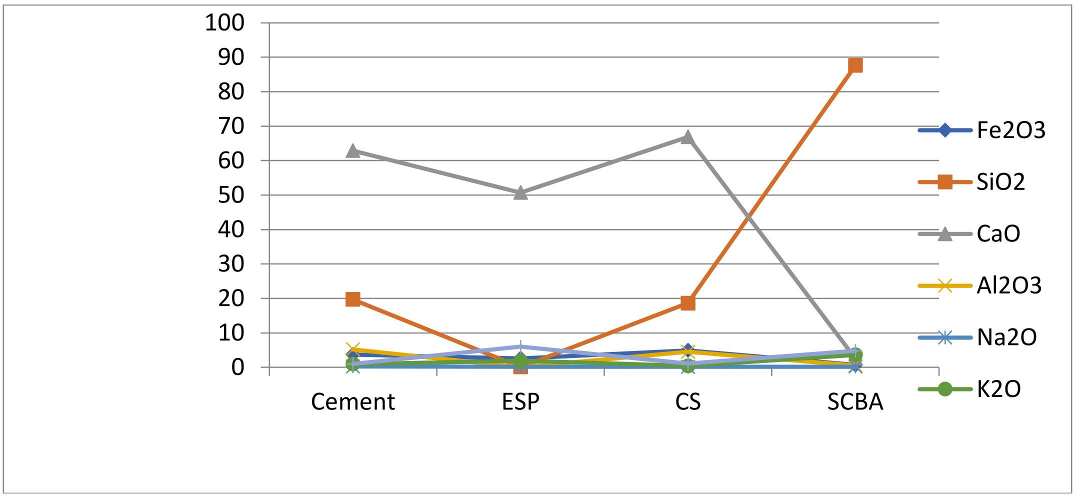
6. MATERIAL

Cement: Ordinary Portland Cement (OPC- 43 grade)
Water: Potable tap water fulfilling the requirement of concrete
Waste material: Eggshell powder(ESP), Copper slag(CS), Sugarcane baggase ash(SCBA) all these material are sieved from 150µ sieve.
Fine Aggregate: Clean river sand of zone- II was used

Chemical Composition

Constituents	**CEMENT (%)**	**ESP (%)**	**CS (%)**	**SCBA (%)**
Fe2O3	3.7	2.6	4.94	0.67
SiO2	19.71	0.11	18.61	87.59
CaO	62.91	50.7	66.87	2.59
Al2O3	5.20	0.05	4.51	0.51
Na2O	0.25	0.14	0.12	0.17
K2O	0.90	1.88	0.43	3.64
L.O.I	0.96	6	1.05	4.8

Table 1 Chemical composition



Comparison of Chemical Composition

Cement binder and mortar cubes was cast in 50mm×50m×50mm moulds. At a room temperature of 27 ± 2º C the mixing of binder and mortar was carried out. The mix was poured in these cubes by giving proper compaction and after 24 hr the cubes are demoulded. Then the ready cubes of binder and mortar are immersed in water for curing of 7 days and 28days. After completion of curing the cubes are taken to compression testing machine for compression testing as per IS 516-1959.the result are noted of average of 3 cubes per proportion.

7. RESULTS

7.1 Consistency

By replacing these waste materials with cement it was observed that the amount of water for concrete/ consistency was increased due to its fineness. The result of different proportion are shown in table 2.

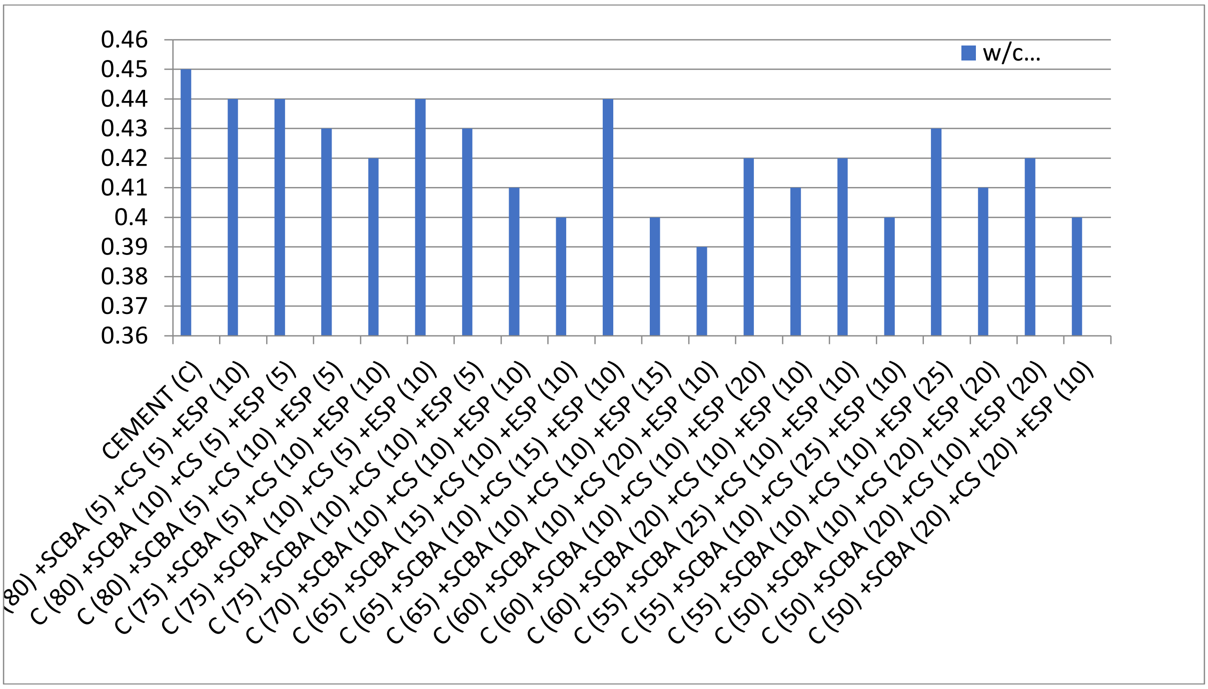
7.2 Water absorption

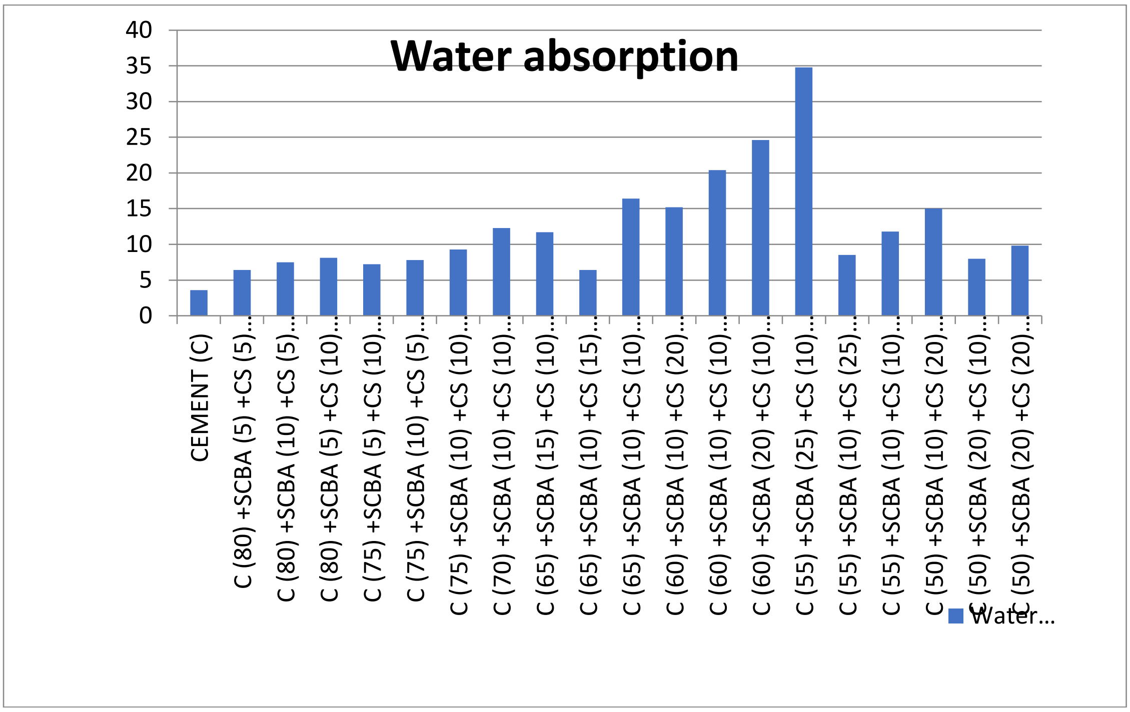
The results of water absorption are shown in table 2.

Abbreviation	**Binder mixes**	**W/C ratio for standard consistency**	**Water absorption (%)**
C	CEMENT (C)	0.45	3.6
Q1	C (80) +SCBA (5) +CS (5) +ESP (10)	0.44	6.4
Q2	C (80) +SCBA (10) +CS (5) +ESP (5)	0.44	7.5
Q3	C (80) +SCBA (5) +CS (10) +ESP (5)	0.43	8.1
Q4	C (75) +SCBA (5) +CS (10) +ESP (10)	0.42	7.2
Q5	C (75) +SCBA (10) +CS (5) +ESP (10)	0.44	7.8
Q6	C (75) +SCBA (10) +CS (10) +ESP (5)	0.43	9.3
Q7	C (70) +SCBA (10) +CS (10) +ESP (10)	0.41	12.3
Q8	C (65) +SCBA (15) +CS (10) +ESP	0.40	11.7

	(10)		
Q9	C (65) +SCBA (10) +CS (15) +ESP (10)	0.44	12.4
Q10	C (65) +SCBA (10) +CS (10) +ESP (15)	0.4	16.4
Q11	C (60) +SCBA (10) +CS (20) +ESP (10)	0.39	15.2
Q12	C (60) +SCBA (10) +CS (10) +ESP (20)	0.42	20.4
Q13	C (60) +SCBA (20) +CS (10) +ESP (10)	0.41	24.6
Q14	C (55) +SCBA (25) +CS (10) +ESP (10)	0.42	34.8
Q15	C (55) +SCBA (10) +CS (25) +ESP (10)	0.4	8.5
Q16	C (55) +SCBA (10) +CS (10) +ESP (25)	0.43	11.8
Q17	C (50) +SCBA (10) +CS (20) +ESP (20)	0.41	15
Q18	C (50) +SCBA (20) +CS (10) +ESP (20)	0.42	8
Q19	C (50) +SCBA (20) +CS (20) +ESP (10)	0.4	9.8

Table 2





7.3 Compressive strength

The results of compressive strength of binder and mortar (1:4) are shown in table 3.

Abbreviation	Mixes	7 days (N/mm2)		28 days(N/mm2)	
		Binder	Mortar (1:4)	Binder	Mortar (1:4)
C	CEMENT (C)	10.52	34.5	18.16	55.4
Q1	C (80) +SCBA (5) +CS (5) +ESP (10)	10.05	33.91	18.1	55.12
Q2	C (80) +SCBA (10) +CS (5) +ESP (5)	9.61	33.54	17.02	54.92
Q3	C (80) +SCBA (5) +CS (10) +ESP (5)	8.48	33.02	16.8	54.63
Q4	C (75) +SCBA (5) +CS (10) +ESP (10)	8.32	32.87	16.62	54.3
Q5	C (75) +SCBA (10) +CS (5) +ESP (10)	10.45	34.12	18.13	55.32
Q6	C (75) +SCBA (10) +CS (10) +ESP (5)	7.5	32.65	16.01	54.02
Q7	C (70) +SCBA (10) +CS (10) +ESP (10)	7.22	31.98	15.8	53.88
Q8	C (65) +SCBA (15) +CS (10) +ESP (10)	6.59	31.67	15.56	53.59
Q9	C (65) +SCBA (10) +CS (15) +ESP (10)	6.12	31.35	15.19	53.3
Q10	C (65) +SCBA (10) +CS (10) +ESP (15)	5.10	31	15.56	52.79

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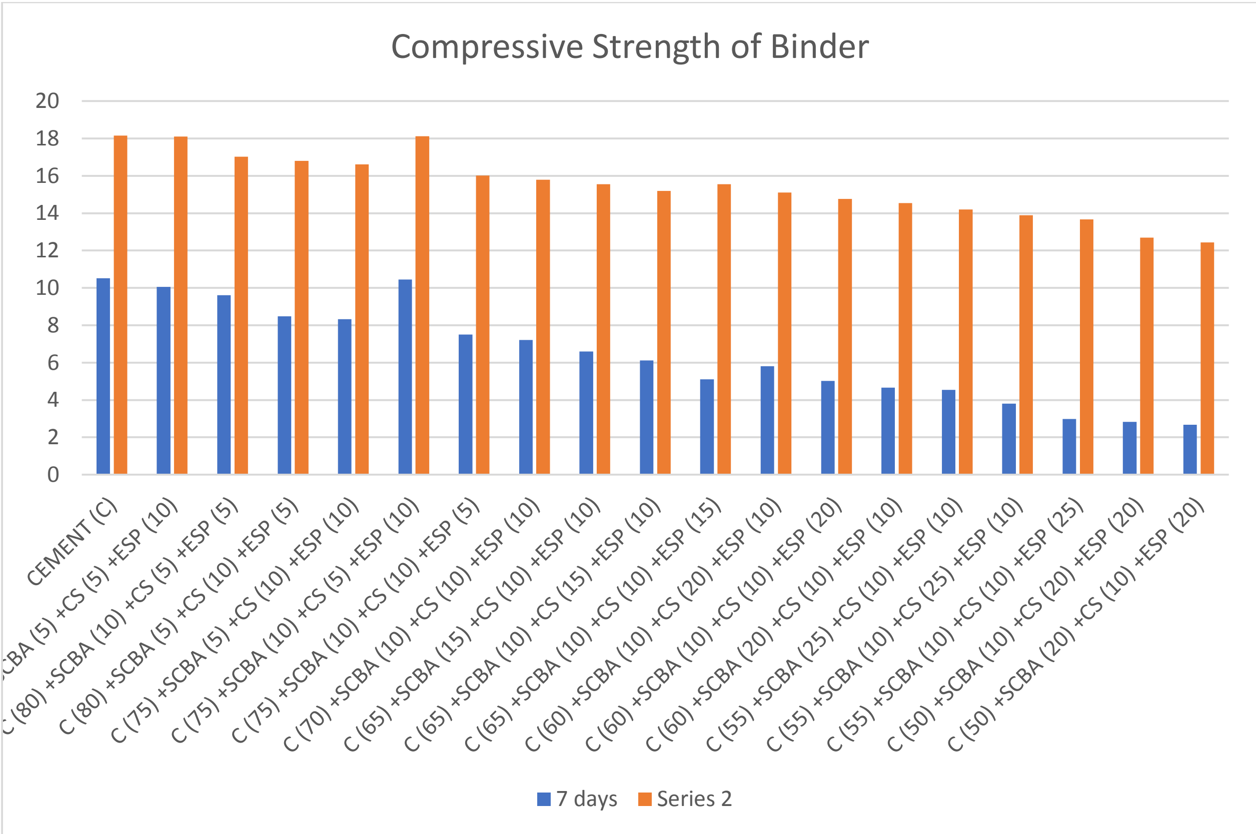
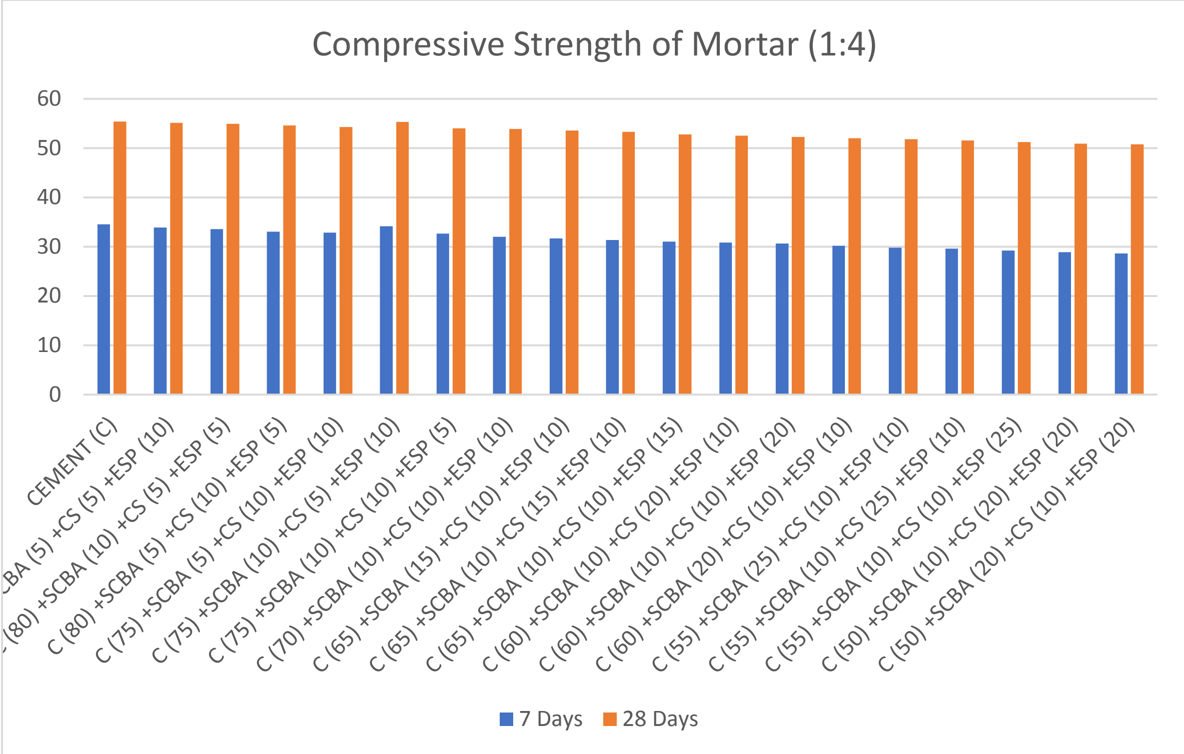
Q11	C (60) +SCBA (10) +CS (20) +ESP (10)	5.81	30.84	15.1	52.5
Q12	C (60) +SCBA (10) +CS (10) +ESP (20)	5.02	30.65	14.76	52.29
Q13	C (60) +SCBA (20) +CS (10) +ESP (10)	4.67	30.2	14.54	51.97
Q14	C (55) +SCBA (25) +CS (10) +ESP (10)	4.55	29.78	14.2	51.78
Q15	C (55) +SCBA (10) +CS (25) +ESP (10)	3.8	29.6	13.9	51.55
Q16	C (55) +SCBA (10) +CS (10) +ESP (25)	2.98	29.2	13.67	51.2
Q17	C (50) +SCBA (10) +CS (20) +ESP (20)	2.83	28.9	12.7	50.9
Q18	C (50) +SCBA (20) +CS (10) +ESP (20)	2.67	28.6	12.44	50.74
Q19	C (50) +SCBA (20) +CS (20) +ESP (10)	2.87	26.1	11.89	50.2



COMPRESSIVE STRENGTH OF BINDER



COMPRESSIVER STRENGTH OF MORTAR

8. XRF TEST

XRF (X-ray fluorescence) is a non-destructive analytical technique used to determine the elemental composition of materials. XRF analyzers determine the chemistry of a sample by measuring the fluorescent (or secondary) X-ray emitted from a sample when it is excited by a primary X-ray source. Each of the elements present in a sample produces a set of characteristic fluorescent X-rays ("a fingerprint") that is unique for that specific element, which is why XRF spectroscopy is an excellent technology for qualitative and quantitative analysis of material composition.

Sr. No	**Customer Sample ID**	**JNARDDC sample code no**
1	OPC 43 grade cement	JNA/20-21/Mar/27
2	Eggshell Powder	JNA/20-21/Mar/28
3	Copper Slag	JNA/20-21/Mar/29
4	Sugarcane Baggase Ash	JNA/20-21/Mar/30

Sr No	**Test Parameters**	**Test Method**	**Results in %**			
			JNA/20-21/Mar/27	**JNA/20-21/Mar/27**	**JNA/20-21/Mar/27**	**JNA/20-21/Mar/27**
1	Al_2O_3	JNARDDC/QTP/XRF	5.04	0.10	5.10	5.25
2	Fe_2O_3	JNARDDC/QTP/XRF	2.58	0.69	58.58	2.58

3	SiO_2	JNARDDC/QTP/XRF	22.77	0.59	26.47	52.11
4	CaO	JNARDDC/QTP/XRF	61.05	50.62	2.96	6.45
5	SO_3	JNARDDC/QTP/XRF	2.09	0.19	1.21	0.71

9. RESULTS AND CONCLUSION

Based on the experimental investigation related to water absorption, consistency, Compressive strength of Binder and mortar we have got following results-
(1) For Consistency, the calculated consistency of cement only is 0.45 as we partially add waste material in cement the values of consistency are get fluctuated, but mostly they are decreasing in nature as compared to cement.
(2) For water absorption, from graphs we can conclude that as we start partially replacing cement the water absorption capacity of mix is get increased.
(3) For compressive strength of Binder, from graph we can see that Mix no. Q5 gives high compressive strength and further after the strength get decreased as we increases the % of waste materials in mix.
(4) For compressive strength of Mortar, as we see in graphs, the results are relatively same but for Mix no.Q5 it gives slightly higher compressive strength as compared to other mix proportions.

Compression testing   Failure of specimen

10. REFERENCE

[1] Bandhavya G.B, Sandeep K, Bindhushree G.B (2017) An Experimental Study On Partial Replacement Of Cement With Egg Shell Powder In Concrete International Research Journal Of Engineering And Technology (IRJET)

[2] Ashfaque Ahmed Jhatial, Samiullah Sohu, Muhammad Jaffar Memon, Nadeem-Ul-Karim Bhatti, Darya Memon(2019) Eggshell Powder As Partial Cement Replacement And Its Effect On The Workability And Compressive Strength Of Concrete. International Journal Of Advanced And Applied Sciences, 6(9) 2019, Pages: 71-75.

[3] Elisabeth Arif,MalcolmW.Clark,Neal Lake (2016);Sugar Cane Bagasse Ash From A High Efficiency Co-Generation Boiler: Applications In Cement And Mortar Production.Construction And Building Materials 128 (2016) 287–297 Contents Lists Available At Science Direct.

[4] NuntachaiChusilp, Chai Jaturapitakkul ,KraiwoodKiattikomol (2009);Utilization Of Bagasse Ash As A Pozzolanic Material In Concrete.Construction And Building Materials 23 (2009) 3352–3358.
[5] M. Kiruthika(2018).Experimental Study On Partial Replacement Of Cement And Fine Aggregate By Silica Fume And Copper Slag In Concrete. January 2018 | IJIRT | Volume 4 Issue 8 | ISSN: 2349-6002
[6] John J Lawrence, M. Jemimah Carmichael(2017)Utilization Of Copper Slag To Enhance The Impact Strength Of Concrete. International Journal Of Chemtech Research Vol.10 No.8, Pp 628-633, 2017
[7] Sagar W. Dhengare, Dr. Ajay L. Dandge and Harshal R. Nikhade, "Economical Concrete by Utilizing Sugarcane Bagasse Ash and Ceramic Waste‖", IAETSD Journal, Volume 4, Issue 7, December 2017.
[8] Sagar W. Dhengare, S. P. Raut, N. V. Bandwal and A. Khangan, "Investigation into Utilization of Sugarcane Bagasse Ash as Supplementary Cementitious Material in Concrete‖", IJEERT Journal, Volume 3, Issue 4, April 2015.
[9] Sagar W. Dhengare, Sourabh Amrodia, Mohanish Shelote, Ankush Asati, Nikhil Bandwal and Anand Khangan, "Utilization of Sugarcane Bagasse Ash as A Supplementary Cementitious Material in Concrete and Mortar – A Review", IJCIET Journal, Volume 6, Issue 4, 2014-2015
[10] Sagar W. Dhengare, Dr.R.L.Sharma, Dr.Jaskiran Sobti, Dr.A.R.Gajbhiye, Rajesh Bhagat, "Binary Concrete Expansion by means of Copper Slag, Fly Ash, Sugarcane Bagasse Ash and Rice Husk Ash as a Partial Replacement of Cement", IJAST, Vol. 29,No.7, Pp. 9973-9993, Jun. 2020.