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A STUDY ON THE REPLACEMENT OF CEMENT IN CONRETE BY USING COW DUNG ASH

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ABSTRACT

This paper presents the possibility of utilizing Cow dung ash (CDA) as a supplementary cementing material in cement mortar and concrete. Experimental investigations carried out to study the cow dung ash on the strength of mortar and concrete. Cement was partially replaced with four percentages (5%, 10%, 15%, and 16%) of cow dung ash by weight. Consistency limits and chemical composition of ordinary Portland cement (OPC), cow dung ash and OPC mixed with cow dung ash were determined. The compressive strengths of the mortar and concrete specimens were determined at 7, 14 and 28 days respectively. Test results indicated that the consistency limits increased up to an optimum content and decreased further with the increase in the % of CDA in cement. The compressive strength is increased when the cement is replaced by 5% of CDA and decreased with the increase in the cow dung ash content. Hence, it is concluded that the 5% cement can be replaced with CDA in mortar. The compressive strength of the concrete is reduced with the increase in CDA and in strength increase with the increase in curing days. As observed in mortar, 5% of cow dung may be used as a partial replacement to cement in concrete.

KEY WORDS: Compressive Strength, Consistency, Cement mortar, Cow dung ash, cement concrete, Ordinary Portland Cement (OPC).

1. INTRODUCTION

Portland cement is a basic ingredient of concrete, mortar and most non-specialty grout. The most common use for portland cement is in the production of concrete. Concrete is a composite material consisting of aggregate (gravel and sand), cement, and water. As a construction material, concrete can be cast in almost any shape desired, and once hardened, can become a structural (load bearing) element. Portland cement may be grey or white. Many researchers have used different materials as alternate to cement in concrete.

Dr. S. L Patil, J. N. Kale and S. Suman (2012) found that the consistency of cement has increased with the addition of Fly Ash from (32% for 0%) to (48% for 50%).The initial setting time has increased from 155 minutes for 0% fly ash to 250 minutes for 50% fly ash. The workability of cement concrete mix has increased from 25 mm (For 0% fly ash) to120 mm (For 25% fly ash). After 90 days of curing the concrete containing 10% of fly ash, related to cement mass, gained a compressive strength about 6% higher than the concrete without addition for Ordinary Portland cement.

Utsev, J. T. and Taku, J. K. (2012) found that the partial replacement of binding material by Coconut Shell Ash [CSA] has increased the setting times with increase in the amount of CSA i.e., the initial setting time increased from 1 hour 5 minutes at 0% replacement to 3 hours 26 minutes at 30% replacement while the final setting time increased from 1 hour 26 minutes at 0% replacement to 4 hours 22 minutes at 30% replacement.

K. A. Mujedu, S. A. Adebara, I. O. Lamidi (2014) found that partial replacement of cement by Corn Cob Ash [CCA], the compressive strength of the concrete cubes always increases with curing ages and decreased with increased amount of the percentage of CCA and suggested that CCA up to 10% replacement of Ordinary Portland cement in concrete would be acceptable to enjoy maximum benefit of strength gain.

Godwin A. Akeke et al (2013) found that rice husk ash could be substituted for OPC at up to 25% in the production of concrete with no loss in workability or strength and suggested that it is good for the structural concrete at 10% replacement level.

S. Barathanand and B. Gobinath (2013) is used wood ash as partial replacement of cement and found that the compressive strength of cement increases significantly over hydration time. The compressive strength of 20% WA sample shows more strength at 4 weeks than the OPC sample. The water requirement increased with the increase with WA addition, 20% WA sample shows higher degree of hydration and compressive strength than OPC.

M.R. Karim et al (2012) is used rice husk as partial replacement to cement and found that the 90 days compressive strength of concrete with RHA up to 40% was higher than the corresponding strength of concrete without RHA.

Sooraj V.M. (2012) found that the Palm Oil Fuel Ash [POFA] is an excellent pozzolanic material and can be used as an alternative cement replacement in concrete and suggested that 20% replacement of POFA could be the optimum level for the production of concrete.

D. Gowsika et al (2014) found that partial replacement of cement by 5% Egg shell powder + 10% Micro silica replacement in cement yields higher Split Tensile strength as compared to other compositions.

T. S. Abdulkadir et al (2014) found that partial replacement of binding material by Sugar Cane Bagasse Ash [SCBA] and the compressive strength of the concrete cubes for all the mix ratios increased with curing age and decreased as the SCBA content increased.He recommended that SCBA can be used as partial replacement of cement in concrete production up to 20%. For environmental sustainability, SCBA can be utilized for the production of lightweight, durable and cheap concrete.

From the above observations, it is necessitated the need to intensify the search for supplementary cementitious materials (SCMs) for utilization as partial substitute for cement. Several notable researchers have proven that the utilization of SCMs like Sawdust Ash (SDA), Rice husk Ash (RHA) and wood ash as partial replacement of cement in concrete and mortar is successful. The use of SCMs has also been established as one way of reducing the amount of CO_2 emissions and embodied energy usage associated with in cement production. Concrete mixtures with high Portland cement contents are susceptible to cracking and increased heat generation. These effects can be controlled to a certain degree by using supplementary cementitious materials [Md. Moinul Islam & Md. Saiful Islam, 2010]. Hence, an attempt has been made to find the compressive strength of concrete by partially replacing the cement with cow dung ash.

2. METHODOLOGY

The experimental program was planned to quantify the consistency and compressive strength of mortar and concrete using cow dung ash as replacement of cement.

Cement replacement at various percentages levels were used in this investigation to observe the effects of different cow dung ash levels in cement to find the compressive strength of mortar and concrete at various ages of curing. Table 1 shows the chemical analysis of cement and cow dung ash. It is found that that the loss of ignition is almost equal for both cement and cow dung ash. Also observed that the silica percentage is at higher value in the cow dung ash and alumina is slightly higher than the cement values.

TABLE 1 CHEMICAL ANALYSIS OF ORDINARY PORTLAND CEMNET

CHEMICAL COMPOUNDS, %	O.P.C(53GRADE)	COW DUNG ASH
Loss of ignition (L.O.I)	4.83	4.25
Silica (SiO_2)	18.78	79.22
Alumina (Al_2O_3)	2.87	5.62
Ferric Oxide (Fe_2O_3)	4.03	2.98
Calcium Oxide (CaO)	54.66	3.71
Magnesium Oxide (MgO)	3.46	1.88
Sulphuric Anhydride (SO_3)	1.13	0.19
Insoluble Residue (IR)	9.69	1.65

Four different mix proportions of cement and cow dung ash (95:5, 90:10, 85:15 and 84:16) were used as cementitious material. Cement cow dung ash mix ratio of 100:0 i.e., plain cement mortar and concrete specimens were also made for comparing the properties of cow dung ash mixed mortar and concrete.

3. RESULTS AND DISCUSSION

3.1 Consistency

The consistency characteristics of the cement pastes with different replacement ratios are presented in Table 2. The increase in cow dung ash ratio caused an increase in the values of consistency. This can be attributed to the porosity and fineness of cow dung ash. From the table, it can be concluded that the consistency increased up to the 16% ash partial replacement to cement and reduced with the increase in the CDA% in the cement. Hence, the optimum percentage of ash can be added to cement is 16%.

TABLE 2 VARIATION OF CONSISTENCY OF CEMENT WITH CDA

Cement in %	100	95	90	85	84	83
Cow dung ash in %	0	5	10	15	16	17
Consistency (% of water)	29	31	32	36	42	35

3.2Chemical Analysis

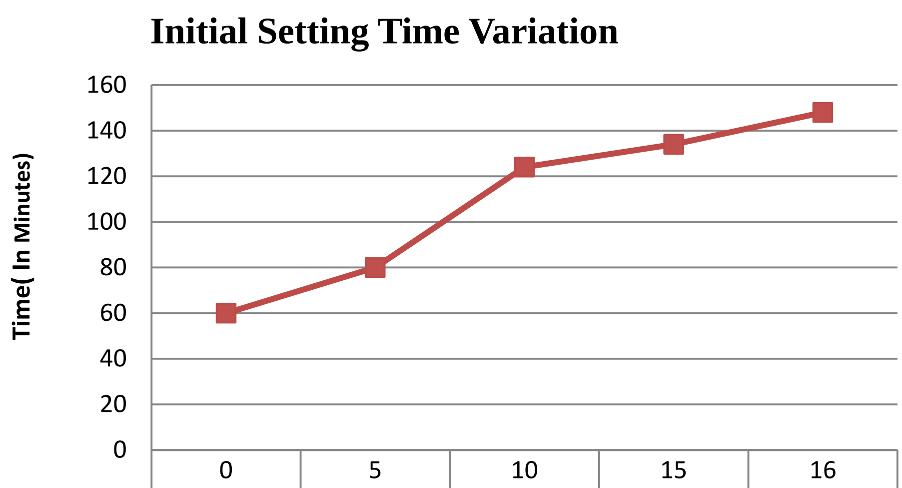
As per IS 4032 (1985), the chemical analysis of_different components in cement and cow dung ash found and shown in table 3. From the table, it is observed that the increase in the cow dung ash in cement, the silica and insoluble residue values are increased. The calcium oxide content is reduced with the increase of cow dung ash in cement. The ferric oxide and the alumina values are almost equal. The concern of the high LOI [From Table 1] of CDA is that it may affect the reactivity of the cow dung ash in mortar or concrete and may increase the water requirement of the concrete or mortar due to the presence of impurities.

TABLE 3 CHEMICAL COMPOSITION OF CEMENT AND CDA

S.NO	Chemical Compound	5% C.D.A	10% C.D.A	15% C.D.A	16% C.D.A
1.	Loss on Ignition (L.O.I)	2.26	2.38	2.42	2.47
2.	Silica (SiO_2)	30.26	36.82	36.79	37.4
3.	Alumina (Al_2O_3)	4.66	4.83	4.82	4.71
4.	Ferric Oxide (Fe_2O_3)	3.21	3.02	3.46	3.69
5.	Calcium Oxide (CaO)	52.9	44.74	44.2	43.02
6.	Magnesium Oxide (MgO)	2.26	3.02	3.4	3.26
7.	Sulphuric Anhydride(SO_3)	1.21	1.1	1.12	1.21
8.	Insoluble Residue(I.R)	2.69	3.39	3.76	3.69

3.3 Initial and Final Setting Times

Setting, which refers to the development of rigidity in fresh concrete, is an extremely important process. Before setting the concrete, it is plastic and behaves like a fluid, and after setting the concrete is rigid and behaves like a solid. This transition from fluid to solid is gradual and progressive. Initial set marks the end of period in which the fresh concrete can be mixed and moulded. Final set marks the beginning of strength development. Setting is generally recognized to reflect the micro structural changes that take place during hydration of the portland cement. Test has been conducted on cement by adding different percentages of cow dung ash and Figs. 1 and 2 shows the variation of initial and final setting times. It is observed that the setting times have been increased with the increase in % of cow dung ash in cement. This trend may be attributed to the ability of CDA to delay the hydration of cement and consequently prolong the setting times. Also, the delay in setting times is due to the reduction of C_3S ($3CaO.SiO_2$) content and C_3A ($3CaO.Al_2O_3$) and thus increase e in C_2S ($2CaO.SiO_2$) contents.



	0	5	10	15	16
Time (In Minutes)	60	80	124	134	148

Fig. 1 Variation of Initial Setting Time with Varying C.D.A Percentage

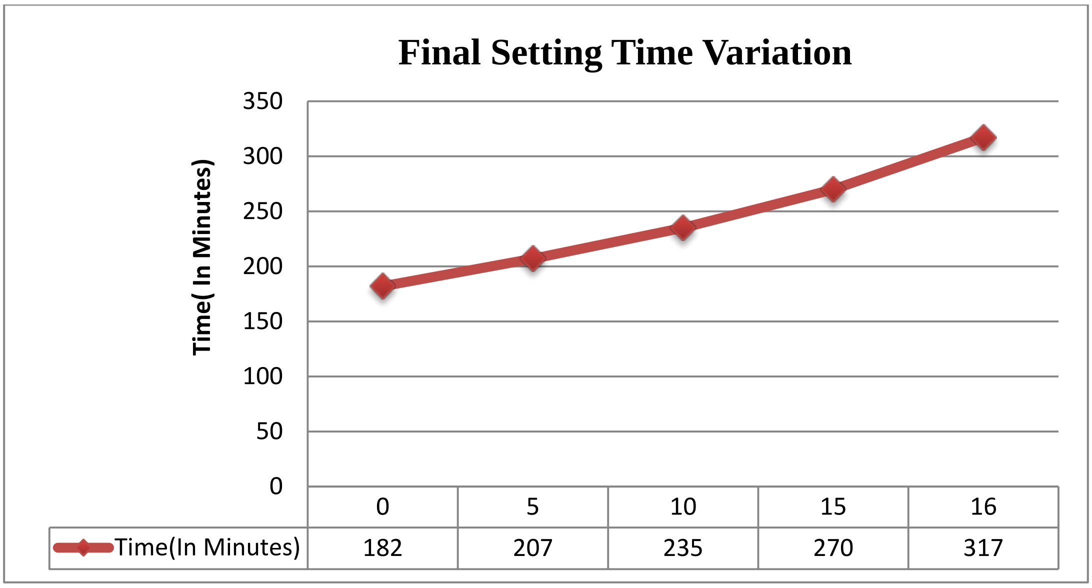


Fig. 2 Variation of Final Setting Time with Varying C.D.A Percentage

3.4 Workability

The workability of the concrete is tested for different cow dung ash percentage mixed in cement. Figure 3 shows the workability of concrete tested through compaction factor test. The high demand for water as CDA increases is due to increased amount of silica in the mixture. The general behavior pozzolanic cement concrete in which the silica – lime reaction would require more water in addition to the water needed during hydration of cement.

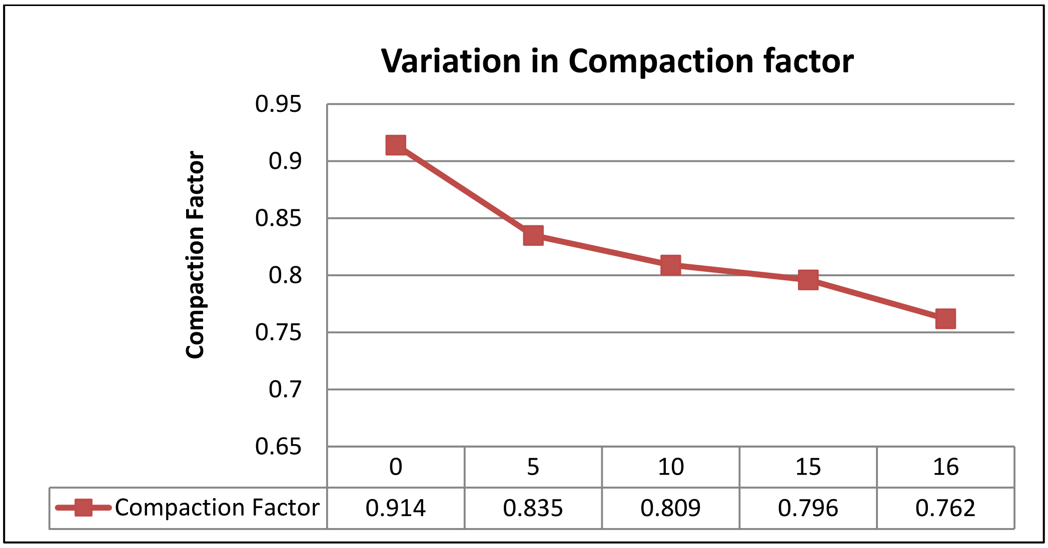


Fig. 3 Variation of Compaction Factor with Varying C.D.A Percentage

3.5 Strength activity index

Strength Activity Index (S.A.I) is the ratio of 20% replacement levels of cement with C.D.A to the control expressed as a percentage. The S.A.I was conducted in accordance with ASTM C 311-12. The test of strength activity index is used to determine whether the pozzolana will result in an acceptable level of strength development when used with hydraulic cement in concrete (or) mortar.

Strength Activity Index was determined using equation:-

$$S.A.I = \frac{Fc.d.a * 100}{F\ o.p.c}$$

$F_{c.d.a}$ =Average compressive strength of the three specimen made with 20% CDA.

TABLE 4: TEST RESULT OF STRENGTH ACTIVITY INDEX AT 7DAYS

MIX ID	Compressive Strength (N/mm^2)	Avg Compressive Strength (N/mm^2)
CDA-00-01	36.44	36.593
CDA-00-02	37.78	
CDA-00-03	35.56	
CDA-20-01	30.22	28.62
CDA-20-02	27.11	
CDA-20-03	28.53	
S.A.I = (28.62/36.593) = 0.7821*10 = 78.21%		

The strength activity index of Cow dung ash was determined to be 78.21% as shown in Table 4. This value is greater than the 75% minimum specified by ASTM C 618 which indicates that Cow dung ash may react well with ordinary Portland cement to produce concrete of acceptable strength levels.

3.6 Compressive Strength

The compressive strength of cubes is found as per IS: 456-2000. The strength of cement mortar has been reduced with the increase in the cow dung ash content in cement. But it is found that when the CDA is 5% in cement the strength initially raised for all the curing days considered in the present investigation and when the CDA content is increased then there is a reduction in the strength of the cement is observed. Table 5 shows the values of compressive strength of mortar cubes

TABLE 5 VARIATION OF COMPRESSIVE STRENGTH OF CEMENT WITH THE VARIATION OF CDA

CDA %	Compressive Strength (N/mm^2)		
	7 days	14 days	28 days
0%	11.87	14.64	20.98
5%	14.01	15.2	22.94
10%	10.76	10.86	16.8
15	4.76	6.53	8.56
16	3.81	6.33	6.93

It is observed from the table that the compressive strength is increased with the curing days and also found the 5% CDA can be replaced in the cement to use as cement mortar.

The compressive strength of cubes is found as per IS: 456-2000. The strength of cement concrete has been reduced with the increase in the cow dung ash content in cement.

TABLE 6 VARIATION OF COMPRESSIVE STRENGTH AFTER 7 DAYS

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% C.D.A	PRACTICAL VALUES
0	36.59
5	34.07
10	31.41
15	29.70
16	31.7

TABLE 7 VARIATION OF COMPRESSIVE STRENGTH OF CONCRETE AFTER 14 DAYS

% C.D.A	PRACTICAL VALUES
0	40.15
5	38.52
10	38.37
15	37.4
16	36.65

Table 7 shows the compressive strength of concrete after 14 days of curing. As observed in Table 7 that the strength is reduced with the addition of cow dung ash in cement concrete after 14 days. Similar trend is observed for 28 days testing (Table 8).

TABLE 8 VARIATION OF COMPRESSIVE STRENGTH OF CONCRETE AFTER 28 DAYS.

% C.D.A	PRACTICAL VALUES
0	46.81
5	44.29
10	41.48
15	40.15
16	40.06

4. Concluding Remarks

This trend of strength variation may be due to the pozzolanic activity of CDA. It is observed that the 5% CDA can be added in cement as partial replacement where as in concrete 5% CDA can be used as partial replacement to cement. But more detailed study is essential to find the compressive strength at longer ages. During hydration, the Calcium Hydroxide (CH) produced reacts with the silica from CDA over time to form the more stable Calcium Silicate Hydrates(C-S-H) which can be responsible for the appreciable strength gain. It has been reported by several researchers that incorporation of pozzolanic materials into cement reduces the CH formation (which promotes micro cracking) and enhances formation of C-S-H, which promotes later strength gain. Hence, it is possible that the increase in strength can be observed at the later curing ages (i.e. 60 and 90 days) than at the early curing periods of 7 and 28days.

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