IJPRSE Progressive Research
International Journal of Progressive Research in Science and Engineering
Volume-1, Issue-5, August-2020
www.ijprse.com

Experimental Study On Concrete by Partial Replacement of Aggregates

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Abstract: - Natural aggregates are becoming increasingly scarce. The availability of natural sand and coarse aggregates is reducing drastically. In this investigation, fine and coarse aggregates are partially replaced with copper slag and ceramic tile waste respectively. Copper slag was replaced in proportions of 20%, 40% and 60% for fine aggregate and the tile waste are used in proportions of 10%, 30% and 50% respectively. Copper slag is the waste generated during the production of copper. The ceramic tile waste is nothing but the waste tile products from construction industry. M40 grade concrete was prepared for the experimental investigations, which showed that the ideal replacement for copper slag was 40% and that of tile waste was 30%.

Key Words: — ***Cement, Ceramic tile waste, Copper slag.***

I. Introduction

After water, concrete is the world's second most utilized material. We can also recycle the concrete and use them as a recycled aggregate. The use of concrete in the construction industry is twice as much of all the other construction materials combined. But the materials for concrete production such as fine aggregate and coarse aggregate are becoming scarce. So the use of an alternative material for the aggregates becomes inevitable.

Copper slag is a by—product obtained from the smelting of copper. The disposal of such a huge quantity of copper slag creates environmental problems. So the waste copper slag can be used as an alternative for fine aggregate or cement. This is advantageous in many ways such as to reduce the cost of disposal, to reduce the cost of concrete and reduce the pollution.

As far as coarse aggregates are concerned, their availability is a major concern in the construction sector. So an alternative material for coarse aggregate is ceramic tile waste. They are hard, durable and resist degradation forces. The ceramic tile wastes are nothing but waste tiles used in buildings. The waste accumulated during construction and demolition activities contributes almost 70% worldwide.

Also the waste generated during the production of tile is about 60%. So dumping such a huge quantity of waste creates environmental problems. By using them the cost of concrete is reduced.

II. Objective

- The main objective of this study is to find a suitable % of replacement for both copper slag and tile waste respectively.
- To test the properties of concrete on fresh and hardened states such as workability, compressive strength test, split tensile strength and flexural strength.

III. Materials Used

Cement:

Ordinary Portland cement of grade 53 was used for this study. Cement is generally present in powder form, which can be converted into a paste by addition of water. The specific gravity of cement is determined as 3.12 based on the test carried out and it has a fineness modulus of 4%.

Fine Aggregate:

The fine aggregate used for this investigation was clean river sand passing through 4.75mm sieve. It has the specific gravity 0f 2.56 and fineness of 3.62.

Coarse Aggregate:

Coarse aggregate should pass through the 20mm IS sieve and retained on IS 12.5mm sieve. Coarse aggregate used for this study is crushed stone aggregate having a specific gravity of 2.63 and fineness modulus of 7.2%.

Copper Slag:

Copper slag is a glassy material. It has the particle size similar to that of fine aggregate with a high specific gravity of 3.93.

Ceramic Tile Waste:

Ceramic tile waste is nothing but broken tile pieces which are obtained from demolition of buildings as well as during manufacturing process. It has a specific gravity of 2.38.

Water:

Another important ingredient of concrete is water. Water initiates the hydration reaction of cement in concrete which provides the binding capacity for cement.

IV. MIX DESIGN

Concrete mixes of M40 grade was prepared with a water cement ratio of 0.40. The mix proportion of materials was calculated as per IS 10262-2009. Chemical admixture is not used here. The fine aggregates and coarse aggregates were partly replaced by copper slag and ceramic tile waste respectively. The specimens were prepared. The copper slag was replaced in proportions of 20%, 40% and 60% whereas the tile wastes are replaced in proportions of 10%, 30% and 50% respectively. The mix design is as follows:

Table 3.1 Mix proportion

cement	Fine aggregate	Coarse aggregate	Water
493	640	1114	197
1	1.29	2.25	0.40

Table 3.2 Design mixes with copper slag and tile waste

Mix No	% Of Copper Slag	% Of Tile Waste
M1	0	0
M2	20	10
M3	40	30
M4	60	50

V. RESULTS AND DISCUSSION

The concrete of grade M40 was prepared and cured in water. The concrete cubes and specimens were prepared by partially replacing fine and coarse aggregates with copper slag and ceramic tile waste respectively. The concrete was then tested in fresh state as well as in the hardened state to know the physical and mechanical properties of the concrete. The concrete was tested for workability in its fresh state and the mechanical properties were calculated in its hardened state. The results and discussions are listed below:

A. Workability Test

The workability of concrete was found out by conducting slump cone test. This test is usually conducted on fresh concrete. Fresh concrete is nothing but a stage in which the concrete can be casted in moulds and it is in plastic state. It is used to find the water cement ratio of the concrete. The slump test is carried out as per the guidelines of IS 1199-1959. It is performed in a metal mould, which is in the shape of a frustrum of cone. The mould is of diameter 10mm at the top and 20mm at the bottom with a height of 300mm.

Table 4.1 slump for copper slag replacement

% of copper slag	Slump value
0	26
20	27.3
40	31.8
60	34.7

Table 4.2 slump for tile waste replacement

% of tile waste	Slump value
0	26
10	26.5
30	27.3
50	28

B. Compressive Strength Test

This test is conducted using universal testing machine. This test is carried out preparing concrete cubes and curing them in water and tested after 7 days and 28 days of curing respectively to find out the compressive strength. The concrete cubes were prepared with cube moulds of size

150mm×150mm×150mm. The concrete cubes were then cured in water for 28 days. After 28 days of curing, the concrete cubes were then tested in UTM. In between, the compressive strength was also calculated after 7 days of curing. The test results are discussed in table below:

Table 4.3 compressive strength @ 7 days

Mix no	Mix design	Compressive strength @ 7 days (N/mm^2)	Increase in %
M1	0% CS+ 0% CW	29.5	100
M2	20%CS+ 10% CW	32.24	109.3
M3	40% CS+ 30% CW	35.20	119.5
M4	60% CS+ 50% CW	31.26	106

The above test result shows the compressive strength of concrete @ 7 days by replacing both copper slag and ceramic tile waste. For this purpose, 2 cubes for each mix were prepared and the compressive strength was calculated as the average of the two values. 8 cubes were tested to find out the 7-day compressive strength. The same procedure is repeated to find the compressive strength @ 28 days.

Table 4.4 compressive strength @ 28 days

Mix no	Mix design	Compressive strength @ 28 days (N/mm^2)	Increase in %
M1	0% CS+ 0% CW	38.80	100
M2	20% CS+ 10% CW	40.26	103.7
M3	40% CS+ 30% CW	41.70	107.4
M4	60% CS+ 50% CW	36.14	93.14

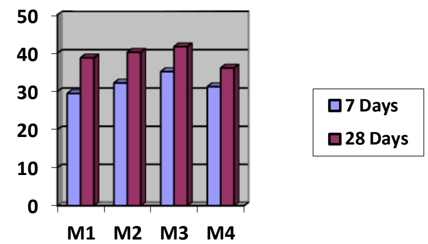

Fig 4.1 comparison of compressive strength

C. Split Tensile Strength Test

The tensile strength is one of the basic properties of concrete which determines the extent of cracking in the concrete structures. Since concrete is a brittle material, it is really weak in tension. So if the tensile force applied on the concrete exceeds its tensile strength, crack may develop in the concrete. The mould used for split tensile test is a cylinder of 3mm thick with the diameter of 150mm and height 300mm. For this test, 4 cylinders for each mix were casted and tested on 7 days and 28 days of curing with 2 specimens each for 7 and 28 days respectively. The tensile strength is listed in table below:

Table 4.5 tensile strength @ 7 days

Mix no	Mix design	Tensile strength @ 7 days (N/mm^2)	Increase in %
M1	0% CS+ 0% CW	2.23	100
M2	20% CS+ 10% CW	2.3	103.13
M3	40% CS+ 30% CW	2.36	106.8
M4	60% CS+ 50% CW	2.28	102.2

Table 4.6 Tensile strength @ 28 days

Mix no	Mix design	Tensile strength @ 28 days (N/mm^2)	Increase in %
M1	0% CS+ 0% CW	3.20	100
M2	20% CS+ 10% CW	3.26	101.7
M3	40% CS+ 30% CW	3.39	105.8
M4	60% CS+ 50% CW	3.32	103.7

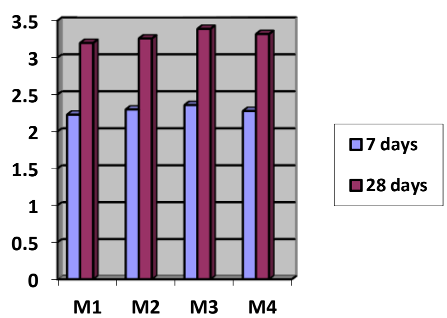

Fig 4.2 comparison of tensile strength

D. Flexural Strength Test

The flexural strength is similar to that of tensile strength with an exception that the tension is measured indirectly in the flexure test. In case of bending, if a slab or a beam is able to withstand the failure, the ability is called flexural strength. The flexural strength test was carried out by three-point load test. From the values of compressive and tensile strength test, the ideal replacement of both copper slag and tile waste was calculated. For that value, the beam was casted in the laboratory and the value of flexural strength was calculated. The flexural strength test was carried out on the beam after 28 days of curing.

Flexural strength of the beam @ 28 days = 4.76 N/mm^2

VI. CONCLUSION

From the various tests conducted on physical and mechanical properties of concrete, the ideal % of replacement for both copper slag and ceramic tile waste was calculated. The grade of concrete adopted was M40. The following conclusions were derived in this project which is discussed below:

- The workability test conducted on concrete after addition of copper slag and ceramic tile waste showed that as the % of copper slag and ceramic waste increased, the workability also increased simultaneously.
- The workability increased drastically up to 32.7% on 60% addition of copper slag when compared to conventional concrete. The addition of copper slag up to 40% is allowable as there was bleeding when more copper slag was added.
- The addition of ceramic tile waste doesn't seem to have much of an impact on the workability although the slump value increased 7% when 50% tile was added.
- Thus the increase in workability is mainly influenced by copper slag due to its porous nature whereas the ceramic tile waste increases the workability to a considerable level.
- Compressive strength @ 7 days showed an increase of 19.5% when 40% copper slag and 30% tile waste was used in the concrete. Beyond which the compressive strength decreases.
- Similarly, @ 28 days, the compressive strength showed an increase of 7.4% for 40% copper slag and 30% tile waste but beyond that value, the compressive strength decreased 6.86% when compared to the conventional concrete.
- The same is the case with tensile strength as well as there was an increase of 6.8% and 5.8% on 7 and 28 days respectively when compared to the conventional concrete.
- Based on the results obtained, the ideal % of replacement was calculated as 40% of copper slag for fine aggregate whereas for coarse aggregate, we can replace them with ceramic tile waste up to 30%.

- These replacements can reduce the cost of concrete as nearly 70% of the aggregates are replaced by waste materials. Also environmental impacts caused due to the dumping of such waste materials in the land can be reduced.

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