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STUDY ON THE MECHANICAL PROPERTIES OF FIBRE REINFORCED CONCRETE MADE OF POLYPROPYLENE FIBRE AND STEEL INDUSTRIAL WASTE

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Abstract - *Sand is a prime material used for preparation of mortar and concrete and which plays a major role in mix design. In conventional concrete, one of the ingredient sand is replaced by steel industrial waste (SIW) and its nature is studied in this project. In this study, extensive laboratory investigations have been undertaken to study the effect of varying steel industrial waste contents on the mechanical properties such as compressive strength, split tensile strength and flexural strength. The same study is made by adding polypropylene fibre with the dosage of 1.2% by weight of cement to the steel industrial waste concrete. Polypropylene fibre increases the mechanical properties of concrete. It prevents crack formation and provides reinforcement to the concrete structure. Steel industrial waste concrete and steel industrial waste with polypropylene fibre reinforced concrete specimens were casted, cured and tested for mechanical properties. Conventional concrete specimens were also casted and tested for reference. In this experiment the results of steel industrial waste concrete, polypropylene fibre with steel industrial waste concrete and plain concrete are discussed for M30 grade of concrete.*

Key Words: ***Steel industrial waste, Polypropylene fibres, Compressive strength, Spilt tensile strength, Flexural strength***.

1. INTRODUCTION

Concrete is one of the oldest and most common construction materials in the world. Conventionally concrete is a mixture of cement, water and aggregates. Plain concrete is good in compression but weak in tensile strength with very limited ductility and little resistance to cracking. Conventionally reinforced steel bars are used to reduce cracks and impart improvements in tensile property of concrete members. But they provide tensile strength to concrete members , they however do not increase the tensile strength of concrete itself.

Concrete has ability to consume and recycle waste. Minimum use of natural resources and recycling of unused materials are key elements in sustainable development. Nowadays, different waste materials are used in concrete production. A lot of waste is produced from steel plants while producing pig iron, steel and end products. If these wastes are incorporated into the concrete production, cost of production will be reduced along with reduction in health hazards and helping in creating eco-friendly environment.

Fibre-reinforced Concrete (FRC) is concrete containing fibrous material which increases its structural integrity. It contains short discrete fibres that are uniformly distributed and randomly oriented. Fibres include steel fibres, glass fibres, synthetic fibres and natural fibres- each of which lend varying properties to the concrete. Polypropylene fibre can improve cohesion, pump ability over long distances, resistance to plastic shrinkage during curing, structural strength, ductility and durability.

In this study, steel industrial waste is used as replacement to fine aggregate with the addition of polypropylene fibre. Strength properties and durability properties of this concrete is carried out.

2. METHODOLOGY

1) Literature review
2) Collection of materials
3) Tests on materials
4) Mix design
5) Tests on fresh concrete
6) Tests on hardened concrete
7) Results and discussions

3. MATERIALS

3.1 Cement

Ordinary Portland cement of 53 grade conforming to IS 12269-1976 was used throughout the experiment. OPC 53 grade cement is a prime brand cement with the remarkably high C_2S (Tri Calcium Silicate) providing long-lasting durability and serviceability to concrete structures. Different tests and investigations were done to ensure that it conforms the requirements of Indian Standard Specification IS: 1489-1(1991).

3.2 Fine aggregate

The aggregates which pass through 4.75 mm IS sieve and retained on 150 microns IS sieve is taken. Locally available M-Sand was used for the study. It was tested as per Indian Standard Specification IS:383-1970.

3.3 Coarse aggregate

Coarse aggregates are the particles that retain on 4.75mm sieve. Crushed stone of 20 mm size are used as coarse aggregate. The aggregate properties are tested in accordance with IS: 383-1970.

3.4 Water

Water is the most important ingredient of the concrete. Water is used in the pre hardening state i.e., the fresh state as well as in the post hardening state for the curing of concrete. Water is the chemical partner of the concrete which actively take part in the chemical reactions with the cement to form the binding material. Tap water free from injurious salts was used for mixing and curing of concrete.

3.5 Polypropylene fibre

Polypropylene fibre is the light weight synthetic fibre, transformed from 85% propylene, and used in a variety of applications. The Polypropylene fibre is an economic material that offers a combination of outstanding physical, mechanical, thermal and electrical properties not found in any other synthetic fibres.

In this study polypropylene fibres of blended type are used. The project deals with the addition of polypropylene fibre on the properties of concrete in fresh and hardened state.

Fig-1. Polypropylene fibre

3.6 Steel industrial waste

Utilization of industrial waste materials in concrete compensates the lack of natural resources, solving the disposal problem of waste and to find alternative technique to safeguard nature. At present many steel plants are being setup across the globe causing a huge production of solid waste materials and disposing of these materials will have negative impact on environment. In the present study we are using the steel industrial waste as replacement for fine aggregates of concrete.

Fig-2. Steel industrial waste

4 MIX DESIGN

Grade of concrete = M30

Type of cement	OPC 53 Grade
Maximum size of aggregate	20mm
Water cement ratio	0.45
Exposure condition	Severe
Specific gravity of cement	3.05
Specific gravity of F.A	2.6
Specific gravity of C.A	2.55
Degree of workability	20-50 mm
Minimum cement content	320 kg/m^3

Grading of F.A	Zone 2

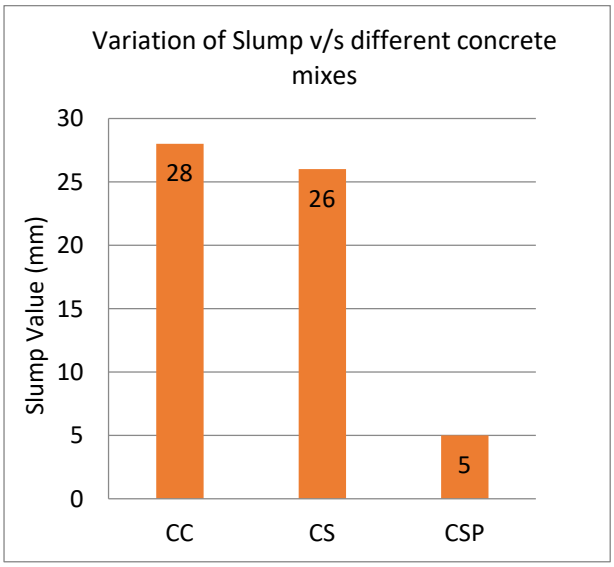
MIX PROPERTIONS- 1:1.57:2.63:0.45

5 TESTS ON FRESH CONCRETE

5.1 Slump cone test

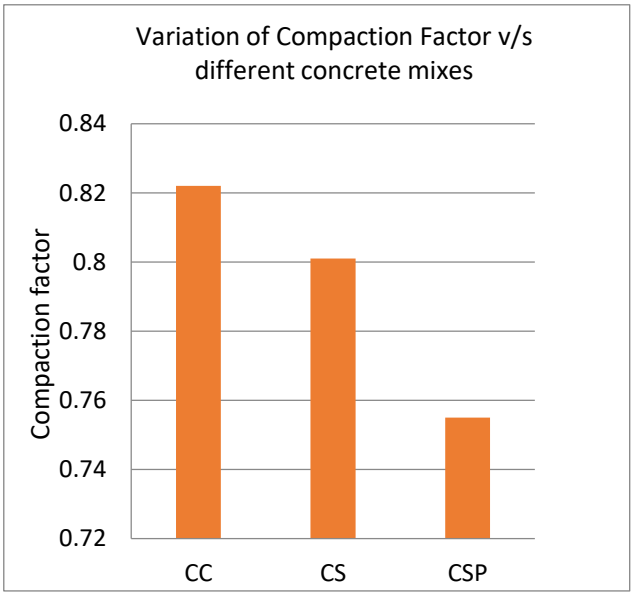
The slump test is a measure of the behavior of a compacted inverted cone of concrete under the action of gravity. It measures the consistency or the wetness of the concrete.

Designation	w/c ratio	Slump observed in mm
CC	0.45	28
CS	0.45	26
CP	0.45	5



5.2 Compaction factor test

It is the most efficient test for measuring workability of concrete. The below chart shows the variation compaction factor vs different concrete mixes.

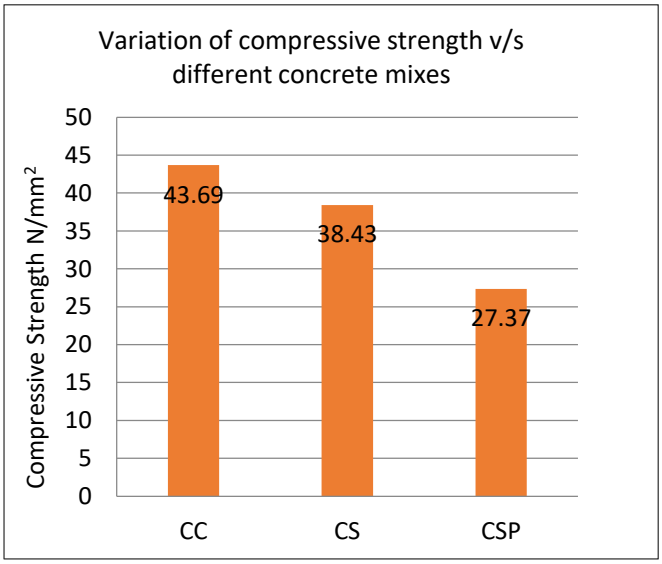


6 TESTS ON HARDENED CONCRETE

6.1 Compressive strength test

One of the important properties of concrete is its strength in compression. The strength in compression has a definite relationship with all the other properties of concrete, i.e., these properties are improved with the improvement in compressive strength, hence, the importance of the test. Moulds of size (150x150x150)mm are used for casting the specimens. The test results are shown in below table.

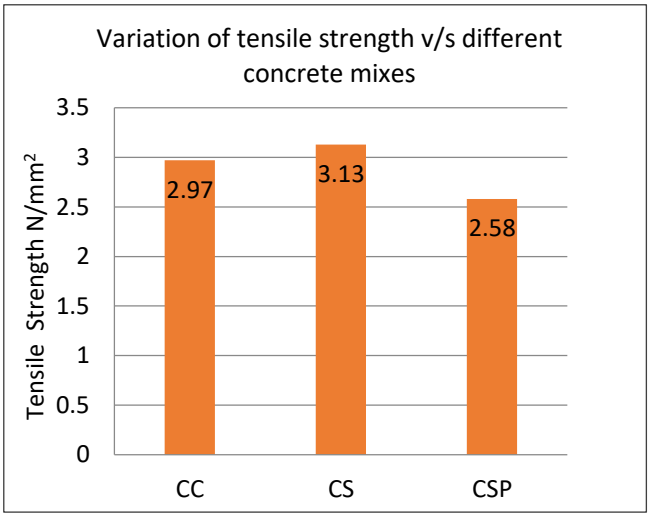
Designation	% of Steel industrial waste, Polypropylene	Age of concrete in days	Average compressive strength N/mm^2
CC	0,0	28	43.69
CS	20,0	28	38.43
CSP	20,1.2	28	27.37



6.2 Split tensile strength test

The tensile strength is one of the basic important properties of the concrete. The concrete is not usually expected to resist the direct tension because of its low tensile strength and brittle nature. However, the determination of tensile strength of concrete is necessary to determine then load at which the concrete members crack. The cracking is a form of tension failure. The specimens are casted using the cylindrical mould of internal diameter 150mm and height 300mm.The below table gives the 28 days split tensile strength of different concrete mixes.

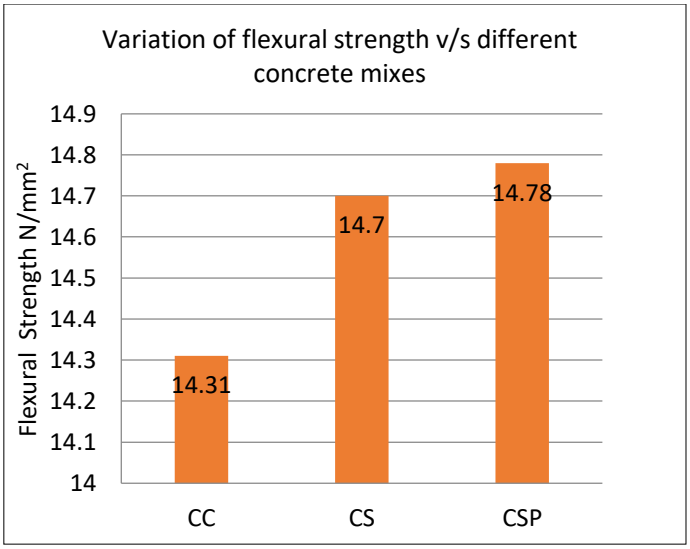
Designation	Percentage of Steel industrial waste, Polypropylene fibre	Age of concrete in days	Average split tensile strength N/mm²
CC	0,0	28	2.97
CS	20,0	28	3.13
CSP	20,1.2	28	2.58



6.3 Flexural strength test

Flexural strength is a measure of the tensile strength of concrete beams or slabs. It is a measure of an un-reinforced beam or slab to resist failure in bending. The specimens are casted in beam mould of size (150×150×700)mm. Results are tabulated in the below table

Designation	% of Steel industrial waste, Polypropylene	Age of concrete in days	Average flexural strength N/mm²
CC	0,0	28	14.31
CS	20,0	28	14.7
CSP	20,1.2	28	14.78



7. RESULTS AND DISCUSSIONS

1. The reduction of slump is noticed with increase in polypropylene fibre content.
2. A small amount of reduction in slump is seen with the adding of steel industrial waste.
3. Polypropylene fibre reinforced concrete gives less workable concrete as compared to concrete with steel industrial waste.
4. The compressive strength is decreased with the replacement of sand by steel industrial waste.
5. The compressive strength is largely decreased in with the addition of 1.2% of polypropylene fibre along with steel industrial waste compared to that of conventional concrete.
6. The split tensile strength in steel industrial waste concrete is increased by an amount of 5.38% when compared to conventional concrete whereas in case of polypropylene fibre reinforced concrete it decreases by 13% compared to conventional concrete.
7. In steel industrial waste concrete the flexural strength is increased by amount of 2.73% and it further increases in case of polypropylene fibre reinforced concrete by an amount of 3.28% when compared to conventional concrete.

8. Conclusions

Based on the experiment conducted following conclusions are obtained

1. Compressive strength properties of both the types of concrete are decreased with 20% replacement of sand by steel industrial waste and 1.2% addition of polypropylene fibre.
2. Tensile strength properties of steel industrial waste concrete are increased and it is decreased in polypropylene fibre reinforced concrete.
3. Flexural strength properties of both the types of concrete are increased.

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