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Experimental Investigation on Low Grade Cement by Using Waste Products

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ABSTRACT

Demand and consumption of cement is increasing day by day which has led researchers and scientists to search for locally available alternate binders that can replace cement partially and are ecofriendly and contribute towards waste management. In this research cementious materials such as hydrated lime, fly ash, sugarcane bagasse ash, sewage sludge ash, and ceramic waste are used as replacement to reduce costs and environmental pollution associated with the production of cement. OPC 53 grade cement is used in the study. In this research study the (OPC) cement has been replaced by hydrated lime, fly ash, sugarcane bagasse ash, sewage sludge ash, and ceramic waste accordingly in the range of 0%, 45%, 50%, 55% & 60% by weight. The effect of replacement of cement by above waste products is tested and compared in terms of compressive strength to the conventional mortar. Mortar was proportioned in 1:5 cement sand ratio. The compressive strength test was conducted on the masonry mortar cubes.The compressive strength of mortars was measured at 7 and 28 days. As a result, the compressive strength achieved up to 50% replacing cement with above waste products.

Keywords: Waste Products, OPC, Eco-Friendly, Low Grade Cement, Cementious Material, Mortar

I. INTRODUCTION

In the field of construction cement plays vital role. Without cement, mortar and concrete cant possible because cement is used as binder. Manufacturing Process of cement are one of the major industry. Nowadays in building construction high grade cement were used for every stage but in some units high grade cement is not require such as plastering and brickwork. We are aware that a lot of damage is done to environment in the manufacture of cement. It involves lot of carbon emission associated with other chemicals. The researches has shown that every 1 ton of cement manufacture releases half ton of carbon dioxide, so there is an immediate need to control the usage of cement.

On the hand materials wastes such as Sugarcane Bagasse Ash, Sewage sludge ash, Ceramic waste, are difficult to dispose which in return is environmental Hazard. The use of this waste material in replacement of cement not only reduces the environmental pollution but also enhances the properties of cement and also reduces the cost.

In addition to its negative environmental impact cement is also one of the most expensive materials when compared to the other constituents of concrete.

The raw materials for the cement production like lime are also being exploited in large amount which may result in running out of them, as it is predicted to happen in some places of the world.

II. LITERATURE REVIEW

2.1 Amarnath Yerramala

1. Compressive strength increased with curing age for all fly ash replacements. Irrespective of fly as percentage the compressive strength decreased at early age when compared to reference mortar. However, at later curing age mortars made with 5%, 10% and 15% showed higher strength than reference mortar.

2. Similar to concrete the maximum efficiency was at 10% for mortars. However, the efficiency factor was higher for fly ash mortars than fly ash concretes up to nearly 20%, further increase in fly ash percentage reduced efficiency factor for fly ash mortars than fly ash concretes in terms of strength.

2.2 Mao-Chieh Chi

Sugar cane bagasse ash (SCBA), a by-product of sugar and alcohol production, is one of the potential pozzolanic materials that can be blended with Portland cement. In this study, SCBA with particle sizes <45 μ m was used to replace type 1 Ordinary Portland cement with various dosages (10 %, 20 %, and 30 %) by weight of binder. The water/cementitious material (w/cm) and sand/binder ratios were kept at constants of 0.55 and 2.75, respectively. Composites were mixed, and effects of SCBA on properties were investigated by conducting flow test, water absorption test, initial surface absorption test, drying shrinkage test, compressive strength test, rapid chloride penetration test (RCPT), thermal gravimetric analysis (TGA), and scanning electron microscopy (SEM). Experimental results show that the flow spread of fresh mortars would decrease with an increase of SCBA replacement. The specimens with 10 % SCBA have the superior performance on compressive strength, drying shrinkage, water absorption, initial surface absorption, and chloride ion penetration, TGA, and SEM at the age of 56 days. It indicates that 10 % cement replacement of SCBA may be considered as the optimum limit.

The flow spread of fresh mortars would decrease with the increase of bagasse ash replacement. The specimens with 10 % bagasse ash as a Portland cement replacement have the superior performance on compressive strength, drying shrinkage, water absorption, initial surface absorption, and chloride ion penetration at the age of 56 days.

2.3 Wong Yih Kang

The aim of this research is to study the partial replacement of cement with sewage sludge ash, SSA in mortar through experimental works. The experimental works were carried out to access the feasibility of utilizing SSA as a construction material. An attempt has been made to replace 10% and 15% of the mass of cement with 600°C and 800°C incinerated SSA into the mortar. The result of the compressive strength test shows that the mortar with 10% replacement of 800°C burnt SSA increase in compressive strength up to 1.14% and 5.06% at the ages of 28 days and 90 days, respectively. The total porosity of the mortar also decreases up to 7.05% after the replacement of 10% 800°C burnt SSA after 90 days. The XRD and XRF tests show that the major components in sewage sludge are SiO_2, Al_2O_3 and Fe_2O_3.

2.4 Amitkumar D. Raval, Dr.Indrajit N. Patel, Prof. Jayeshkumar Pitroda

In this research study the (OPC) cement has been replaced by ceramic waste powder accordingly in the range of 0%, 10%, 20%, 30% 40%, & 50% by weight of M-20 grade concrete. Concrete mixtures were produced, tested and compared in terms of compressive strength to the conventional concrete. These tests were carried out to evaluate the mechanical properties for 7, 14 and 28 days. As a result, the compressive strength achieved up to 30% replacing cement with ceramic waste. This research work is concerned with the experimental investigation on strength of concrete and optimum percentage of the partial replacement by replacing cement via 0%, 10%, 20%, 30%, 40% and 50% of ceramic waste.

The Compressive Strength of M20 grade concrete increases when the replacement of Cement with Ceramic Powder up to 30% replaces by weight of Cement and further replacement of Cement with Ceramic Powder decreases the Compressive Strength.

III. METHODOLOGY

3.1 Materials

3.1.1 Fly ash

Fly ash is one of the most common pozzolan and is being used quite extensively. The utilization of fly ash in cement has increased rapidly as it contains high siliceous and aluminous compounds. Apart from different concretes, mortar also has its intended uses in construction field. Mortar has been used for centuries as a means of adhering bricks or concrete blocks to one another. Further, cement mortar continues to be used in many different types of constructions like plastering and quick repairs. Although it is possible to obtain advantages of using fly ash in mortar. In this fly ash was collected from khaparkheda thermal power plant.

Table 1. Chemical Properties of Fly Ash

Chemical Components	Cement	Fly Ash
SiO_2	21.8	58.3
Al_2O_3	6.6	31.7
Fe_2O_3	4.1	5.9
CaO	60.1	2.0
MgO	2.1	0.1
Na_2O	0.4	0.8
K_2O	0.4	0.8
SO_3	2.2	0.2
Loss Of Ignition	2.4	0.3

3.1.2 Sugarcane Bagasse Ash

Bagasse is a by-product from sugar industries which is burnt to generate power required for different activities in the factory. The burning of bagasse leaves bagasse ash as a waste, which has a pozzolanic property that would potentially be used as a cement replacement material. It has been known that the worldwide total production of sugarcane is over 1500 million tons. In this research bagasse ash was obtained from Vainganga sugar power limited Devhala. Physical and chemical properties of the bagasse ash are mentioned in Table.

Table 2. Chemical Properties of Sugercane Bagasse Ash

Chemical Components	Sugercane Bagasse Ash
SiO_2	87.40
Al_2O_3	3.6
Fe_2O_3	4.95
CaO	2.56
MgO	0.69
Na_2O	0.15
K_2O	0.47
SO_3	0.11
Loss Of Ignition	8.25

3.1.3 Sewage Sludge Ash (SSA)

The disposal of sewage sludge is a challenging issue in India. India produces nearly 960 million tonnes of sewage sludge annually from 316 sewage treatment plants (2016-17). Most of this sludge is disposed of through land filling, and incineration. Although incineration results in optimum volume reduction and stabilization for sewage Sludge. Different methods of SSA disposal have different degrees of environmental impact and cost effectiveness. Therefore, there is an urgent need to develop alternative methods of SSA disposal. The sewage sludge was collected from sewage treatment plant bhandewadi.

Table 3. Chemical Properties of Sewage sludge Ash

Chemical Components	Sewage sludge ash
SiO_2	48
Al_2O_3	13.7
Fe_2O_3	6.2
CaO	3.6
MgO	1.9
Na_2O	1.0
K_2O	2.1
SO_3	1.7

3.1.4 Ceramic Waste

Indian ceramic production is 100 Milliontonne per year. In the ceramic industry, about 15%-30% waste material generated from the total production. This waste is not recycled in any form at present. However, the ceramic waste is durable, hard and highly resistant to biological, chemical, and physical degradation forces. The Ceramic industries are dumping the powder in any nearby pit or vacant spaces.This leads to serious environmental and dust pollution and occupation of a vast area of land, especially after the powder dries up so it is necessary to dispose the Ceramic waste quickly and use in the construction industry. Ceramic waste was obtained from Padma industries Nagpur.

Table 4. Chemical Properties of Ceramic Waste

Chemical Components	Ceramic Waste
SiO_2	63.29
Al_2O_3	18.29
Fe_2O_3	4.32
CaO	4.46
MgO	0.72
Na_2O	0.75
K_2O	2.18
SO_3	0.10
Loss Of Ignition	1.61

3.1.5 Cement (OPC)

In this experimental work Ordinary Portland cement (Grade 53) conforming to IS 12269-1987 in all trial mixes is used. The physical properties of the cement obtained on conducting appropriate tests conforming to process laid down in IS: 269/4831 has been performed. The results are mentioned in table 1 shown below

Table 5

Property of cement	Value
Fineness of cement(m^2/kg)	320
Specific gravity	3.15
Grade	53 grade OPC
Standard consistency	35%
Initial setting time	90 mins
Final setting time	265 mins
Compressive strength	61.00 N/mm^2

3.1.6 Fine Aggregate

In this study stone dust passing through 4.75 mm sieve conforming to Zone II as per IS: 383-1970 is used as fine aggregate. The fine aggregate is free from clay, silt and organic impurities.

Table 6

Physical test	Fine aggregate
Specific gravity	2.59
Fineness modulus	2.36
Bulk density (kg/m^3)	1.58

3.1.7 Water

Water is an important ingredient of Mortar as it actually participates in the chemical reaction with cement. Since it helps to from the strength giving cement gel, the quantity and quality of water are required to be looked into very carefully. Fresh potable drinking water of Ph value (6.5- 7.2) free from organic impurities is being used which is available in college campus.

3.2 Mix Proportions of mortar

In order to investigate strength properties of hydrated lime, fly ash, sugarcane bagasse ash, sewage sludge ash, and ceramic waste mortars , sixteen mixes were employed. Reference mix (M1 to M16) . All the mixes was made with cement to fine aggregate ratio of 1:5.

Water to cementitious ratio of 25% was adopted for all the mixes.

3.3 Experimental Methodology

The evaluation of above waste for use as a replacement of cement material begins with the mortar testing. Mortar contains cement, water, fine aggregate. With the control mortar, i.e. 0%, 45%, 50%, 55% & 60% of the cement is replaced with hydrated lime, fly ash, sugarcane bagasse ash, sewage sludge ash, and ceramic waste,the data from the above waste is compared with data from a standard mortar without above waste. Three cube samples were cast on the mould of size 50x50x50 mm for each 1:5 mortar mix with partial replacement of cement with a w/c ratio as 0.25 were also cast. After about 24hr the specimens were de-moulded and water curing with gunny bags was continued till the respective specimens were tested after 7 and 28 days for compressive strength test.

Table 7

MIX PROPORTIONS(IN PERCENTAGE)							
SR. NO	MIX	CEMENT (C)	HYDRATED LIME (L)	FLY ASH (10% OF C+L)	CERAMIC WASTE (10% OF C+L)	SUGARCANE BAGASSE ASH (10% OF C+L)	SEWGE SLUDGE ASH (10% OF C+L)
1	M1	0.55	0.45	10	0	0	0
2	M2	0.55	0.45	0	10	0	0
3	M3	0.55	0.45	0	0	10	0
4	M4	0.55	0.45	0	0	0	10
5	M5	0.55	0.45	10	10	0	0
6	M6	0.55	0.45	10	0	10	0
7	M7	0.55	0.45	10	0	0	10
8	M8	0.55	0.45	0	10	10	0
9	M9	0.55	0.45	0	10	0	10
10	M10	0.55	0.45	0	0	10	10
11	M11	0.55	0.45	10	10	10	0
12	M12	0.55	0.45	10	10	0	10
13	M13	0.55	0.45	0	10	10	10
14	M14	0.55	0.45	10	0	10	10
15	M15	0.55	0.45	10	10	10	10
16	M16	0.55	0.45	0	0	0	0

Table 8

MIX PROPORTIONS (BY WEIGHT)								
SR. NO	MIX	CEMENT	HYDRATED LIME	FLY ASH (10% OF C+L)	CERAMIC WASTE (10% OF C+L)	SUGARCANE BAGASSE ASH (10% OF C+L)	SEWGE SLUDGE ASH (10% OF C+L)	TOTAL WEIGHT (IN GM)
1	M1	250	200	50	0	0	0	500
1	M2	250	200	0	50	0	0	500
3	M3	250	200	0	0	50	0	500
4	M4	250	200	0	0	0	50	500
5	M5	230	190	10	10	0	0	500
6	M6	230	190	10	0	10	0	500
7	M7	230	190	10	0	0	10	500
8	M8	230	190	0	10	10	0	500
9	M9	230	190	0	10	0	10	500
10	M10	230	190	0	0	10	10	500
11	M11	210	170	10	10	10	0	500
12	M12	210	170	10	10	0	10	500
13	M13	210	170	0	10	10	10	500
14	M14	210	170	10	0	10	10	500
15	M15	200	160	35	35	35	35	500
16	M16	275	225	0	0	0	0	500

IV. RESULT AND DISCUSSION

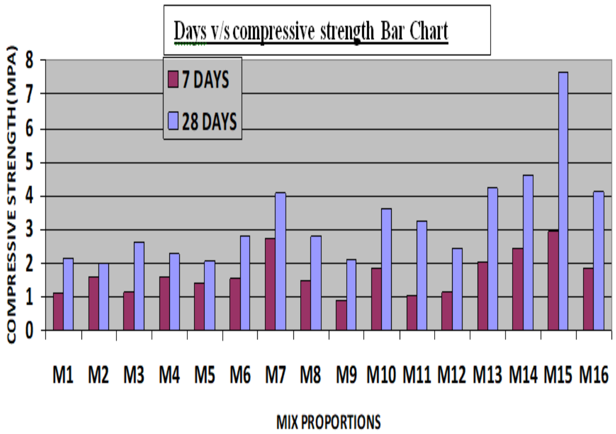
Compressive strength tests were performed on Universal testing machine using cube samples. Three samples per batch were tested with the average strength values reported in this paper. The comparative studies were made on their characteristics for mortar mix ratio of 1:5 with partial replacement of cement with waste products as 0%, 45%, 50%, 55% and 60%. The Strength was calculated by deviding area from the load taken by the cube in N/MM^2.

The compressive strength developments of all mix proportioned mortars are presented in Table no. 9 It can be seen from the table that, the strength increased with curing age for M15 replacement with cement. The trend in the figure shows that the increase in strength was 14% & 35% for curing ages of 7 and 28 days respectively for reference mortar with respect to seven days of curing. As the waste products percentage increased, the strength rate increased with curing period. The strength of M15 was 2.94 mpa at 7 days and it increased 2.5 times at the age of 28 days i. e. 7.61 mpa.

Table 9. Compressive Strength Of Cubes (50x50x50mm) At 7 & 28 Days

MIX	COMPRESSIVE STRENGTH N/MM^2)	
	7 DAYS	28 DAYS
M1	1.1	2.14
M2	1.6	2.0
M3	1.15	2.62
M4	1.6	2.27
M5	1.44	2.08
M6	1.54	2.79
M7	2.75	4.1
M8	1.5	2.8
M9	0.9	2.1
M10	1.86	3.62
M11	1.06	3.27

M12	1.15	2.45
M13	2.04	4.24
M14	2.45	4.62
M15	2.94	7.61
M16	1.86	4.13



V. CONCLUSIONS

Based on experimental investigations concerning the compressive strength of mortar, the following observations are made:

a) The Compressive Strength of mortar increases when the replacement of Cement with hydrated lime, fly ash, sugarcane bagasse ash, sewage sludge ash, and ceramic waste up to 60% replaces by weight of Cement and further replacement of Cement with above wastes decreases the Compressive Strength.

b) Mortar on 60% replacement of Cement with above wastes, Compressive Strength obtained is 7.61 N/mm^2 and vice-versa the cost of the cement is reduced up to 28% and hence it becomes more economical for construction of partition wall and plastering work than the standard mortar. It becomes technically and economically feasible and viable.

c) Utilization of waste products and its application are used for the development of the construction industry.

d) It is the possible alternative solution of safe disposal of waste products.

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