Study on Strength Behaviour of High-Performance Concrete Using Industrial Waste and Plastic Fiber

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***Abstract* - Due to rapid industrialization energy demand increases day by day. Energy generation through thermal power plants produce large quantity of coal ashes in which only 40% of that is being utilized in construction field and balance ashes are disposed over lands. Coal ash consists of different ashes, namely, class-F fly ash, class-C fly ash and copper slag. In this research, a study is carried out on concrete using class-f fly ash and copper slag as a partial replacement for cement and fine aggregate, respectively. In addition, waste plastic bottles are made into fibers and are used in concrete in volume fraction as 0.5%, 1%, 1.5% and 2%. The specimens are prepared with partial replacements of cement by 30% of class-f fly ash and 10% of silica fume and partial replacement of sand by 20% of copper slag for all specimens. Super plasticizer is added to improve the workability of concrete. The sample specimens consist of concrete cubes, cylinders and prisms. The compressive strength, split tensile strength and flexural strength tests are carried out and the test results are compared with that of conventional concrete.**

INTRODUCTION

The ashes are used in concrete for the purpose of economy, ecofriendly and most importantly reduction in cement content and sand content. Concrete structures will play the major role for developing country like India. Concrete is mixture of cement, fine aggregate and coarse aggregate with water.

The excessive excavation of river sand is becoming a serious environmental problem. Erosion and failure of riverbanks, lowering of riverbeds, saline water intrusion into the land and coastal erosion are the major adverse effects due to intensive river sand mining. As a result, the Government has banned sand mining in some identified areas of major rivers. At present, the construction industry in India is facing a serious shortage of sand due to over exploitation and government banning of river sand mining and on other side disposal of coal ashes from thermal power plants, leading to many environmental problems. So here I replace sand with pond ash. The cement production consumes huge amounts of limestone and clay and production of cement releases large amount of CO2 into the atmosphere. CO2 gas is a major contributor to greenhouse effect. The carbon dioxide emission and green house emission are some challenges to the human society. To eliminate such kind of environmental problem and excess extraction of river sand and for the purpose of eco- friendly, economy most importantly reduction in cement content and sand content the disposed coal ashes are used effectively in the partial replacement for cement and fine aggregate. Among different waste fractions, plastic waste deserves special attention on account non-biodegradable property which is creating a lot of problems in the environment.

OBJECTIVES OF THE STUDY

This study was aimed at covering the following parameters

- To utilize the waste raw material such as fly ash, copper slag and plastic fibers effectively in the field of concrete.
- To use micro silica to improve the performance of concrete.
- To study the compressive strength, split tensile strength and flexural strength of blended concrete with coal ashes and plastic fibers for the structural applications.
- To utilize this high-performance concrete as paver blocks in Pedestrian plazas, shopping complexes ramps, car parks, housing colonies, office complexes, rural roads with low volume traffic, beach sites, tourist resorts local authority footways, residential roads, etc.

LITERATURE REVIEW

The following literature studies gave a glimpse of how industrial wastes are used in concrete and about fiber reinforced concrete. A review of literature state that several investigations are previously performed on fly ash concrete.

Mohd Syahrul Hisyam et al, [2010] mentioned that Bottom ash (BA) from Thermal power plant is estimated to increase in the develop country such as India China, Malaysia and other countries where landfill for damped is limited. This coal bottom ash is physically coarse, porous, glassy, granular, greyish and incombustible materials that are collected from the bottom of furnaces that burn coal. The type of bottom ash produced depends on the type of furnace and also the sources of coal. From the burning process of coal, 80% of product will become fly ash and remain 20% of product is bottom ash. The aim of their study is to investigate the Feasibility and potential use of washed bottom ash in the application of concrete.

R.Kandaswamy and Murugesan [2011] investigated that there are many different kind of fiber reinforced concrete, the fiber which can be steel, asbestos. nylon, polythene and glass etc. the addition of fibers in concrete will improve the properties of concrete. There are many research done on fiber reinforced concrete using steel fibers. Hence in their project they made an attempt to study the influence of addition of plastic fibers i.e. polythene fibers at a dosage of 0.5 % by weight of cement. And M20 grade of concrete specimen were casted and tested at the day of 7 and 28 days of curing. And the compressive strength of FRC is compared with normal conventional concrete. And the results indicates that the addition of plastic fiber in concrete improves the strength of the concrete up to 2.45% when compare to normal conventional concrete. The split tensile strength of plastic fiber reinforced concrete (PFRC) shows good strength when compare to conventional concrete without plastic fibers.

MIX DESIGN AND EXPERIMENTAL INVESTIGATION

MIX DESIGN OF M20 GRADE CONCRETE: An example of calculating the required quantities of different materials for a considered proportion is given below

Target mean strength = 26.6 N/mm2
Water cement raio = 0.55
Cement content = 338 kg/m3
Volume of Concrete = 1 m3
Volume of Cement = 0.108 m3
Volume of Water = 0.186 m3
Volume of Aggregates = 0.686 m3
Mass of Coarse Aggregate = 1158 kg/m3
Mass of Fine Aggregate = 659 kg/m3

M20 grade of concrete is used and mix design is done as per IS 10262:2009and mix proportion is carried out by percentage replacement of cement by 25% of class-f fly ash, 10% of silica fume and fine aggregate (river sand) by 20 % of copper slag for all specimens. And waste plastic fiber by 0.5, 1, 1.5 and 2% by volume of concrete. The various mix proportion are shown in Table.4.8. - Addition of Plastic Fiber

S.No	Coarse Agg %	Cement %	Fly ash %	Silica fume%	Fine Agg %	Copper Slag%	Plastic Fibre%
Mix -1	100	60	30	10	100	0	0.5
Mix -2	100	60	30	10	90	10	1.0
Mix -3	100	60	30	10	80	20	1.5
Mix -4	100	60	30	10	70	30	2.0

MIX DESIGN OF M35 GRADE CONCRETE: An example of calculating the required quantities of different materials for a considered proportion is given below

MIX PROPORTIONS

1. Cement = 413kg/m³
2. Water = 186 kg/m³
3. Fine aggregate = 659kg/m³
4. Coarse aggregate 20mm = 1158 kg/m³
5. Water-cement ratio = 0.45

STEP 2: Replacement of cement with 30% flyash (as per Literature)

STEP3: Replacement of cement with silica fume. (in addition to 30% Flyash) Cement is replaced with silica fume of 0%, 5%, 10%, 15% and optimum mix is considered for further investigation.

STEP4: Replacement of Fine aggregates with 0, 10, 20, 30% of copper slag in the above optimum mix and finding the optimum value at copper slag and optimum new mix.

STEP5: To the above optimum new mix, addition of plastic fibre in different dosages of 0.5%, 1%, 1.5%, 2% and studying the strength and durability parameters.

M35 grade of concrete is used and mix design is done as per IS 10262:2009and mix proportion is carried out by percentage replacement of cement by 30% of class-f fly ash, 10% of silica fume and fine aggregate (river sand) by 20 % of copper slag for all specimens. And waste plastic fiber by 0.5, 1, 1.5 and 2% by volume of concrete. The various mix proportion are shown in Table.4.9.

Table Mix Proportion

Replacement of Cement with Silica Fume

S. No	Cement %	Flyash %	Silica fume %	Fine Aggregate%	Copper Slag%
Mix -1	70	30	0	100	_
Mix -2	65	30	5	100	_
Mix -3	60	30	10	100	_
Mix -4	55	30	15	100	_

By Literature Maximum Replacement of cement with fly ash is 30%.

Step : 2 Replacement of Sand with Copper Slag

S.No	Cement %	Flyash %	Silica fume %	Fine Aggregate%	Copper Slag%
Mix -1	60	30	10	100	0
Mix -2	60	30	10	90	10
Mix -3	60	30	10	80	20
Mix -4	60	30	10	70	30

Table

Addition of Plastic Fiber

S.No	Coa rese Agg %	Cem ent %	Fly ash %	Silic a fume %	Fin e Ag g %	Coppe r Slag%	Plas tic Fibr e%
Mix -1	100	60	30	10	10 0	0	0.5
Mix -2	100	60	30	10	90	10	1
Mix -3	100	60	30	10	80	20	1.5
Mix -4	100	60	30	10	70	30	2

Table

CASTING OF CUBES

In this study totally 30 cubes of 150x150x150mm are casted. And after 24 hours the specimens are de-moulded and kept in curing tank for curing. The cubes are used to determine the compression strength. After the 7 and 28 days of curing the cube specimens are tested and the results are obtained. The figure shows the cube casted.

CASTING OF CYLINDERS

In this study totally 30 cylinders of 100x300mm are casted. And after 24 hours the specimens are de-moulded and kept in curing tank for curing. After the 7 and 28 days of curing the specimens are tested under hydraulic load using compressive testing machine. The cylinders are used to determine the split tensile strength. The figure shows the concrete cylinder.

Figure Cylinder specime

CASTING OF BEAMS

In this study totally 30 cylinders of 100x100x500mm are casted. And after 24 hours the specimens are de-moulded and kept in curing tank for curing. The prism are used to determine the flexural strength. After the 7 and 28 days of curing the beam specimens are tested and the results are obtained. The figure 4.8 shows the concrete prism.

Figure Beam specime

COMPRESSIVESTRENGTH TEST OF CONCRETE FOR M20 GRADE

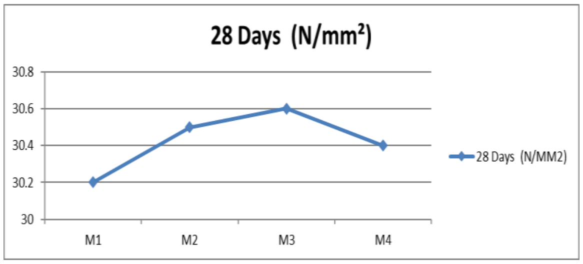
The cubes of size 150x150x150mm are tested for compressive strength at the age of 7 and 28 days and the results are shown in Figure . The cubes are taste during compressive testing machine (CTM). It can be seen that the average strength at7th and 28th day for mix-1 mix-2, mix-3, mix-4 specimens show high strength when compare to normal mix.

Step: 1 Replacement of Cement with Silica Fume

Addition of Plastic Fiber

Mix Designation	28 Days (N/mm²)
M1	30.2
M2	30.5
M3	30.6
M4	30.4

Table



Graph

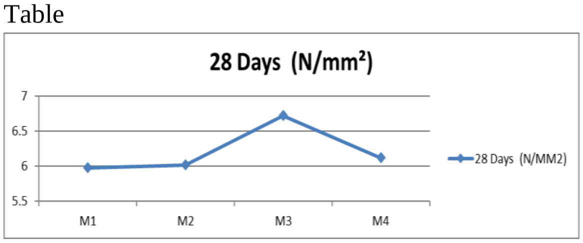
SPLIT TENSILE STRENGTH TEST OF CONCRETE FOR M20 GRADE

The cylinders of size 150 mm diameter and length of 300 mm are tested for split tensile strength at the age of 7 and 28 days and the results are shown in Figure. The cylinders are tested using CTM. It is observed in the 7th and 28th day results that as the percentage of fiber increases the spilt tensile strength increases.

Addition of Plastic Fiber

Mix Designation	28 Days (N/mm²)
M1	5.98
M2	6.02
M3	6.72
M4	6.12

Table



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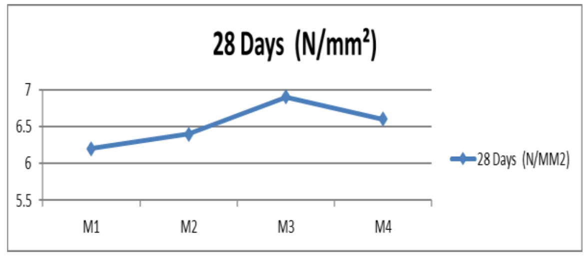
FLEXURAL STRENGTH TEST OF CONCRETE FOR M35 GRADE

The prisms of size 100x100x500 mm are tested for flexural strength at the age of 14 and 28 days and the results are shown in Figure . The prisms are tested using Universal testing Machine (UTM). And the flexural strength results of concrete with fibers shows high strength when compared to normal conventional concrete

Addition of Plastic Fiber

Mix Designation	28 Days (N/mm²)
M1	6.2
M2	6.4
M3	6.9
M4	6.6

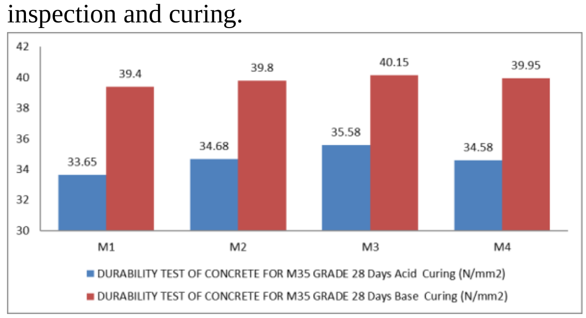
Table



Graph

DURABILITY TEST OF CONCRETE FOR M35 GRADE

Durability of concrete is determined by its ability to resist weathering action, chemical attack, abrasion, or any other process of deterioration, and will retain its original form, quality and serviceability when exposed to its environment. Durable concrete is result of proper design, proportioning, placement, finishing, testing, inspection and curing.



Graph

CONCLUSIONS

1.The optimum mix proportion is obtained when cement is replaced with 30% fly ash, 10% silica fume, fine aggregate is replaced with 20% of copper slag and added 1.5% of plastic fiber to M20 mix proportions.

a. There is an increase in compressive strength of 5.51 % is observed.

b. There is in increase in spilt tensile strength of 62.31% is observed .

c. There is in increase in flexural strength of 72.74% is observed.

d. There is in increase in durability for acid of 7.13% and for base of 7.38% is observed.

2. The optimum mix proportion is obtained when cement is replaced with 30% fly ash, 10% silica fume, fine aggregate is replaced with 20% of copper slag and added 1.5% of plastic fiber to M35 mix proportions.
a. There is an increase in compressive strength of 4.87 % is observed.
b. There is in increase in spilt tensile strength of 41.62% is observed.
c. There is in increase in flexural strength of 32.69% is observed.
d. There is in increase in durability for acid of 5.98% and for base of 6.20% is observed.
3.As the strength of optimum mixes are more than the conventional M20 and M35 grades of concrete, there mixes can be used at all the places where conventional concrete is used with lower cost.
4. As industrial waste is used in making the concrete, environmental pollution will be decrease.
5.Useful for disposal of industrial waste.
6. This concrete is Eco friendly.

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