Experimental Study of Partial Replacement of Fine Aggregate with Waste Material from China Clay Industries

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Abstract: With the Industrial Revolution, Technology developed rapidly and the manufacturing age came into view. Early industries were on at small scale and produced smoke as the main Pollutant. But as the number of factories increased and work on the large scale the issue of industrial pollution started to take on too much importance. So for this purpose, the utilization of industrial and agricultural waste produced by the industrial process has been the focus of waste reduction research for economical, environmental and technical reasons. The problem arising from continuous technological and industrial development is the disposal of waste material. A partial substitution of cement or fine aggregate by an industrial waste is not only economical but also improves the properties of fresh and hardened concrete as lowering the shrinkage and minimize the cracks and enhance the durability characteristics besides the safe disposal of waste material thereby protecting the environment from pollution. This paper deals with the partial replacement of fine aggregate with the industrial waste from China Clay industries. The compressive strength, split tensile strength and flexural strength of conventional concrete and fine aggregate replaced concrete are compared and the results are tabulated.
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Key Words: Industrial Waste, China clay (Kaolin) waste, compressive strength, Concrete, Fine aggregate, Flexural strength, Split tensile strength.

Introduction:

Portland cement concrete is made with coarse aggregate, fine aggregate, Portland cement, water and in some cases selected admixtures (mineral & chemical). China clay (Kaolin) waste is a product after purification of china clay from their ore which is one of the major waste materials. (Priyank Bhimani, 2013). To produce one ton pure china clay eight to nine ton waste generates. (A.Seeni, Dr.S.U.Kannan, 2008).

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. (Priyank Bhimani, 2013). 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, and conserve public health. (Priyank Bhimani, 2013).

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. (Gurpreet Singh and Rafat siddique, 2011).

Concrete is the most widely consumed material in the world, after water. 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. (John zachar and Tarun R.naikin, 2007). 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.

Objectives And Scopes:

1. To check out experimentally the results for the fine aggregate which are partially replaced by industrial waste in different ratio such as 15, 30%, and 50% which are designated as M1, M2 and M3 respectively.

2. To determine the compressive strength, Split tensile strength and Flexural strength and compare it with the normal concrete strength. (1:2:4 without any replacement, without any admixture).

Materials And Methods:

Ordinary Portland cement (OPC):

Cement can be described as a material with adhesive and cohesive properties which make it capable of bonding mineral fragment into a compact whole and solid in the presence of water. Cement of 53 grade was purchased and used in this experiment. The properties of the cement used in the experiments are given in the following table.

Table 1. Properties of Cement

Sr no.	Property	Value
1	Specific Gravity	3.15
2	Fineness	97.8
3	Initial setting time	45min
4	Final setting time	385min
5	Standard consistency	30%
6	Fineness Modulus	6%

Aggregate:

Aggregates are as important as other constituents of 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 aggregate. 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 meant increased economy, higher strength, lower shrinkage and greater durability.

Aggregate is divided into two types:

- Coarse aggregate
- Fine aggregate

***1.* Coarse aggregate:**

Table 2: Properties of Coarse aggregates

Sr. No.	Property	Value
1	Specific Gravity	2.8
2	Fineness modulus	7.5
3	Water Absorption	0.50%
4	Particle Shape	Angular
5	Impact value	15.2
6	Crushing value	18.6

The aggregates with mean size of 20mm to 4.75 mm are referred to as coarse aggregates. Coarse aggregates is from crushed Basalt rock. The Flakiness and Elongation Index were maintained well below 15%. The properties of coarse aggregate used are given in table 2.

***2.* Fine aggregate:**

The purpose of fine aggregate is to fill the voids in the coarse aggregate and to act as a workability agent. Fine aggregates are sub-divided into two categories:

a) Sand:

River sand was used as fine aggregate. The size of the sand used is 4.75 mm and down size. The properties of (sand) investigated are presented in table 3.

Table 3: Properties of Fine aggregate(Sand)

Sr no.	Property	Value
1	Specific Gravity	2.8
2	Fineness Modulus	3.1
3	Water Absorption	0.50%
4	Surface Texture	Smooth

b) China clay:

China clay waste is the spoil resulting from the production of china clay. It is largely produced in the district of Mianwali, Pakistan. To produce one ton pure china clay eight to nine ton waste generates. The size of the clay used is 4.75 mm and below. The properties of china clay used are:

Table 4. Properties of Industrial waste (China clay)

Sr no.	**Property**	**Value**
1	Specific Gravity	2.7
2	Fineness Modulus	2.7
3	Water Absorption	0.50%
4	Surface Texture	Smooth

Water:

Normal Drinking water is used in this Project. The properties of water are given below.

Table 5: Properties of Water

Description	Properties
pH	7.1
Chloride Content mg/L	30
Hardness mg/L	336
TDS	21

Preparation of Specimen:

The details of mix designation and specimens used in experimental program are given in table 5.

Table 5 Mix Details

Sr No.	Mix Designation	Cement	Fine Aggregate		Coarse Aggregate
			Sand	China Clay	
1	M0 (0%)	100%	100%	0%	100%
2	M1 (15%)	100%	85%	15%	100%
3	M2 (30%)	100%	70%	30%	100%
4	M3 (50%)	100%	50%	50%	100%

Testing of Specimen:

For each batch of concrete, 3 cubes of 150mm x 150mm x 150mm size were tested to determine compressive strength of concrete, 3 cylinders of 150mm diameter and 300 mm length were tested to determine split tensile strength of concrete and three prisms of 100mm x 100mm x 500mm were tested to determine flexural strength of concrete.

Figure 01: Casted Specimens

Results And Discussions:

Compressive Strength Test:

From Table 6 the compression strength test results, it can be seen that the strength of partially replaced concrete samples is higher than the pure concrete samples. It is found that the compressive strength of the control concrete was 25.4 N/mm^2. The compressive strength was found to be maximum at 30% (27.13 N/mm^2) replacement of fine aggregate by industrial waste which was greater than the conventional concrete. The compressive strength reduced beyond 30% replacement. Thus it is evident that fine aggregate can be replaced by the waste material from china clay industries up to 30%. The test is carried out according to ASTM Standard C39 / C39M - 14a.

Table 6: Compressive Strength test of concrete

Sr no.	Mix designation	3 Days N/ mm^2	7 Days N/ mm^2	28 Days N/ mm^2
1	M0	13.35	18.08	25.40
2	M10	14.2	18.51	26.26
3	M30	15.07	19.38	27.13
4	M50	14.64	18.94	25.83

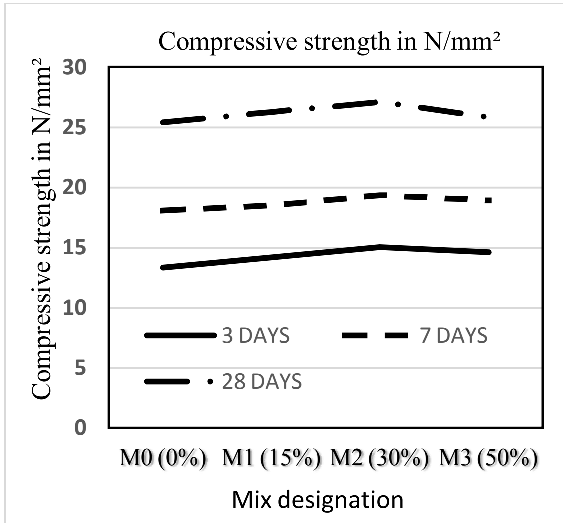

Figure 2. Compressive Strength Test Results

The graphs showing the compressive strength of the different mixes at 03, 07 and 28 days of curing are shown in figure 2.

Splitting Tensile Strength Test:

From Table 7 the split tensile strength Test results, it can be seen that the strength of partially replaced concrete samples is higher than the pure concrete samples. It is found that the split tensile strength after 28 days of the control concrete was 2.88 N/mm^2. The split tensile strength was found to be maximum at 30% (3.43 N/mm^2) replacement of fine aggregate by industrial waste which was greater than the conventional concrete. The split tensile strength reduced beyond 30% replacement. Thus it is evident that fine aggregate can be replaced by the waste material from china clay industries up to 30%. This test is conducted according to ASTM Standard C496 / C496M – 11.

Table 7: Split tensile strength of concrete

Sr no.	Mix designation	3 Days N/ mm^2	7 Days N/ mm^2	28 Days N/ mm^2
1	M0	1.51	2.06	2.88
2	M10	1.71	2.26	3.15
3	M30	1.85	2.47	3.43
4	M50	1.65	2.13	3.02

The graphs showing the split tensile strength test of the different mixes at 03, 07 and 28 days of curing are shown in figure 3.

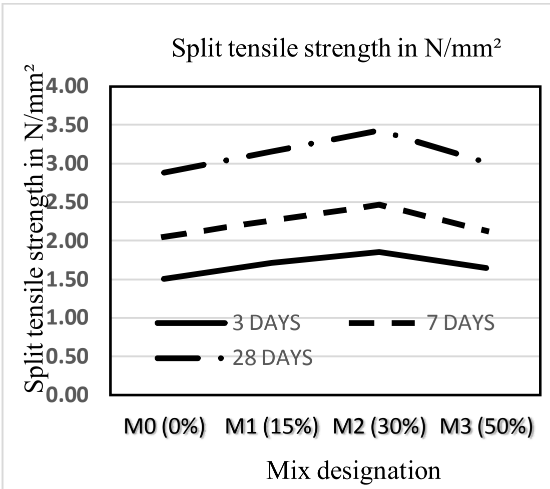

Figure 3. Split tensile strength test Results

Flexural Strength Test:

From Table 8 the flexural strength test results, it can be seen that the strength of partially replaced concrete samples is higher than the pure concrete samples. It is found that the flexural strength test after 28 days of the control concrete was 2.88 N/mm^2. The flexural strength was found to be maximum at 30% (3.43 N/mm^2) replacement of fine aggregate by industrial waste which was greater than the conventional concrete. The flexural strength reduced beyond 30% replacement. Thus it is evident that fine aggregate can be replaced by the waste material from china clay industries up to 30%. This test is conducted according to the ASTM Standard C78 / C78M - 10e1.

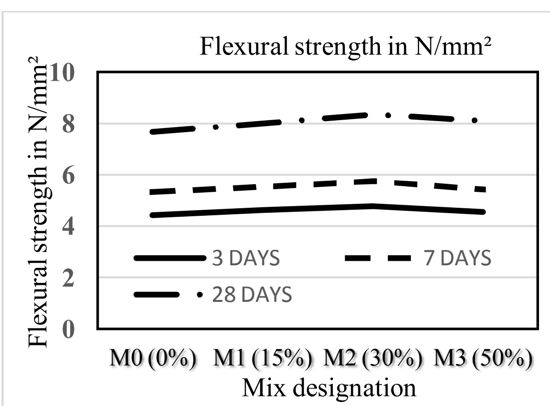

Figure *4.* Flexural Strength Test results

The graphs showing the split tensile strength test of the different mixes at 03, 07 and 28 days of curing are shown in figure 4.

Table 8: Flexural strength test of concrete

Sr no.	Mix designation	3 Days N/mm^2	7 Days N/mm^2	28 Days N/mm^2
1	M0	4.42	5.32	7.66
2	M10	4.62	5.52	7.98
3	M30	4.78	5.74	8.33
4	M50	4.55	5.42	8.1

Conclusion:

From the results of experimental investigations conducted it is concluded that the waste material from china clay industries can be used as a replacement for fine aggregate. It is found that 30% replacement of fine aggregate by industrial waste give maximum result in strength and quality aspects than the conventional concrete. The results proved that the replacement of 30% of fine aggregate by the industrial waste induced higher compressive strength, higher split tensile strength and higher flexural strength. Thus the environmental effects from industrial waste can be significantly reduced. Also the cost of fine aggregate can be reduced a lot by the replacement of this waste material from china clay industries.

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