EXPERIMENTAL STUDY OF BAGASSE ASH AS A CEMENT REPLACING MATERIAL

Dhrmveera Singh[1], Siddharth Jain[2]

[1]*Dhrmveera Singh, Post Graduate Student, Radha Govind Group of Institutions, Uttar Pradesh, India*
[2]*Siddharth Jain, Guide & Assistant Professor, KIET Group of Institutions, Uttar Pradesh, India*

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Abstract – *This research is therefore, conducted to examine the potential of bagasse ash as a cement replacing material bagasse ash samples are collected from Wonji's sugar factory and its chemical properties are investigated. The bagasse ash are then ground until the particles passing the 63 µm reaches about 85%, which is similar to that of Ordinary Portland Cement. Ordinary Portland cement and Portland Pozzolana Cement are replaced by ground bagasse ash. Normal consistency and setting time of the pastes containing ordinary Portland cement and bagasse ash from 5% to 30% replacement were investigated. The compressive strength of mortars containing ordinary Portland cement and pozzolana Portland cement with bagasse ash from 5% to 30% replacements are also investigated. Four different concrete mixes with the bagasse ash replacing 0%, 5%, 15% and 25% of the ordinary Portland cement were prepared for 35MPa concrete with water to cement ratio of 0.55 and 350kg/m^3 cement content. The properties of these mixes have then been assessed both at the fresh and hardened state.*

Key Words: Bagasse, Concrete, Cement Hydration eliminate

1. INTRODUCTION

Concrete is the most commonly used construction material in the world. It is basically composed of two components: paste and aggregate. The paste contains cement and water and sometimes other cementitious and chemical admixtures, whereas the aggregate contains sand and gravel or crushed stone. The paste binds the aggregates together. The aggregates are relatively inert filler materials which occupy 70% to 80% of the concrete and can therefore be expected to have influence on its properties. The proportion of these components, the paste and the aggregate is controlled by; the strength and durability of the desired concrete, the workability of the fresh concrete and the cost of the concrete.

Cement which is one of the components of concrete plays a great role, but is the most expensive and environmentally unfriendly material. Therefore requirements for economical and more environmental-friendly cementing materials have extended interest in other cementing materials that can be used as partial replacement of the normal Portland cement.

$$C3S + 4.3H\ C1.7SH3 + 1.3CH$$
$$C2S + 3.3H\ C1.7SH3 + 0H$$

Ground granulated blast furnace slag, fly ash, silica fume, etc. have been used successfully for this purpose.

2. CASE STUDY

Recently sugarcane bagasse ash, which is a byproduct of sugar factories found after burning sugarcane bagasse which in turn is found after the extraction of all economical sugar from sugarcane, has been tested in some parts of the world for its pozzolanic property and has been found to improve some of the properties of the paste, mortar and concrete like compressive strength and water tightness in certain replacement percentages and fineness. However, nothing has been done to check the feasibility of the bagasse ash produced in Ethiopia for this purpose

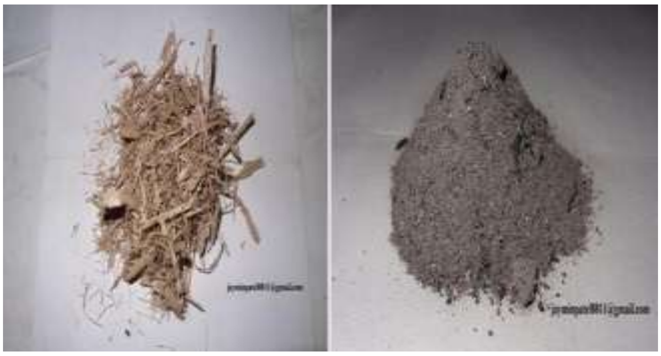
Table 2.1 Typical composition of ordinary Portland cement

Chemical Name	Chemical formula	Shorthand	
Notation Weight percentage			
Tricalcium silicate	3CaO.SiO2	C3S	55
Dicalcium silicate	2CaO.SiO2	C2S	18
Tricalcium aluminate	3CaO.Al2O3	C3A	10

Tetra calcium Aluminoferrite	$4CaO.Al_2O_3.FeO_3$	C4AF	8
Calcium sulfate dehydrate (gypsum)	$CaSO_4.2H_2O$	CSH2	6

Hydration of C3A. The hydration of C3S and C2S are shown in Eq.2.1 and Eq.2.2:

After a rapid initial reaction C3S will pass through a dormant stage which has a practical significance because it allows concrete to be placed and compacted before setting and hardening commences.



the levels found in china, which is about 800 kilograms and India about 125 kilograms per capita.

Table 2.2 Cement production in Ethiopia in 2009.

Plant Name	Max Capacity	2009 Capacity		
		PPC	OPC	Total
Mugher Cement	900,000	775,000	89,000	864,000
Messebo Cement	900,000	845,000		845,000
National Cement	300,000	300,000		300,000
Jemma Cement	240,000		200,000	200,000
Abyssinia Cement	150,000		100,000	100,000
Midroc Dejen	90,000		90,000	90,000
Red Fox Intl	150,000		150,000	150,000
CGOCC Cement	150,000	100,000		100,000
Total	**2,880,000**	**2,020,000**	**629,000**	**2,649,000**

Despite the rising supply, the cement demand in the country has been increasing even more than the supply due to large-scale public sector infrastructure projects (roads, power plants) and private sector construction activity for residential housing, industry, and real- estate developments. Table 2.3 below shows the consumption estimates and the growth rate of cement in Ethiopia:

Table 2.3 Cement consumption in Ethiopia (million)

Year (G.C)	Consumption Estimate (million tons)	Growth rate (%)
1996	0.67	…….
1997	0.77	14.9
1998	0.75	- 2.60

1999	0.74	- 1.30
2000	0.82	10.80
2001	0.82	0.00
2002	0.97	18.30
2003	1.04	7.20
2004	1.17	12.50
2005	1.81	54.70
2006	2.00	10.50
2007	2.50	25.00
2008	3.20	27.00

3. USED MATERIALS AND METHODOLOGY

3.1 USED MATERIALS

Following materials are used in this experiment -

- Cement
- Fine aggregate
- Coarse Aggregate
- Water
- Bagasse Ash

3.2 METHODOLOGY

3.2.1 WORKABILITY

The workability of cement concrete is tested as per using standard sizes of Slump Molds as per IS: 1199 – 1999.

3.2.2 COMPRESSIVE STRENGTH

For find out compressive strength of cement concrete we casted steel cube mold of size of 150mm*150mm*150mm. After 24 hour casting of cube removing the mold and allowed for curing in a curing tank for a period of 28 days. After 7days & 28 days of curing of cube we tested the cube on Universal Testing Machine. The test procedure is used as per IS: 516-1979.

4. RESULTS & CONCLUSIONS

4.1 RESULTS

In this Study we will compare cement mortar with OPC-BA mortar-

- **COMPRESSIVE STRENGTH OF OPC-BA MORTAR**
  - **Twenty eight Days Compressive strength of OPC-BA mortar**

No.	Age(days)	Dimension (mm)			Weight (gm)	Failure Load (KN)	Compressive Strength (MPa)
		L	W	H			
BAM 0							
1	28	50.1	50.1	50.0	271	137.0	54.82

		9	2	0			
2		50.39	50.38	50.04	275	134.2	53.68
3		50.01	50.12	50.23	276	132.7	53.09
Average					**274**	**134.6**	**53.86**
BAM 5							
1	28	49.52	50.15	49.84	271	141.5	56.62
2		49.80	50.03	49.17	268	142.2	56.86
3		50.12	50.23	50.11	268	136.4	54.56
Average					**269**	**140.1**	**56.01**
BAM 10							
1	28	49.84	50.11	51.13	267	141.7	56.70
2		50.31	50.02	50.17	272	139.1	55.66
3		50.24	50.01	50.13	271	134.8	53.91
Average					**270**	**138.5**	**55.42**
BAM 15							
1	28	49.71	50.58	50.01	266	134.8	53.94
2		50.10	50.17	50.33	271	132.1	52.83
3		50.11	50.12	50.42	267	135.4	54.15
Average					**268**	**134.1**	**53.64**
BAM 20							
1	28	49.96	50.24	50.55	270	128.3	51.32
2		50.42	50.04	50.05	264	126.8	50.72
3		50.33	50.14	50.53	264	125.0	50.00
Average					**266**	**126.7**	**50.68**
BAM 25							
1	28	50.30	50.25	50.29	262	114.4	45.76
2		50.01	49.97	50.22	264	116.5	46.61
3		50.11	49.56	50.04	266	113.6	45.47
Average					**264**	**114.8**	**45.95**
BAM 30							
1	28	50.2	50.5	50.4	266	112.2	44.89

		2	5	2			
2		50.01	50.07	50.05	265	107.2	42.87
3		49.74	50.02	50.14	261	108.6	43.46
Average					**264**	**109.3**	**43.74**

In this Study we will compare cement mortar with PPC-BA mortar

- **COMPRESSIVE STRENGTH OF PPC-BA MORTAR**
  - **Twenty eight Days Compressive strength of PPC-BA mortar**

No.	Age (days)	Dimension (mm)			Weight (gm)	Failure Load (KN)	Compressive Strength (MPa)
		L	W	H			
BAM 0							
1	28	50.21	50.18	50.25	271	107.6	43.03
2		50.14	50.11	50.26	274	109.9	43.96
3		50.21	50.47	50.25	271	110.3	44.14
Average					**272**	**109.3**	**43.71**
BAM 5							
1	28	50.31	50.41	50.01	267	94.5	37.81
2		50.42	50.33	50.01	264	90.1	36.03
3		50.12	50.13	50.41	264	97.5	39.02
Average					**265**	**94.1**	**37.62**
BAM 10							
1	28	50.41	50.65	51.14	263	93.8	37.51
2		50.21	50.13	50.12	267	92.1	36.83
3		50.58	50.14	50.12	265	94.1	37.65
Average					**265**	**93.3**	**37.33**
BAM 15							
1	28	50.15	50.12	50.03	264	93.2	37.29
2		50.00	50.01	50.21	264	89.1	35.63
3		50.38	50.12	50.01	267	90.8	36.31
Average					**265**	**91.0**	**36.41**
BAM 20							

1	28	50.21	50.44	50.11	265	86.4	34.57
2		50.21	50.12	49.65	261	89.8	35.94
3		50.15	50.19	50.30	263	88.2	35.30
Average					**263**	**88.1**	**35.27**
BAM 25							
1	28	50.14	50.12	50.38	263	78.4	31.35
2		50.11	50.10	50.20	259	80.3	32.11
3		50.74	50.21	50.12	261	80.7	32.27
Average					**261**	**79.8**	**31.91**
BAM 30							
1	28	50.62	50.41	50.21	257	67.5	27.01
2		50.32	50.41	50.12	261	68.8	27.53
3		50.21	50.13	50.32	262	73.1	29.25
Average					**260**	**69.8**	**27.93**

In this Study we will compare cement-$Ca(OH)_2$ mortar with OPC-BA- $Ca(OH)_2$ mortar

- **COMPRESSIVE STRENGTH OF OPC-BA-$Ca(OH)_2$ MORTAR**

  - **Twenty eight Days Compressive strength of OPC-BA-$Ca(OH)_2$ mortar**

No.	Age (days)	Dimension (mm)			Weight (gm)	Failure Load (KN)	Compressive Strength (MPa)
		L	W	H			
BAM 0							
1	28	50.41	50.3	50.4	273	130.3	52.11
2		50.39	50.4	50.30	277	132.3	52.94
3		50.05	50.52	50.33	278	131.6	52.65
Average					**276**	**131.4**	**52.57**
BAM 15							
1	28	50.65	50.51	50.4	266	131.4	52.58
2		50.63	50.67	50.5	265	128.1	51.25
3		50.22	50.24	50.5	267	127.6	51.04
Average					**266**	**129.0**	**51.62**
BAM 15-3							
1	28	50.24	50.2	51.4	267	127.3	50.94
2		50.51	50.24	50.53	271	130.8	52.32
3		50.42	50.3	50.4	269	130.1	52.07

Average					**269**	**129.4**	**51.78**
BAM 15-6							
1	28	50.45	50.6	50.09	266	129.4	51.78
2		50.45	50.15	50.3	270	130.1	52.03
3		50.45	50.48	50.5	271	129.0	51.60
Average					**269**	**129.5**	**51.80**

In this Study we will compare cement concrete with OPC-BA concrete

- **COMPRESSIVE STRENGTH OF OPC-BA CONCRETE**
  - **Twenty eight Days Compressive strength of OPC-BA concrete**

No.	Age (days)	Dimension (mm)			Weight (gm)	Failure Load (KN)	Compressive Strength (MPa)
		L	W	H			
BA 0							
1	28	152.44	150.36	149.93	8037	985.9	43.82
2		150.15	150.0	149.5	8113	957.4	42.55
3		151.2	152.51	152.4	8180	936.9	41.64
Average					**8110**	**960.1**	**42.67**
BA 5							
1	28	151.33	150.53	150.21	8005	1029.6	45.76
2		151.5	152.02	150.1	8203	972.2	43.21
3		152.31	150.72	149.8	7972	1022.2	45.43
Average					**8060**	**1008.0**	**44.80**
BA 15							
1	28	152.58	150.01	149.53	7950	921.6	40.96
2		152.64	150.0	151.1	8067	900.7	40.03
3		150.73	150.3	151.21	8013	960.1	42.67
Average					**8010**	**927.5**	**41.22**
BA 25							
1	28	153.0	152.7	149.34	8122	821.9	36.53
2		151.23	149.9	149.82	7749	859.7	38.21
3		151.56	150.2	150.4	8057	835.4	37.13
Average					**7976**	**839.0**	**37.29**

  - **Fifty six Days Compressive strength of OPC-BA concrete**

No	Age (days)	Dimension (mm)			Weight (gm)	Failure Load (KN)	Compressive Strength (MPa)
		L	W	H			
BA 0							
1	56	151.30	149.67	150.32			45.50

					7965	1023.7	
2		151.24	150.16	150.50	8028	1017.7	45.23
3		151.35	150.47	150.5	8076	1062.2	47.21
Average					**8023**	**1034.5**	**45.98**
BA 5							
1	56	150.15	149.43	152.70	7850	1113.9	49.51
2		152.21	150.20	151.0	8203	1080.7	48.03
3		151.03	150.35	150.75	7854	1111.0	49.38
Average					**7969**	**1101.9**	**48.97**
BA 15							
1	56	151.94	149.86	149.88	7838	959.2	42.63
2		150.73	150.65	159.54	7786	1017.2	45.21
3		151.23	150.45	148.96	7830	1043.5	46.38
Average					**7818**	**1006.6**	**44.74**
BA 25							
1	56	149.90	150.00	149.83	7787	910.1	40.45
2		150.32	150.10	149.32	7802	974.9	43.33
3		151.24	150.45	149.81	7835	883.1	39.25
Average					**7808**	**922.7**	**41.01**

4.2 CONCLUSIONS

The use of bagasse ash as a cement replacing material in concrete production is studied and after the research work is done, the following conclusions are made:

1. The chemical composition test reveals that the bagasse ash from Wonji's sugar factory can be assigned as class N pozzolana, as prescribed by ASTM C 618, i.e. SiO_2+ Al_2O_3+ Fe_2O_3 is greater than 70%.

2. Higher replacements of cement by bagasse ash resulted in higher normal consistency (implying higher water demand for certain workability) and longer setting time.

3. The workability of mortar and concrete containing bagasse ash decreases slightly as the bagasse ash content increases which is due to the higher water demand of bagasse ash.

4. The investigation of this thesis has revealed that replacement of ordinary Portland cement by bagasse ash from 5% to 10% results in a better compressive strength than that of the control mortar with 100% ordinary Portland cement. And the compressive strength decreases as the bagasse ash replacement increases over 10%.

Moreover, all of the OPC- BA blended mortars satisfy the ASTM C 618 minimum pozzolanic activity index requirement i.e. 75%.

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