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MECHANICAL BEHAVIOUR OF INDUSTRIAL WASTE ADMIXED WITH POLYPROPYLENE FIBER IN CONCRETE

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Abstract- Globally construction industry has enormous growth year by year. This leads to increase the need for construction materials. We are taking the materials from natural resources because of this natural resource depletion occurs at a faster rate. Also this affects the environment. Cement production leads to higher amount of CO2 emission similarly depletion in river sand leads to ground water problems. So we have to find some alternate materials to conserve the earth for next generation. The faster industrial growth generates large amount of industrial wastes. Industrial waste material management is such a challenging area. Handling and disposal of industrial waste is a big issue for every country around the world. Ferrous slag is considered as an industrial waste which is obtained from iron smelting process. To minimize the environmental problems ferrous slag is used in concrete as a partial replacement of fine aggregate. Concrete is strong in compression and weak in tension. Using Polypropylene fibre we can increase the tensile strength of concrete. Mainly polypropylene fiber resists the micro plastic shrinkage cracks. Here polypropylene fibers added as micro reinforcement. A few researchers have already found it possible to use ferrous slag as a fine aggregate similarly polypropylene fiber as a micro reinforcement. But not much research has been carried out to study the combined behaviour of ferrous slag and Polypropylene fiber. The percentages of replacements of sand by granulated ferrous slag are 0%, 20%, & 50% and also the fiber dosage is maintained as constant 0.5% of cement. This research focused on the combined behaviour of ferrous slag and polypropylene fiber in study strength and transport properties.

Keywords: ***Polypropylene Fibre, Ferrous Slag, Ordinary Portland cement 53, Compressive Strength, Split Tensile Strength, Evaporation, Absorption, Moisture Migration.***

GENERAL

The global use of concrete is second only to water. As the demand for concrete as a construction material increase, so the demand for Fine aggregate also increases. The concrete industry globally will consume 8 – 12 billion tons annually of natural aggregate after the year 2010. Such large consumption of natural aggregates will cause destruction to the Environment. In the last few decades there has been rapid increase in the waste materials and by-products production due to the exponential growth rate of population, development of industry and technology and the growth of consumerism. The basic strategies to decrease solid waste disposal problems have been focused at the reduction of waste production and recovery of usable materials from the waste as raw material as well as utilization of waste as raw materials whenever possible.

Several efforts are in progress to reduce the use of natural river sand as fine aggregate in concrete in order to address the ground water issues & natural aggregate depletion. Ferrous Slag is a by-product material produced from the process of manufacturing Iron. . The beneficial use of by-products in concrete technology has been well known for many years and significant research has been published with regard to the use of materials such as coal fly ash, pulverized fuel ash, blast furnace slag and silica fume as partial replacements for Portland cement. It is totally inert material and its physical properties are similar to natural sand. Ferrous Slag is a by-product in the manufacture of pig iron and the amounts of iron and slag obtained are of the same order. The slag is a mixture of lime, silica, and alumina, the same proportion. Similarly M-Sand also used as fine aggregate. M-Sand is processed from the crushed rock of gravel.

FERROUS SLAG

Ferrous slag is an industrial by-product obtained during the matte smelting and refining of pig iron. It has been estimated that approximately 300 to 540 kg per tonne of pig or crude iron are produced. The amount of slag produced by many of the countries in the world in large amounts and many of them export the slag in large amounts such as China, USA, Japan and Nepal about 602120, 30000, 23868 and 13138 tons respectively. Although ferrous slag is widely used in the cement industry and in the manufacturing of slag cement, the remainder is disposed of without any further reuse or reclamation. For example, ferrous slag has a number of favorable mechanical properties for aggregate use such as excellent soundness characteristics, good abrasion resistance and good stability. Also, ferrous slag exhibits pozzolanic properties since it contains high CaO content and other oxides such as Al_2O_3, SiO_2, and Fe_2O_3. Use of ferrous slag in the concrete industry as a replacement for cement and/or fine aggregates can has the benefits of reducing the costs of disposal and helps protecting the environment.

Ferrous slag used in this work was brought from JSW Steel Ltd, Bellary, Karnataka, India. JSW Steel Ltd is producing ferrous slag during the manufacture of Steel. It is a by-product obtained during the matter smelting and refining of iron. To produce every ton of steel, approximately 2.2– 3.0 tons ferrous slag is generated as a by-product material.

POLYPROPYLENE FIBER

Concrete is by nature a brittle material that performs well in compression, but is considerably less effective when in tension. Reinforcement is used to absorb these tensile forces so that the cracking which is inevitable in all high-strength concretes does not weaken the structure. For many years, steel in the form or bars or mesh (also known as "re-bar") has been used as reinforcement for concrete that are designed to experience the tensile loading.

Latest developments in concrete technology now include reinforcement in the form of fibers, notably polymeric fibers, as well as steel or glass fibers 1-5. Fiber-reinforcement is predominantly used for crack control and not structural strengthening. Although the concept of reinforcing brittle materials with fibers is quite old, the recent interest in reinforcing cement-based materials with randomly distributed fibers is quite old. The recent interest in reinforcing cement based materials with randomly distributed fibers is based on research starting in the 1960's. Since then, there have been substantial research and development activities throughout the world. It has been established that the addition of randomly distributed polypropylene fibers to brittle cement based materials can increase their fracture toughness, ductility and impact resistance. Since fibers can be premixed in a conventional manner, the concept of polypropylene fiber concrete has added an extra dimension to concrete construction.

It is a thermo plastic fiber and its structure is based on C_nH_{2n} monomer. This is manufactured from propylene gas in presence of titanium chloride. Poly propylene has an intermediate level of crystallinity between low density polyethylene (LDPE) and high density polyethylene (HDPE). The first polypropylene resin was produced by Giulio Natta in Spain, although commercial production began in 1957.

SCOPE

Concrete is strong in compression and week in tension. To increase the tensile strength of the concrete we are adding polypropylene fiber. Also it resists the plastic shrinkage cracks. Now a day due to the rapid industrial growth, waste material management is a challenging field. It possesses lot of environmental impact. Due to the rapid growth in construction field, construction material scarcities will arise. So we need to find some alternate material for construction. Ferrous slag is a waste material from the Iron smelting process. By using this as fine aggregate we can prevent the natural aggregate depletion. This avoids so much of environmental problems.

OBJECTIVE

The main objective is to study the effect on utilization of ferrous slag in polypropylene fiber reinforced concrete composite here ferrous slag is replaced in fine aggregate under various levels and addition of polypropylene fiber 0.5% by weight of the cement. The ferrous slag replacement is done in weight batching basis.
To study the mechanical and transport properties of concrete

- ★ Compressive test on concrete cubes (150 × 150 × 150 mm)
- ★ Split tensile strength on cylinders (Ø 100 mm & 200 mm long)
- ★ Evaporation test on cubes (150 × 150 × 150 mm)
- ★ Water absorption test on cubes (150 × 150 × 150 mm)
- ★ Moisture migration test on cubes (150 × 150 × 150 mm)

MATERIALS AND PROPERTIES

CEMENT

Cement is the most important material in the concrete and it act as the binding material. Ordinary Portland cement of 53 grade manufactured by Dalmia cements is used in this investigation. Various properties of the cement has been tested according to IS 12269-1987 and IS 4031 -1988.

AGGREGATE

The basic objective in proportioning any concrete is to incorporate the maximum amount of aggregate and minimum amount of water into the mix, and thereby reducing the cementinious material quantity, and to reduce the consequent volume change of the concrete.

COARSE AGGREGATE

Selection of the maximum size of aggregate mainly depends on the project application, workability, segregation, strength and availability. In this research aggregates that are available in the crusher nearby was used. The maximum size of aggregate was varying between 26 -12.5 mm.

FINE AGGREGATE

The amount of fine aggregate usage is very important in concrete. This will help in filling the voids present between coarse aggregate and they mix with cementinious materials and form a paste to coat aggregate particles and that affect the compactability of the mix. The workability of a concrete depends on the fineness of fine aggregates in most of the cases. The aggregates used in this research are without impurities like clay, shell and some of the organic matters. It is passing through 4.75mm sieve.

FERROUS SLAG

Ferrous slag is an industrial by-product obtained during the matte smelting and refining of pig iron. It has been estimated that approximately 300 to 540 kg per tonne of pig or crude iron are produced. Although ferrous slag is used in many of the industries large amounts of the slag is still left out as dumping waste. So the ferrous slag properties are checked over and they resembles nearer to the aggregates and glassy properties they are used as the substitute materials in the cement and concrete as the raw materials. In this project we are using the slag that had been produced in the JSW Steel Ltd.

POLYPROPYLENE

Polypropylene (PP) is a thermoplastic polymer that are widely used in many applications including labelling, packaging, textiles (e.g. ropes, carpets), stationary, plastic parts and reusable containers of various types, laboratory equipment, loudspeakers, automotive components and polymer bank notes. An addition polymer made from the monomer propylene, it is rugged and unusually resistant to many chemical solvents, bases and acids.

WATER

Water acts lubricant for the fine and coarse aggregate and acts chemical with cement to form the binding paste for the aggregate water is used for curing the concrete after it has cast into the forms. Water used for both mixing and curing should be free from contaminants. Portable water is generally considered satisfactory for mixing and curing of concrete. If water contains any sugar or an excess of acid, alkali it should not be used. Ordinary tap water used in the preparation of concrete.

TABLE 1: PHYSICAL PROPERTIES OF CEMENT

S.no	Particulars	Results
1	Specific gravity	3.05
2	Initial setting time	170 min
3	Final setting time	230 min
4	Consistency	25%
5	Fineness	298 m^2/kg
6	Compressive Strength of cement at 3, 7, 28 days	35, 46, 58 N/mm^2

TABLE 2: PROPERTIES OF COARSE AGGREGATES

S.no	Particulars	Results
1	Type	Crushed stone
2	Specific Gravity	2.6
3	Water absorption	0.8%
4	Fineness modulus	7.98
5	Size	20 mm (max)
6	Density	1.48

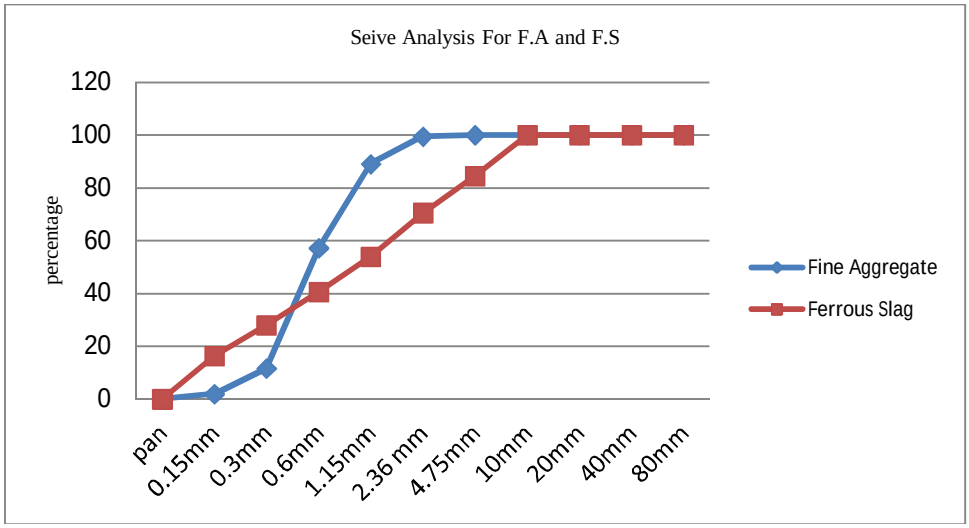
TABLE 3: PROPERTIES OF FINE AGGREGATES

S.no	Particulars	Results
1	Type	River sand
2	Specific Gravity	2.4
3	Water absorption	1%
4	Fineness modulus	3.40
5	Grading	Zone-III
6	Density	1.57

TABLE 4: PHYSICAL PROPERTIES OF FERROUS SLAG

S.no	Particulars	Results
1	Type	Industrial Waste
2	Specific Gravity	3.4
3	Water absorption	4%
4	Fineness modulus	3.06
5	Grading	Zone II

GRAPH 1: SIEVE ANALYSIS FOR FERROUS SLAG AND FINE AGGREGATES



MIX PROPORTIONING:

TABLE 5: MIX PROPORTIONS

Mix	Cement	C.A 12mm	C.A 20mm	Fine Aggregate	Ferrous Slag	Polypropylene Fiber	W/C
M1	350	727	502	646	0	0	0.55
M2	350	727	502	646	0	1.75	0.56
M3	350	727	502	516	130	1.75	0.56
M4	350	727	502	323	323	1.75	0.57

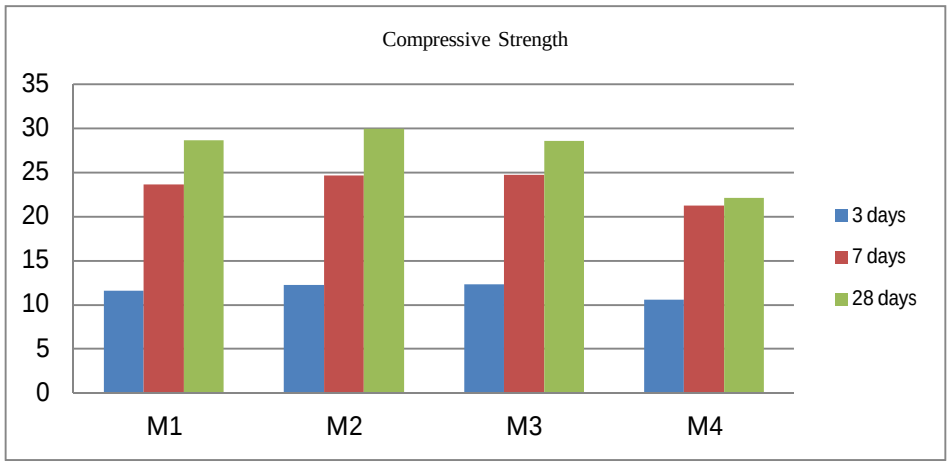
EXPERIMENTAL INVESTIGATION

COMPRESSIVE STRENGTH TEST:

TABLE 6: COMPRESSIVE STRENGTH OF DIFFERENT MIXES

Compressive strength N/mm^2			
MIX	3 days	7 days	28 days
M1	11.57	23.62	28.66
M2	12.23	24.66	29.92
M3	12.34	24.75	28.59
M4	10.6	21.25	22.07

GRAPH 2: COMPRESSIVE STRENGTH OF DIFFERENT MIXES

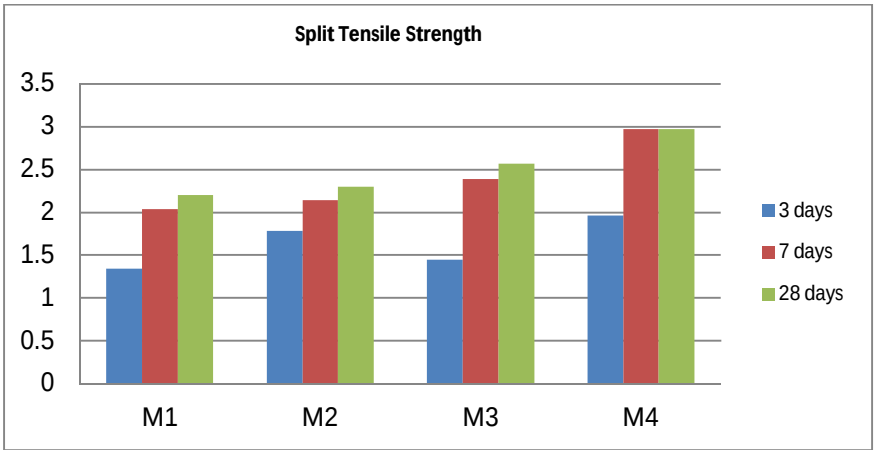


SPLIT TENSILE STRENGTH

TABLE 7: SPLIT TENSILE STRENGTH FOR DIFFERENT MIXES

Split Tensile Strength N/mm^2			
MIX	**3 days**	**7 days**	**28 days**
M1	1.34	2.04	2.2
M2	1.78	2.14	2.3
M3	1.45	2.39	2.57
M4	1.96	2.97	2.97

GRAPH 3 : SPLIT TENSILE STRENGTH OF DIFFERENT MIXES

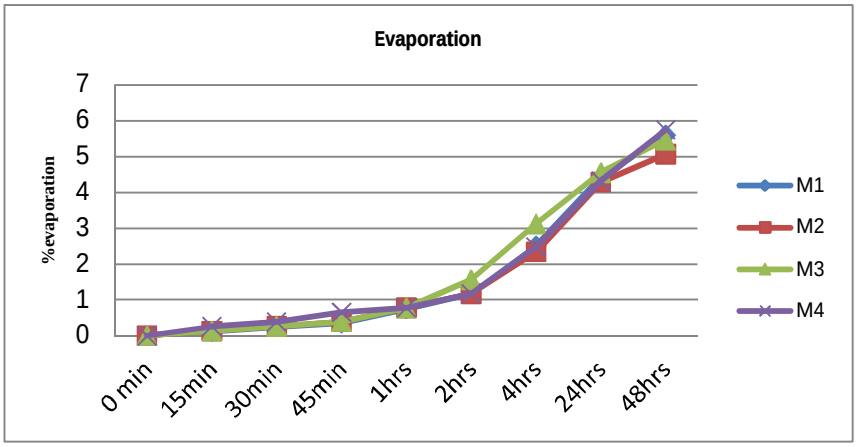


EVAPORATION TEST:

TABLE 8: EVAPORATION PERCENTAGES IN DIFFERENT MIXES

Evaporation in %									
MIX	**0 min**	**15min**	**30min**	**45min**	**1hrs**	**2hrs**	**4hrs**	**24hrs**	**48hrs**
M1	0	0.12	0.25	0.35	0.75	1.18	2.5	4.4	5.6
M2	0	0.13	0.26	0.39	0.78	1.17	2.34	4.29	5.07
M3	0	0.13	0.26	0.39	0.78	1.56	3.12	4.55	5.46
M4	0	0.26	0.39	0.65	0.78	1.17	2.48	4.31	5.75

GRAPH 4: EVAPORATION PERCENTAGES IN DIFFERENT MIXES

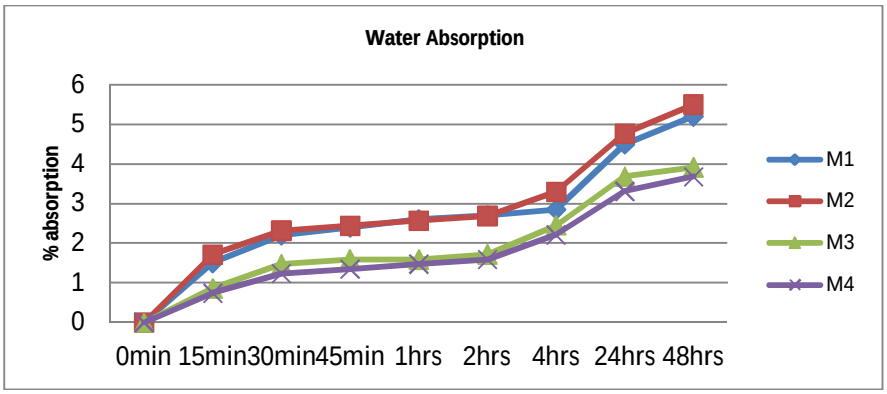


WATER ABSORPTION TEST:

TABLE 9: WATER ABSORPTION PERCENTAGES IN DIFFERENT MIXES

Water Absorption in %									
MIX	**0min**	**15min**	**30min**	**45min**	**1hrs**	**2hrs**	**4hrs**	**24hrs**	**48hrs**
M1	0	1.5	2.2	2.4	2.6	2.7	2.85	4.5	5.2
M2	0	1.71	2.32	2.44	2.57	2.69	3.3	4.77	5.5
M3	0	0.86	1.47	1.59	1.59	1.72	2.45	3.68	3.92
M4	0	0.74	1.23	1.35	1.47	1.59	2.21	3.31	3.68

GRAPH 5: WATER ABSORPTION PERCENTAGES IN DIFFERENT MIXES

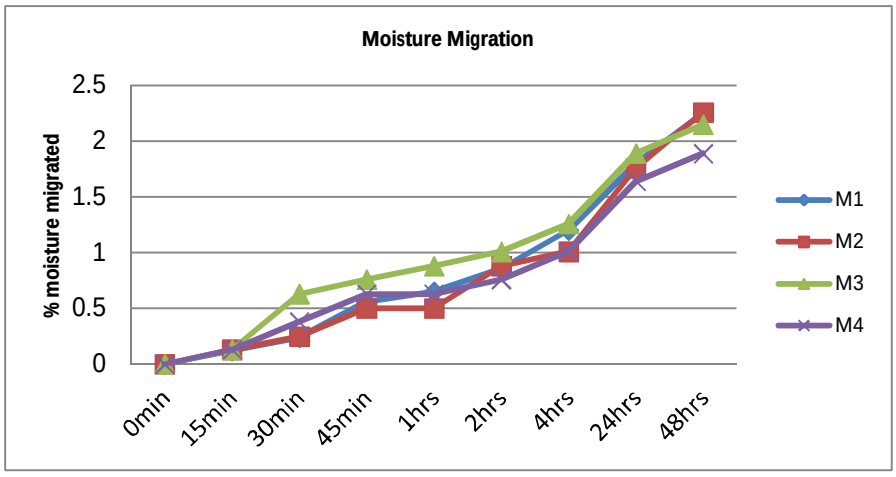


MOISTURE MIGRATION TEST:

TABLE 10: MOISTURE MIGRATION PERCENTAGES IN DIFFERENT MIXES

Moisture Migration in %									
MIX	**0min**	**15min**	**30min**	**45min**	**1hrs**	**2hrs**	**4hrs**	**24hrs**	**48hrs**
M1	0	0.12	0.24	0.56	0.65	0.86	1.2	1.8	2.25
M2	0	0.13	0.25	0.5	0.5	0.88	1.01	1.76	2.26
M3	0	0.13	0.63	0.76	0.88	1.01	1.26	1.89	2.15
M4	0	0.13	0.38	0.63	0.63	0.76	1.01	1.64	1.89

GRAPH 6: MOISTURE MIGRATION PERCENTAGES IN DIFFERENT MIXES



CONCLUSION

All the material tests, strength test such as compression, split tensile and the transport properties like evaporation, water absorption and moisture migration had been carried out in the laboratory and as per code provision only .Results of experiments on different properties of different mixes that replace fine aggregate with ferrous slag are shown.

The following conclusions are drawn from the investigation

- The replacement of fine aggregate with ferrous slag in concrete improves the environmental condition and economy too.
- Behaviour of the ferrous slag is very similar too the river sand.
- Fineness is more and its cohesiveness with granular slag is good
- Compressive strength is increased when it is replaced with 20% and further it may reduce.
- Split tensile property of the concrete has been constantly increased in this study as fiber added made large change in this. Slag has not affected the tensile property.
- The slag is similar to sand in all material properties so the transport properties also have not made any notable changes.
- The presence of more fineness and grained particles in slag the concrete had made a denser concrete. So there is no problem of permeability and cracks.
- Hence to conclude that slag usage in concrete as replacement to fine aggregate can be done with optimum percentages as per the investigation.
- Research can be carried out to explore the chemical properties of the concrete when slag is used.

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