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PARTIAL REPLACEMENT OF AGGREGATES IN CONCRETE BY USING WASTE FOUNDRY SAND AND WASTE CLAY TILE

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ABSTRACT

For the past years various researchers had done work in concreting and invent various techniques and methods to produce concrete which has the desired properties. The current area of research in the concrete is the introduction of waste foundry sand (WFS) and waste clay tiles (WCT). Waste foundry sand is the by-product of metal casting industries, which causes environmental problems because of its improper disposal. Construction industries requires huge amount of clay tiles for architectural works, the production of which are drastically increased. Over production probably leads to wastage during manufacturing and handling. Thus, its usage as building material in construction and in other fields is essential for reduction of environmental problems. This research was carried out to produce an eco-friendly concrete. This project recommends the effective use of waste foundry sand as a partial replacement for fine aggregate and waste clay tiles as a partial replacement for coarse aggregate in concrete. Ingredients for concrete are cement, coarse aggregate, waste clay tiles, fine aggregate (M sand) and waste foundry sand. An experimental investigation was carried out on concrete containing waste foundry sand (WFS) in the range of 0%, 15%, 20%, 25% and 30%, and waste clay tiles (WCT) in the range of 0%,15%, 20%,25% and 30% by weight for M-20grade concrete. Concrete will be produced, tested and compared with conventional concrete for workability, compressive strength, durability and split tensile strength. These tests were carried out on standard cubes and cylinders to determine the properties of concrete, mainly the strength characteristics of 28th day.

Keywords: Concrete, Foundry sand, Waste clay tile, Replacement, Strength

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1. INTRODUCTION

In the present research, experimental investigations can be carried out on concrete to investigate the effect of waste foundry sand (WFS) and waste ceramic tiles (WCT) as partial replacement of fine aggregate and coarse aggregate respectively on mechanical properties of concrete such as strength and workability. Foundry sand is high quality silica sand with uniform physical characteristics. It is produced from ferrous and nonferrous metal casting industries, where sand has been used for centuries as a moulding material because of its thermal conductivity. This sand is treated as waste from casting industry and because of high silica content it cannot be disposed easily. Waste foundry sand is made up of mostly natural sand material. The considerable disposal expense has made the current practice of WFS disposal in landfills less favourable. Besides the financial burden to the foundries, land-filling WFS also make them liable for future environmental costs, remediation problems and regulation restrictions. The beneficial use of such by-products in construction materials results in reducing the cost of construction materials' ingredients and also helps in reducing disposal problem. The residue obtained from such materials may contain hazardous compounds, which may possibly affect the environment.

India ranks in the top 3 list of countries in terms of tiles production in the world. This huge amount of clay tiles are not recycled but are often used as pavement material or landfill. Clay tile aggregates are hard having considerable value of specific gravity, rough surface on one side and smooth on other side, having less thickness and are lighter in weight than normal stone aggregates. Using clay tile aggregate in concrete not only it will be cost effective, but also provide considerable strength to the concrete. Construction industries requires huge amount of clay tiles and other ceramic for architectural appearance, the productions of which are drastically increased, due to this waste is also produced during handling and usage of clay tiles. So, we selected these waste tiles as a replacement material to the basic natural aggregate.

Manufacturing of concrete involves the utilization of ingredients like cement, sand, aggregates, water and admixtures. During coarse aggregate production there is large amount of greenhouse gases emissions, which are major concern for global warming and climate change. Excavation of fine aggregate causes environmental problems such as water retention in lakes and rivers. Therefore, there is a need for finding some alternative or suitable material to use for concrete mix. Day by day different type of industries produces a huge amount of waste materials and which

Ultimately causes many environmental issues. Effective usage of waste materials in construction decrease environmental pollution and cost of concrete.

2. MATERIAL INVESTIGATION

2.1. Waste Clay Tiles (WCT)

Waste clay tile is an eco-friendly and economical product which can provide considerable strength to the concrete.

2.2. Waste Foundry Sand (WFS)

The grain size distribution of spent foundry sand is very uniform.Five to 12 percent of foundry sand can be expected to be smaller than 0.075 mm . The particle shape is typically sub angular to round.

The specific gravity of the WFS was found to be:

Table 1 Physical Properties of WFS

Sl. No	Properties	Fine Aggregate (WFS)
1	Specific Gravity	2.42
2	Water Absorption	2%

2.3. Coarse Aggregate

Aggregates of size greater than 4.75 mm are termed as coarse aggregates. Crushed stone and natural gravel are common materials used as coarse aggregate for concrete.

Table 2 Physical Properties of Coarse Aggregate

Sl. No	Properties	Coarse Aggregate
1	Specific Gravity	2.70
2	Water Absorption	0.99

2.4. Fine Aggregate

Fine aggregate is the aggregate most of which passes 4.75 mm IS sieve and contains only so much coarser as is permitted by specification.

Table 3 Physical Properties of Fine Aggregate

Sl.No.	Properties	Fine Aggregate
1	Specific Gravity	2.63
2	Water Absorption	2.15
3	Moisture content	0.67

2.5. Cement

PPC Cement was used in this investigation. The quantity required for the work was assessed and the entire quantity was purchased and stored properly in the casting yard. The specific gravity of cement was known. The following test where conducted in accordance with IS codes.

Table 4 Physical Properties of Cement

<table>
<tr><th colspan="2">Physical Properties</th><th>BIS-1489:1991</th><th>Test Result</th></tr>
<tr><td rowspan="2">Setting time (minutes)</td><td>Initial</td><td>30 minutes</td><td>52 minutes</td></tr>
<tr><td>Final</td><td>10 hours</td><td>345 minutes</td></tr>
<tr><td colspan="2">Specific gravity</td><td></td><td>3.15</td></tr>
</table>

3. CONCRETE MIX DESIGN

The given below table shows the Modified Mix Proportion for Replacement of Fine Aggregate by WFS and Coarse Aggregate by WCT. The table below shows the Modified Mix Proportion for Replacement of fine Aggregate by WFS.

Table 5 Modified Mix Proportion for Replacement of Coarse Aggregate by WCT

Sl. No	Mix identity	Percentage Replacement	Concrete mix design proportion					
			w/c ratio	cement	Fine aggregate	Coarse aggregate	WFS	WCT
1	CC	0% Replacement	0.5	1	1.28	3.98		
2	RC15	15% Replacement	0.5	1	1.28	3.184	0	0.796
3	RC20	20% Replacement	0.5	1	1.28	3.383	0	0.597
4	RC25	25% Replacement	0.5	1	1.28	2.985	0	0.995
5	RC 30	30% Replacement	0.5	1	1.28	2.786	0	1.194

Table 6 Modified Mix Proportion for Replacement of Fine Aggregate by WFS

SI. No	Mix identity	Percentage Replacement	Concrete mix design proportion					
			w/c ratio	cement	Fine aggregate	Coarse aggregate	WFS	WCT
1	CC	0% Replacement	0.5	1	1.28	3.98		
2	RF15	15% Replacement	0.5	1	1.024	3.383	0.256	0.597
3	RF20	20% Replacement	0.5	1	1.088	3.383	0.192	0.597
4	RF25	25% replacement	0.5	1	0.96	3.383	0.320	0.597
5	RF 30	30% replacement	0.5	1	0.896	3.383	0.384	0.597

4. EXPERIMENTAL SETUP

The standard size of specimen was made using metal moulds of cube of dimension 150mm X 150mm X 150mm and cylinders with diameter 150 mm and height 300 mm was used.The waste clay tile concrete and waste foundry sand concrete are manufactured by as similar to the classical concrete. Initially, three cubes of conventional concrete are prepared with general design mix for checking the strength of normal concrete. The average value of strength conventional concrete was noted for comparison study.

4.1. Compressive Strength

The compression test shows the compressive strength of hardened concrete. The compression test shows the best possible strength the concrete can reach in perfect conditions. Concrete cubes of size 150 X 150 X 150 mm were cast with and without WFS and WCT. During casting, the cubes were compacted using tamping rod. After 24 hours the specimens were demoulded and subjected to curing for 28 days in portable water. After curing, the specimens were tested for compressive strength using compression testing machine of 2000 kN capacity. The maximum load at failure was taken. The tests were carried out on a set of triplicate specimens and the average compressive strength values were taken. The procedure is repeated for changing the mix by replacing Fine aggregate and Coarse aggregate by 15%, 20%, 25%, 30% using waste foundry sand and waste clay tiles respectively.

Table 7 Compressive strength on partial replacement of coarse aggregate using waste clay tile

Sl. No	Mix identity	Percentage replacement by WCT	Compressive Strength (N/mm^2) 28 days
1	CC	0 %	28.55
2	RC15	15%	30.22
3	RC20	20%	31.68
4	RC25	25%	27.31
5	RC 30	30%	25.23

Table 8 Compressive Strength on 20% Replacement of Coarse Aggregate And Corresponding Percentage Replacement of Waste Foundry Sand

Sl no.	Mix identity	Percentage replacement by WFS	Compressive strength (N/mm^2) 28 days
1	CC	0 %	31.68
2	RW15	15%	30.85
3	RW20	20%	30.31
4	RW25	25%	29.4
5	RW 30	30%	25.3

4.2. Splitting Tensile Strength

The tensile strength of concrete is one of the basic and important properties. Splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete.

Concrete cylinders of size 150 mm diameter and 300 mm height were cast with incorporating WCT and WFS. After 24 hours the specimens were demoulded and subjected to curing for 28 days in portable water. The procedure is repeated for changing the mix by replacing Fine aggregate and Coarse aggregate by 15%, 20%, 25%, 30% using Waste foundry sand and Waste clay tiles respectively.

Table 8 Splitting Tensile Strength Test on Concrete Cubes

Sl no.	Mix Identity	Percentage replacement by WCT	Splitting tensile strength (N/mm^2) 28 days
1	CC	0 %	3.09
2	RC15	15%	3.32
3	RC20	20%	3.57
4	RC25	25%	3.28
5	RC 30	30%	3.08

Table 9 Splitting Tensile Strength Test on Concrete Cubes Obtained at 20% Replacement

Sl. No	Mix identity	Percentage replacement by WFS	Splitting tensile strength (N/mm^2) 28 days
1	CC	0 %	3.57
2	RW15	15%	3.25
3	RW20	20%	2.9
4	RW25	25%	2.6
5	RW 30	30%	2.2

4.3. Slump Test

The test measures consistency of concrete in that specific batch. It is performed to check consistency of freshly made concrete. Consistency refers to the ease with which concrete flows. It is used to indicate degree of wetness.

Table 10 Slump Test Result by Replacing Coarse Aggregate Using WCT

Sl.no.	Percentage Replacement by WCT	Water added	w/c ratio	Slump	Degree of workability
1	0	176.58	0.5	15	Very dry
2	15	176.58	0.5	34	Low
3	20	176.58	0.5	75	Medium
4	25	176.58	0.5	107	High
5	30	176.58	0.5	112	High

Table 11 Slump Test Result By Replacing Fine Aggregate Using WFS

Sl no.	Percentage Replacement by WFS	Water added	w/c ratio	Slump	Degree of workability
1	0	176.58	0.5	18	very dry
2	15	176.58	0.5	75	medium
3	20	176.58	0.5	90	Medium
4	25	176.58	0.5	110	High
5	30	176.58	0.5	121	High

5. RESULT ANALYSIS

The results obtained by conducting the various tests are analysed and various graphs are plotted.

5.1. Compression strength

The test results indicate that for mixtures prepared using up to 20% replacement by waste clay tiles, the compressive strength increased. However for mixtures with 25 and 30% replacement the compressive strength decreased rapidly.20% replacement yielded the highest 28 days compressive strength of about 31.68N/mm^2 whereas the mix with 30% replacement shows lowest compressive strength of the range 25.23 N/mm^2

The test results indicate that for mixtures prepared using up to 20% replacement by waste foundry sand, the compressive strength increased. However for mixtures with 25 and 30% replacement the compressive strength decreased rapidly.15% replacement yielded the highest 28 days compressive strength of about 30.85N/mm^2 whereas the mix with 30% replacement shows lowest compressive strength of the range 25.3 N/mm^2

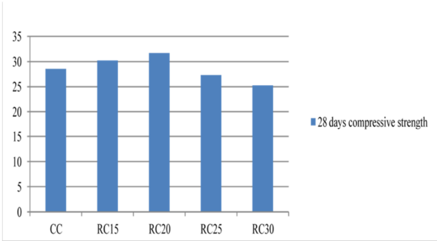

Figure 1 Compressive strength v/s percentage replacement by WCT.

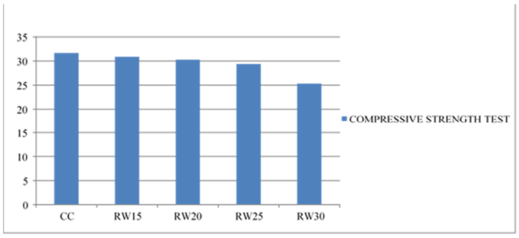

Figure 2 Compressive strength v/s percentage replacement by WFS

5.2. Splitting Tensile Strength Test

The test results indicate that for mixtures prepared using up to 20% replacement by waste clay tiles, the split tensile strength increased. However for mixtures with 25 and 30% replacement the compressive strength decreased rapidly.20% replacement yielded the highes 28 days split tensile strength of about 3.57 N/mm^2 whereas the mix with 30% replacement shows lowest split tensile strength of the range 3.08 N/mm^2.

The test results indicate that for mixtures prepared using up to any percentage replacement by waste foundry sand, the split tensile strength decreased. However for mixtures with 25 and 30% replacement the compressive strength decreased rapidly.15% replacement yielded the highest 28 days split tensile strength of about 3.25 N/mm^2 whereas the mix with 30% replacement shows lowest split tensile strength of the range 3.22 N/mm^2.Moreover the split tensile strength for replacement was observed to be lower than the conventional concrete mix.

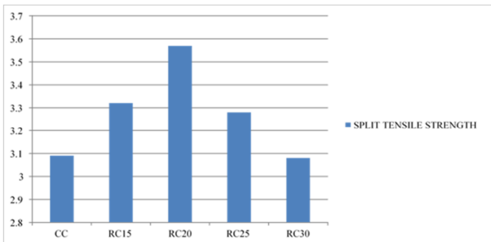

Figure 3 Split tensile strength vs. percentage replacement by WCT

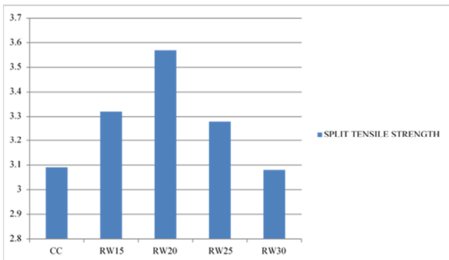

Figure 4 split tensile strength v/s percentage replacement by WFS.

5.3. Slump Test

Workability of concrete mix increases with increase in percentage of waste foundry sand and waste ceramic tiles as compare to regular concrete.For the replacement rates at 20% WCT and 15% replacement of WFS the workability was obtained at satisfied range.

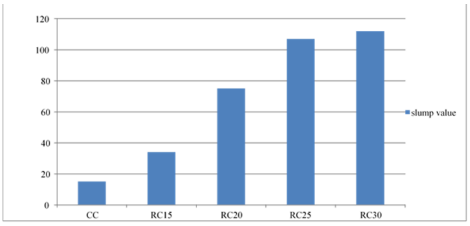

Figure 5 Slump value v/s percentage replacement by WCT

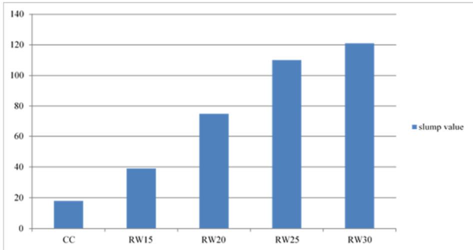

Figure 6 Slump value v/s percentage replacement by WFS

6. CONCLUSIONS

It is found that compressive strength of concrete mix is increased with increase in percentage of waste foundry sand and waste clay tiles as compare to regular concrete. It was maximum for 20 % replacement of waste clay tiles and 15% replacement of waste foundry sand, after that it further replacement reduced the strength.

It is also found that split tensile strength increases with increase in percentage of waste foundry sand and waste ceramic tiles up to 20 % replacement after that it reduces. Workability of concrete mix increases with increase in percentage of waste foundry sand and waste ceramic tiles as compare to regular concrete.

As waste foundry sand is waste from metal industries and waste ceramic tiles is waste from construction industries therefore both waste can be effectively use in concrete mix hence an eco-friendly construction material. By using this waste in concrete, problems regarding to safely disposal is reduced. Thus utilization of WCT and WFS in concrete has the dual benefit of eliminating the costs of disposal and lowering the cost of concrete.

After completion of all experimental program, we concluded that, WFS and WCT can be used in placed of fine and coarse aggregate respectively.

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