IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 08, Issue 6 (June. 2018), ||V (III) || PP 31-34

Ternary Blended Concrete with Metakaolin and Bagasse Ash

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Abstract: Ordinary Portland cement is recognised as major construction material throughout the world. Cement is responsible for about 5% - 8% of global CO_2 emissions. Therefore the utilization of industrial waste has been increased which is environmental friendly. In this paper an attempt has been made to utilize sugarcane bagasse ash (S.C.B.A.) and metakaolin as supplementary cementitious material.

The present study investigates the strength and durability properties of the concrete when the cement is replaced with S.C.B.A. and metakaolin in different proportions. In the first stage the S.C.B.A. (BA I) is partially replaced in percentages of 0 to 20% in increasing steps of 5%, with constant metakaolin replacement of 5%. Further in the second stage the S.C.B.A. (BA II) is heated upto 850°c for about 8 hours in a muffle furnace and is replaced in the percentages of 0 to 20% in increasing steps of 5%, with constant metakaolin replacement of 5%. Compressive strength, split tensile strength and flexural strength are obtained for both the conditions and strength variations are analysed. The results indicate that the utilization of metakaolin and bagasse ash in concrete as cement replacement will improve its properties.

Date of Submission: 01-06-2018 Date of acceptance: 16-06-2018

I. Introduction

Concrete is certainly the most important construction material in the world. Its use is over 10 billion tons per year and when done well, concrete can present good mechanical strength and also, acceptable durability performance. The main component of concrete is the binder that normally is composed of portland cement and in some cases, the presence of mineral additions, such as fly ashes or silica fume, can also be observed in its composition. Cement which is one of the main ingredients of concrete plays a great role, but it is most expensive. Portland cement is the conventional binding material that, actually, is responsible for about 5%–8% of global CO_2 emissions. This environmental problem will most likely be increased due to exponential demand of portland cement. By 2050, demand is expected to rise by 200% from 2010 levels, reaching 6000 million tons per year.

Bagasse ash has pozzolanic property and it can be used as a cement replacement material. With the country's plan to boost the sugar production to over 3 million tons by the end of 2015, the disposal of the bagasse ash will be of a serious concern. Some of raw material having similar composition can be replaced by weight of cement in concrete then cost could be reduced without affecting its quality. For this reason SCBA is one of the main by-product can be used as mineral admixture due to its high content in silica. The ash, therefore, becomes an industrial waste and poses disposal problems. Sugarcane bagasse is an industrial waste which is used worldwide as fuel in the same sugar-cane industry. It is, however, generally used as a fuel to fire furnaces in the same sugar mill that yields about 8-10% ashes containing high amounts of un-burnt matter, silicon, aluminum, iron and calcium oxides. But the ashes obtained directly from the mill are not reactive because of these are burnt under uncontrolled conditions and at very high temperatures. The ash, therefore, becomes an industrial waste and poses disposal problems.

Metakaolin is obtained by thermal activation of kaolin clay. This activation will cause a substantial loss of water in its constitution causing a rearrangement of its structure. To obtain an adequate thermal activation, the temperature range should be established between 600 to 750ºC. Metakaolin is used in oil well cementing to improve the compressive and flexural strength of the hardened cement. Metakaolin also reduces the hardened cement permeability to liquids and gases. Hence by partially replacing Portland cement with Metakaolin not only reduces carbon dioxide emissions but also increases the service life of buildings.

II. Experimental Investigation

In this experimental work, cubes, cylinders and beamswere casted. The standard size of cube 150mm×150mm×150mm, cylinder 150 mm diameters x 300mm height and beam 100mm x 100mm x 500mm are used. The mix design of concrete was done according to Indian Standard guidelines for M 20 grade.

Based upon the quantities of ingredient of the mixes, the quantities of bagasse ash for 0, 5, 10, 15 and 20% and metakaolin for 5% replacement by weight were estimated. The ingredients of concrete were thoroughly
mixed in mixer machine till uniform consistency was achieved. Before casting, machine oil was smeared on the inner surfaces of the cast iron mould. Concrete was poured into the mould and compacted thoroughly and the top surface was finished by means of a trowel. The specimens were removed from the mould after 24 hours and then cured under water for a period of 7, 28 and 56 days. The specimens were taken out from the curing tank just prior to the test. The tests were conducted as per the relevant Indian Standard specifications.

2.1 Material details

The materials used in this investigation are:
Cement: The OPC Cement of 53 grade was used with fineness 1% and standard consistency 31%.
Fine aggregate: Locally available M sand has been used as fine aggregate in the present study.In the present study the sand conforms to zone II as per the Indian standards. The specific gravity of sand is 2.82 and fineness modulus is 2.86.
Coarse aggregate:The crushed granite stone aggregates used 20mm nominal size and are tested as per Indian standards and results are within the permissible limit. The specific gravity of aggregate is 3.128 and fineness modulus is 3.89.
Water:Water available in the campus conforming to the
requirements of water for concreting and curing as per IS:456-2009.
Sugarcane bagasse ash:In this study, sugarcane bagasse ash was collected during the cleaning operation of a boiler operating in the Sakthi Sugar Factory, located in the city of Aapakoodal, Tamilnadu.
Metakaolin:Metakaolin obtained from EshwariChemtech, Hebbal, Bangalore was used for the present investigation. The specific gravity of the metakaolin sample was 2.5.

Table 1 Quantities of different constituents required for per m^3 of mix

Material specimen	Unit
W/C	0.5
Coarse aggregate	1314.88 kg
Fine aggregate	726.544 kg
Cement	394 kg
Water	197 kg

Table 1 indicatesquantities of different constituents required for per m^3 of mix and table 2 indicates mix notations.

Table 2 Mix Notations

<table>
<tr><th colspan="2">Mix Notation</th><th>Cement replaced by Metakaolin%</th><th>Cement replaced by BA%</th></tr>
<tr><td colspan="2">M0B0</td><td>0</td><td>0</td></tr>
<tr><td colspan="2">M5B0</td><td>5</td><td>0</td></tr>
<tr><td rowspan="4">Cooled BA</td><td>M5B5</td><td>5</td><td>5</td></tr>
<tr><td>M5B10</td><td>5</td><td>10</td></tr>
<tr><td>M5B15</td><td>5</td><td>15</td></tr>
<tr><td>M5B20</td><td>5</td><td>20</td></tr>
<tr><td rowspan="4">Heated BA (850°C for 8 hours)</td><td>M5B5</td><td>5</td><td>5</td></tr>
<tr><td>M5B10</td><td>5</td><td>10</td></tr>
<tr><td>M5B15</td><td>5</td><td>15</td></tr>
<tr><td>M5B20</td><td>5</td><td>20</td></tr>
</table>

2.2 Concrete tests

Slump test: Workability of fresh concrete was measured usingslump test. Slump test was conducted as per IS 516:1959.
Compression test: Compressive strength test was conducted at 7 and 28 days on 150mm cubes as per IS 516:1959.

Cylinder splitting tension test: Cylinder splitting tension test was conducted at 28 days on 150mm diameter x 300mm height cylinders as per IS 516:1959.
Flexure test: Flexure test was conducted at 28 days on 100mm x 100mm x 500mm height beams as per IS 516:1959.
Sulphate attack: Cube specimens of size 150mm were cast and after 7 days of water curing were taken out and dried in air and then kept immersed in $MgSO4$ solution for a period of 28 and 56 days. The concentration of $MgSO4$ solution used is 20 g/lit. Compressive strengths of modified concrete mixes were compared with that of control mix.
Chloride attack: Cube specimens of size 150mm were cast and after 7 days of water curing were taken out and dried in air and then kept immersed in NaCl solution for a period of 28 and 56 days. The concentration of NaCl solution used is 100 g/lit. Compressive strengths of modified concrete mixes were compared with that of control mix.

2.3 Experimental results

The strength results obtained from the experimental investigations are showed in Table 3. The durability results obtained from the experimental investigations are showed in Table 4. All the values are the average of the three trails in each case in the testing program of this study. The results are discussed as follows.

Table 3 7^{th} and 28^{th} day cube compressive strength, 28^{th} day split tensile strength and 28^{th} day flexural strength test

Mix ID	7^{th} day compressive strength (N/mm^2)	28^{th} day compressive strength (N/mm^2)	28^{th} day split tensile strength (N/mm^2)	28^{th} day flexural strength (N/mm^2)
M0B0	19.55	28.27	3.11	5.50
M5B0	21.25	30.04	3.24	5.65
M5B5 C	22.58	31.34	3.44	5.87
M5B10 C	23.45	32.72	3.56	6.04
M5B15 C	24.69	34.1	3.67	6.15
M5B20 C	23.25	32.92	3.39	5.86
M5B5 H	22.84	31.82	3.69	5.97
M5B10 H	24.21	33.55	3.84	6.14
M5B15 H	25.55	34.97	3.92	6.32
M5B20 H	24.12	33.24	3.74	6.08

The silica content of pozzolans reacts with free lime released during the hydration of cement and forms additional calcium silicate hydrate (CSH) as new hydration products, which improved the compressive strength, flexural strength and split tensile strength of concrete. When quantity of bagasse ash and metakaolin in mix is higher than the amount required to combine with the liberated lime during the process of hydration, leading to excess silica leaching out, causes a reduction in strength as it replaces part of the cementitious material but does not contribute to strength.

Table 4 Cube compressive strength after 28^{th} and 56^{th} day

Mix ID	Compressive strength after 28^{th} and 56^{th} day in NaCl solution (N/mm^2)		Compressive strength after 28^{th} and 56^{th} day in $MgS0_4$ solution (N/mm^2)	
	28^{th} day	56^{th} day	28^{th} day	56^{th} day
M0B0	29.6	32.70	29.2	31.33
M5B0	30.2	34.33	29.7	32.57
M5B5	30.8	35.55	30.3	33.25
M5B10	31.95	37.44	31.2	36.44
M5B15	33.2	38.67	32.5	38.54
M5B20	32.1	35.73	31.7	35.55

III. CONCLUSION

The results show that the workability of the modified concrete increases with increase in bagasse ash percentage when metakaolin percentage is kept constant. So use of superplasticizer is not essential. The replacement of cement with bagasse ash and metakaolin increases the compressive strength, flexural strength and splitting tensile strength upto 15% replacement. Maximum compressive strength, flexural strength and splitting tensile strength occur at 5% metakaolinand 15% bagasse ash replacement. Durability decreases with increase in bagasse ash content. Optimum strength is obtained for 5% metakaolin and 15% bagasse ash replacement.

REFERENCES

[1]. U.R.Kawade,Mr.V.R.Rathi, Miss Vaishali D. GirgeEffect of use of Bagasse Ash on Strength of Concrete, *International Journal of Innovative Research in Science, Engineering and Technology* 2 (2013), 2997-3000.
[2]. E. E. Maldonado-Bandala, V. Jiménez- QueroElectrochemicalCharacterization of Modified Concretes with Sugar CaneBagasse Ash *International Journal of Electrochemical Science* 6 (2011,) 4915 - 4926
[3]. R .Srinivasan, K.Sathiya Experimental study on bagasse ash in concrete *International Journal for Service Learning inEngineering* 5(2010) 60-66
[4]. AjayGoyal, HattorIKunio, Ogata Hidehiko, MandulaProperties and Reactivity of Sugarcane Bagasse Ash", Department of countries *Ibracon Structures And Materials Journal* 3(2010) 50 - 67
[5]. Noor-ul Amin Use of Bagasse Ash in Concrete and Its Impact on the Strength and Chloride Resistivity *Journal Ofmaterials In Civil Engineering* © Asce (2011) 717-720.
[6]. BirukHailu, AbebeDinkuApplication of Sugarcane Bagasse Ash as a Partial Cement Replacement Material *School of Civiland Environmental Engineering, AAiT, Addis Ababa University* (2010)
[7]. ApurvaKulkarni, SamruddhaRaje, MamtaRajgorBagasse Ash as an Effective Replacement in Fly Ash Bricks *InternationalJournal of Engineering Trends and Technology* (IJETT) 4 (2013), 4484-4489
[8]. Dr.K.Srinivasu M.L, N.KrishnaSai, VenkataSairamKumar.NA Review on Use of Metakaolin in Cement Mortar and Concrete *International Journal of Innovative Research in Science,Engineering and Technology* (2014).
[9]. ShruthiHR, Dr.Heramma,Yashwanth M K,Keerthigowda B S A Study ON Bagasse Ash Replaced Plain Cement Concrete *International Journal Of Advanced Technology in Engineering and Science (*2014).
[10]. Bini M J,ShibiVargheseTernary Blended Concrete with Bagasse Ash and Metakaolin*International Journal of Engineering Research & Technology (IJERT)*ISSN: 2278-0181.
[11]. TehminaAyub, NasirShafiq, SadaqatUllah Khan Durability of Concrete with Different Mineral Admixtures: A Review *International Journal of Civil, Architectural, Structural and Construction Engineering* Vol:7 No:8, 2013
[12]. IS 10262: 2009, "Indian Standard, recommended guidelines for concrete mix designs", Bureau of Indian Standard, New Delhi.
[13]. IS 456: 2000, "Indian Standard, Plane and reinforced concrete- Code of practice", Bureau of Indian Standard, New Delhi, 2000.
[14]. IS 516:1959, "Method of Tests for Strength of concrete", Bureau of Indian Standard, New Delhi.
[15]. IS 383 -1970 "Specifications for Coarse and Fine Aggregates from Natural Sources for Concrete", Bureau of Indian Standards, New Delhi.

Sherwin "Ternary Blended Concrete with Metakaolin and Bagasse Ash." IOSR Journal of Engineering (IOSRJEN), vol. 08, no. 6, 2018, pp. 31-34.