Performance of Concrete with China Clay (Kaolin) Waste

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Abstract - The utilization of industrial waste produced by industrial process has been the focus of waste reduction research for economic, environmental and technical reasons. This is because over a million tons of industrial wastes are being produced per annual by mining industrial process in India. The problem arising from continuous technological and industrial development is the disposal of waste material. If some of the waste materials are found suitable in concrete making then safe disposal of waste material can be achieved and cost of construction also can be cut down. A partial substitution of cement by an industrial waste is not only economical but also improves the properties of fresh and hardened concrete and enhance the durability characteristics besides the safe disposal of waste material thereby protecting the environment from pollution. This research deals with partial replacement of cement with the industrial waste from China Clay industries. The compressive strength, water absorption test of conventional concrete & cement replaced concrete are compared and the results are tabulated.China clay (Kaolin) waste is available in Kutch region of Gujarat and other region in India and worldwide. To produce a 1 ton of pure kaolin it generates a 9 ton of waste. Due to lots of waste generation problem to be created to dispose of the waste and land acquisition. Replacement of kaolin waste in concrete up to 10%, 20%, and 30% can prove the result.

Key words: Industrial Waste, China clay (Kaolin) waste, compressive strength, water absorption

I. INTRODUCTION

China clay (Kaolin) waste is a product after purification of china clay from their ore which is one of the major waste materials. To produce one ton pure china clay eight to nine ton waste generates.

Natural raw materials are becoming scarce, while around the world, millions of tons of inorganic wastes are produced every day in mining, mineral processing and industrial activities, whose disposal is subject to ever stricter environmental legislation. However, some wastes are similar in composition to the natural raw materials used in the construction industries. Thus, upgrading wastes to alternative raw materials is of technological, economic and environmental interest.

Mining and mineral processing wastes have traditionally been discarded in landfills and often dumped directly into ecosystems without adequate treatment. However, possible reuse or recycling alternatives should be investigated and implemented. Today, the reuse and recycling of wastes after their potentialities have been detected is considered an activity that can contribute to reduce production costs, provide alternative raw materials for a variety of industrial sectors, conserve nonrenewable resources, save energy, and improve public health.

Kaolin is an important raw material in various industrial sectors. However the kaolin mining and processing industry generates large amounts of waste. The kaolin industry, which processes primary kaolin, produces two types of wastes. The first type derives from the first processing step (separation of sand from ore).The second type of waste results from the second processing step, which consists of wet sieving to separate the finer fraction and purify the kaolin.

Concrete is the most widely consumed material in the world, after water. Nowadays, most of the construction of buildings and infrastructures are using concrete as a construction material. It is a construction material composed of cement as well as other cementations materials such as slag cement, aggregate, water, and chemical admixtures. Concrete solidifies and hardens after mixing with water and placement due to a chemical process known as hydration. The water reacts with the cement, which bonds the other components together, eventually creating a stone-like material. As it gives benefit to the construction field, it's also given environmental problem. The cement industry is one of the primary producers of carbon dioxide (CO_2), cement kiln CO_2 is released from calcinations of limestone (±50%) and from the combustion of fuels (±50%), and cement production accounts for approximately 5% of the global CO_2 emissions.

According to Environment Institute Association (2006) noted that more than 60% of the CO2 emissions from industrial sources originate from cement manufacturing. The production of the cement is necessary to keep the development of a country, but the environmental problems also should be taken into consideration. The alternative way to let the engineering field giving its benefit for the good of all mankind is to reduce the excessive use of cement in one construction.

The proper mixes and proportion of cement may be important to obtain the standard quality of concrete, the engineer has to come out with a concrete less used of cement in mixes and replace it with another material without having the decrease of the concrete quality.

II EXPERIMENTAL MATERIALS

a) *Ordinary Portland Cement (OPC)*

The cement used is SANGHI OPC 53 grade cement. The Ordinary Portland Cement of 53 grades conforming to IS: 8112-1989 is being used. Tests were conducted on the cement like Specific gravity, consistency tests, setting tests, soundness, Compressive strength N/mm^2 at 28 days.

Figure: 1 Cement

TABLE - 1
PROPERTIES OF CEMENT

Sr. No.	Physical Properties of SANGHI OPC 53 Cement	Result	Requirements as per IS:8112-1989
1	Specific gravity	3.15	3.10-3.15
2	Standard consistency (%)	31.5 %	30-35
3	Initial setting time (hours, min)	91 min	30 minimum
4	Final setting time (hours, min)	211 min	600 maximum
6	Compressive strength N/mm^2 at 28 days	58 N/mm^2	53 N/mm^2 minimum

b) *China Clay waste*

China clay waste is the spoil resulting from the production of china clay. It is largely produced in the Kutch district of Gujarat region of India, for every tone of china clay produced an average of 9 tons of waste are produced.

Figure: 2 China clay waste

c) *Aggregate*

Aggregates are the important constituents in concrete. They give body to the concrete, reduce shrinkage and effect economy. One of the most important factors for producing workable concrete is a good gradation of aggregates. Good grading implies that a sample fraction of aggregates in required proportion such that the sample contains minimum voids. Samples of the well graded aggregate containing minimum voids require minimum paste to fill up the voids in the aggregates. Minimum paste means less quantity of cement and less water, which is further mean increased economy, higher strength, lower shrinkage and greater durability.

i) *Coarse Aggregate*

The fractions from 20 mm to 4.75 mm are used as coarse aggregate. The Coarse Aggregates from crushed Basalt rock, conforming to IS: 383 is being used. The Flakiness and Elongation Index were maintained well below 15%.

Figure: 3 Course aggregate

ii) *Fine Aggregate*

Figure: 4 Fine aggregate

Fine aggregates are the aggregates whose size are less than 4.75 mm. For increased workability and for the economy as reflected by the use of less cement, the fine aggregate should have a round shape. The purpose of the fine aggregate is to fill the voids in the coarse aggregate and to act as a workability agent.

iii) *Grit*

Figure: 5 Grit

Grit is a granular material that can be thought of as a transition stage between a coarse sand and small pebbles. Generally 2-6mm in size, grit has limited use in the construction industry on its own, other than as a surface dressing. However, over recent years with the development in block paving specifications, it has become a viable alternative bedding material for permeable paving and other forms of elemental paving used in areas of high water ingress.

iv) Water

Combining water with a cementitious material form a cement paste by the process of hydration. The cement paste glues the aggregate together, fills voids within it, and makes it flow more freely.

Lower water to concrete ratio will yield a stronger, more durable concrete; while more water will give a freer-flowing concrete with a higher slump. Impure water used to make concrete can cause problems when setting or in causing premature failure of the structure.

Hydration involves many different reactions, often occurring at the same time. As the reactions proceed, the products of the cement hydration process gradually bond together the individual sand and gravel particles and other components of the concrete, to form a solid mass.

III. METHODOLOGY

a) *Compression test (IS 516:1959 Method of test for strength of concrete)*

Compressive strength tests were performed on compression testing machine using cube samples. Three samples per batch were tested and the average strength values reported in this paper. The loading rate on the cube is 35 N/mm^2 per min. The comparative studies were made on their characteristics for concrete mix as pertable no: 3 with partial replacement of cementas 10%, 20%and 30% by China clay (Kaolin) waste.
The compression test shows the compressive strength of hardened concrete. The compression test shows the best possible strength concrete can reach in perfect conditions. The testing is done in a laboratory off-site. The only work done on-site is to make a concrete cube for the compression test. The strength is measured in (MPa) and is commonly specified as a characteristic strength of concrete measured at 28 days after mixing. The compressive strength is a measure of the concrete's ability to resist loads which tend to crush it.

Figure: 6 Universal Compression Test Machine

b) *Water Absorption*

The water absorption test gives a modification of total void space in concrete. The variability of the test method is fairly low however when applied to samples extracted from cubes during production.it gives little useful information. Whilst the absorption value is partially dependent on mix quality, it is also greatly affected by the degree of compaction and effectiveness of initial curing. It is therefore extremely difficult to determine whether high results are caused by material or cube making / curing problems.

The cubes after casting were immersed in water for 28 days curing. They were then weighted and this weight was noted as the wet weight of the cube. These specimens were then oven dried at the temperature 100^0C until the mass became constant and again weighed. This weight was noted as the dry weight of the cube.

% Water Absorption = [(WW – DW) / DW] x 100

Where, WW = Wet Weight of Cube, DW = Dry Weight of Cube.

IV. MIX DESIGN

TABLE: 2

SPECIFIC GRAVITY OF CEMENT, CHINA CLAY WASTE, CA, FA

Cement	3.15
Coarse Aggregate	2.73
Fine Aggregate	2.58
China Clay Waste	2.49

TABLE: 3 MIX DESIGN FOR M40 GRADE CONCRETE

Sr. No	Concrete mix	W/c ratio	Water (ltr)	Cement (Kg)	Kaolin Waste (Kg)	FA (Kg)	Grit (Kg)	C.A. (Kg)
1	PA	0.43	186	432.55	-	592.98	-	1165.27
2	PB	0.43	186	389.29	43.25	592.98	466.1	699.16
3	PC	0.43	186	346.04	86.51	592.98	-	1165.27
4	PD	0.43	186	302.75	129.76	592.98	-	1165.27

Where,

PA – M40 Standard Concrete

PB – M40 Standard Concrete Replacement Cement 10%

PC – M40 Standard Concrete Replacement Cement 20%

PD – M40 Standard Concrete Replacement Cement 30%

V. RESULTS

TABLE: 4 COMPRESSIVE STRENGTHAND WATER ABSORPTION AFTER 28 DAYSFOR M40 GRADE CONCRETE

Types of Concrete	Compressive Strength			Water Absorption after 28 days		
	7 N/mm^2	14N/mm^2	28 N/mm^2	W1	W2	% Diff
PA	21.63	28.30	43.70	8.75	8.86	1.32
PB	18.96	25.33	39.26	8.77	8.91	1.56
PC	19.56	23.56	36.44	8.67	8.89	2.44
PD	18.81	24.30	28.89	8.62	8.77	1.65

VI. CONCLUSION

Based on limited experimental investigations concerning the compressive strength and water absorption of concrete, the following observations are made regarding the resistance of partially replaced China clay (Kaolin) waste:

(a) Compressive strength increase when replacement with China clay (Kaolin) wastepercentage decreases when compare to traditional concrete.
(b) From this test, replacement of OPC cement with this China clay (Kaolin) wastematerial provides maximum compressive strength at 10% replacement.
(c) From this test, replacement of OPC cement with this China clay (Kaolin) waste material provides maximum water absorption at 20% replacement.
(d) People approach to the China clay (Kaolin) wastein concrete will be more and more as it will strengthen the building at economical cost.
(e) Environmental effects of wastes and disposal problems of waste can be reduced through this research and make the environment green.

(f) It will reduce the wastage and solve dumping problem of the industry.

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