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 CO_2 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 fiber 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 behavior 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 behavior of ferrous slag and polypropylene fiber in study strength and transport properties.

Keywords: Polypropylene Fiber, Industrial waste, Ferrous slag, HDPE, LDPE, ASTM

I. INTRODUCTION

1.1 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. 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. Such materials are widely used in the construction of industrial and chemical plants because of their enhanced durability compared with Portland cement. The other main advantage of using such materials is to reduce the cost of construction.

As for as fine aggregate is the concern so many researches are carried out for alternate material. Ferrous Slag is a by-product material produced from the process of manufacturing Iron. 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. The composition of Ferrous Slag is determined by that of the ores, fluxing stone and impurities in the coke charged into blast furnace. Similarly M-Sand also used as fine aggregate. M-Sand is processed from the crushed rock of gravel.

1.2 FERROUS SLAG

1.2.1 General

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. Now a days as the usage of iron increases tremendously which leading to a demand in iron manufacturing companies resulting to have the slag as basic waste product from iron industries. 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. Ferrous slag possesses mechanical and chemical characteristics that qualify the material to be used in concrete as a partial replacement for Portland cement or as a substitute for aggregates. For example, ferrous slag has a number of favourable 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. Utilization of ferrous slag in applications such as Portland cement substitution and/or as aggregates has threefold advantages of eliminating the costs of dumping, reducing the cost of concrete, and minimizing air pollution problems. So, ferrous slag content application in civil construction activites has been started globally in order to reduce environmental effects globally.

Figure 1.1 Sample of Ferrous slag

1.2.2 Manufacturing Process

In nature iron ore is found in impure state, often oxidized and mixed with other metals. During smelting, when the ore is exposed to high temperature, these impurities are separated from the molten metal and can be removed. Slag is the collection of compounds that are removed. In many smelting processes, oxides are introduced to control the slag chemistry, assisting in the removal of impurities and protecting the furnace refractory lining from excessive wear. In this case, the slag is termed synthetic.

Ferrous and non-ferrous smelting processes produce different slags. The smelting of ferrous and non-ferrous for instance, is designed to remove the iron and silica that often occurs with those ores, and separates them as iron-silicate-based slags. As the slag is channelled out of the furnace, water is poured over it. This rapid cooling, often from a temperature of around 2,600 °F (1,430 °C), is the start of the granulatingprocess. This process causes several chemical reactions to take place within the material, and gives the slag its cementinious properties.

The water carries the slag in its slurry format to a large agitation tank, from where it is pumped along a piping system into a number of gravel based filter beds. The filter beds then retain the slag granules, while the water filters away and is returned to the system. When the filtering process is complete, the remaining slag granules, which now give the appearance of coarse beach sand, can be scooped out of the filter bed and transferred to the grinding facility where they are ground into particles of desired size.

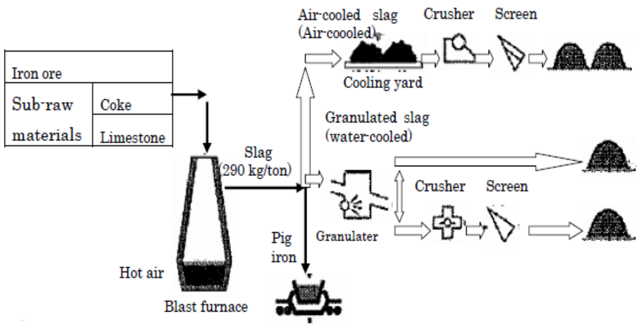


Figure 1.2 Ferrous Slag Production Process

The overall ferrous slag production process is explained as shown in the figure 1.2 which resulting to have slag content as final product of industrial waste obtained due to smelting process of iron in industries. As its disposal is typical and causes environmental effects it can be used as an alternative material of fine aggregates in a concrete mix.

1.2.3 Uses of Ferrous Slag

- They can be used as aggregates in the concrete mixing.
- Used as raw feed in the kiln to produce clinker.
- Slag cements are produced in large amounts.
- They can be used as base and surface materials.

Table 1.1: Chemical Composition of Slags (A Guide to the Use of Iron and Steel Slag in Roads. Revision 2, 2002)

1.3 POLYPROPYLENE FIBER

1.3.1 General

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. 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.

Figure 1.3 Sample of Polypropylene Fiber

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.

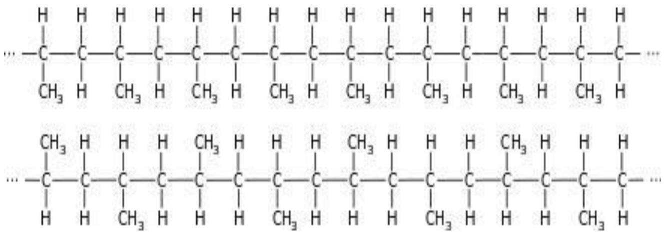


Figure 1.4 Polypropylene Monomer

1.3.2 Manufacturing Process

Polypropylene chips can be converted to fiber/filament by traditional melt spinning, though the operating parameters need to be adjusted depending on the final products. Spun bonded and melt blown processes are also very important fiber producing techniques for nonwovens. As an example, the staple fiber production is shown in following figure1.5.

It consists of following stages:

- Extruder
- Spinning pack
- Ouench duct
- Drawing tensioning
- Hot stretching
- Stabilising
- Crimper
- Cutter

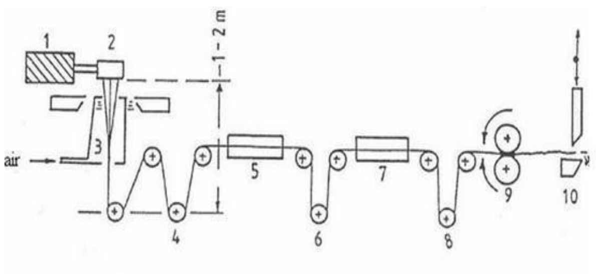


Figure 1.5 Manufacturing process of PPF

1.3.3 Advantages of Polypropylene Fiber

- PPF is a light fiber; its density (0.91 gm/cm³) is the lowest of all synthetic fibers.
- Mainly it reduces the micro plastic shrinkage
- It does not absorb moisture. This means the wet and dry properties of the fibre are identical.
- Low moisture regain is not considered a disadvantage because it helps in quick transport of moisture as is required in special applications like babies' ever-dry nappies.
- It has excellent chemical resistance. PPF is very resistant to most acids and alkalis.
- The thermal conductivity of PPF is lower than that of other fibres and may be used in applications as thermal wear.

1.4 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.

1.5 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 is considered.

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)

II. LITERATURE REVIEW

2.1 FERROUS SLAG

Ferrous Slag although is an industrial by product, exhibits well bonding properties. It permits very high replacement of sand and extends many advantages over conventional cement concrete. The utilization of Ferrous Slag as a sand replacement material is gaining importance due to its improved strength characteristics in concrete composites and also due to the economy achieved. The chemical composition of FS is similar to that of river sand. The performance of slag largely depends on the chemical composition, glass content and fineness of grinding. In India, we produce about 7.8 million tons of FS. All the FS is granulated by quenching the molten FS, although is an industrial by product, exhibits well bonding properties. It permits very high replacement of sand and extends many advantages over conventional cement concrete. The utilization of FS as a sand replacement material is gaining importance due to its improved slag by high power water jet, making 100% glassy slag granules of 0.4 mm size. Indian FS has been recently evaluated.

Exclusive research works have shown that the use of slag leads to the enhancement of intrinsic properties of concrete in both fresh and hardened conditions.

The major advantages are

- Reduced heat of hydration
- Refinement of pore structures
- Reduced permeability to the external agencies
- Increased resistance to chemical attack.

The above beneficial effect of slag will contribute to the many facets of desirable properties of concrete.

2.2 PRODUCTION OF FERROUS SLAG

The term 'ferrous slag' refers to the non-metallic molten material created during the production of hot metal and steel. After this material has slowly cooled in the air, it takes the form of artificial crystalline rock. The manner of its formation thus corresponds to that of natural volcanic rocks such as basalts. Slag can be used in a wide range of applications and is fundamentally different from ash, the residual material from combustion processes. Long ago, when iron working was just beginning, slag had to be beaten off the metal; and the German word for "beating" is "schlagen". Over time, this has evolved into the English word "slag". Today, slag is separated from the metal in the melt flow due to their different densities. The properties of slag are influenced in a targeted manner by a variety of measures taken during the production and cooling processes as well as during the subsequent treatment and processing.

Use of Iron Slag as Partial Replacement of Sand to Concrete

ChetanKhajuria, RafatSiddique

The environment problems are very common in India due to generation of industrial by-products. Due to industrialization enormous by-products are produced and to utilize these by-products is the main challenge faced in India. Iron slag is one of the industrial by-products from the iron and steel making industries. In this paper, the compressive strength of the iron slag concrete was studied. The results confirm that the use of iron slag overcome the pollution problems in the environment. The results shows that the iron slag added to the concrete had greater strength than the plain concrete.

The strength characteristics of concrete mixtures had been computed in the present work by replacing 10%, 20% and 30% iron slag with the sand. On the basis of recent testing, subsequent conclusions were drawn.

After adding 10% iron slag in the mix, there was an increase of 26% after 7 days, 50% increase after 28 days and 43% increase after 56 days as compared to the control mix. By adding 20% and 30% iron slag , there was large amount of increase in percentage i.e. 68%, 91%, 78% and 125%, 113% , 87% after 7, 28 and 56 days respectively.

Performance of Copper Slag and Ferrous Slag as Partial Replacement of Sand in Concrete

MeenakshiSudarvizhi. S, Ilangovan. R

The development of construction materials have posed problems and challenge that initiated worldwide research programs and continued conventional and non-conventional applications leading to ultimate economy. The use of Copper Slag (CS) and Ferrous Slag (FS) in concrete provides environmental as well as economic benefits for all related industries, particularly in areas where a considerable amount of CS and FS is produced. CS and FS ranging from 0% to 100%. The test results of concrete were obtained by adding CS and FS to sand in various percentages ranging from 0%, 20%, 40%, 60%, 80% and 100%. All specimens were cured for 7, 28, 60 & 90 days before compression strength test and splitting tensile test. The results indicate that workability increases with increase in CS and FS percentage. The highest compressive strength obtained was 46MPa (for 100% replacement) and the corresponding strength for control mix was 30MPa.

The integrated approach of working on safe disposal and utilization can lead to advantageous effects on the ecology and environmental also. It has been observed that up to 80% replacement, CS and FS can be effectively used as replacement for fine aggregate. Further research work is needed to explore the effect of CS+FS as fine aggregates on the durability properties of concrete.

Producing Portland Cement from Iron and Steel Slags and Limestone

MonshiA, Asgarani M.K. (1999)

Monshi and Asgarani (1999) producing Portland cement from iron and steel slags after magnetic separation are mixed with limestone of six different compositions. Samples with higher lime saturation factor developed higher C_3S content and better mechanical properties. Blending 10% extra iron slag to a cement composed of 49% iron slag, 43% calcined lime, and 8% steel slag kept the compressive strength of concrete above standard values for type I ordinary Portand cement. From the six different mixtures of limestone, blast-furnace slag, and converter slag, samples M_3, M_5, and M_6 showed relatively good mechanical properties. Cement M_3 was blended with 10% iron slag as in the Portland blast furnace cement, and compressive strengths of 140.3, 193.8, 333.3 kg/cm^2 were obtained after 3, 7, and 28 days, respectively. The bare minimum compressive strength of concrete for type I Portland cement according to ASTM C150-86 for 3, 7, and 28 days are 12, 19, and 28 MPa, respectively (about 120, 190, and 280 kg/cm2).

Reuse of Waste Iron as a Partial Replacement of Sand in Concrete

Ismail Z.Z, AL-Hashmi E.A.

Ismail and Hashmi (2007) reported that the waste iron was reused to partially replaced sand at 10%, 15%, and 20% in a concrete mixture. The tests performed to assess waste-iron concrete quality included slump, fresh density, dry density, compressive strength, and flexural strength tests. This work is functional for 3, 7, 14, and 28 days curing ages for the concrete mixes. The results show that the concrete mixes made with waste iron had higher compressive strengths. The compressive strengths of the concrete mixes made of 20% waste-iron aggregate increase by 22.60%, 15.90% and 17.40% for the 3, 7 and 28 days curing periods.

Thus resulting to notice an tremendous increase in compressive strength of concrete mix by replacing sand with waste of iron so called as slag. So, this alternative method is said to follow up an decrease in environmental side effects caused by disposal of waste into environment.

Mechanical and Durability Characteristics Of Concrete Containing EAF Slag As Aggregate

Pellegrino C, Gaddo V.

Pellegrino and Gaddo (2009) investigated natural aggregates of traditional concrete with Black/Oxidizing Electric Arc Furnace (EAF) slag. The concrete made with EAF slag as aggregate showed good strength characteristics in normal conditions and strength properties of the conglomerate containing EAF slag are totally comparable than those observed for traditional concrete (see Table 2.6). The compressive strength of cubes specimen with traditional and EAF slag aggregates after 7, 28 and 74 days shown in table as below. It is significant to observe that compressive strength stabilizes, after the first 28 days for traditional conglomerate whereas it continues to improve for the EAF slag one and thus EAF slag conglomerate aging appears to develop on a longer time than traditional conglomerate.

Table 2.1 : Compressive strength of average test specimens (Pellegrino and Gaddo, 2009)

Mix type	7 days	28 days	74 days
Traditional	25.3	32.5	30.4
With EAF slag	37.2	42.3	44.4

Properties of Concrete Containing Ground Granulated Blast Furnace Slag (GGBFS) At Elevated Temperatures

Siddique R, Kaur D. (2011).

Siddique and Kaur (2011*)* studied the properties of concrete containing ground granulated blast furnace slag (GGBFS) at elevated temperatures. The compressive strength of concrete mixtures decreased with the increase of GGBFS content at normal temperature (27˚ C) and 350˚C. At room temperature (27˚C), 28-day compressive strength of concrete containing 20%, 40% and 60% GGBFS was respectively 16.8%, 23.9% and 28.5% lower than the control mixture (34.8 MPa). The investigation states that at 28-days, with 0% GGBFS, the residual compressive strength of concrete at 100 ˚C dropped by 28.6% as compared to room temperature strength (34. MPa) and with 20% replacement of cement by GGBFS at 28-days, there is decrease in compressive strength by 11.8% at 100˚C and then an increase by 8% at 200˚C and another increase, by 15.6%, at 350˚C, as compared to room temperature strength (28.9 MPa). But at 40% and 60% replacements of cement with GGBFS at 28-days, the relative residual compressive strength did not change significantly with rises in temperature. After 56-days, the residual compressive strength decreased with the increase in temperature at all percentages of GGBFS. At 0% replacement, the residual compressive strength decreased by 21.9%, 29.9% and 16% at 100, 200 and 350 ˚C, respectively when compared to normal temperature strength (39.8 MPa).

Use of Blast Furnace Slag as an Alternative ofNatural Sand in Mortar and Concrete
PremRanjan Kumar, Dr.Pradeep Kumar T.B

Construction Industry plays a crucial role in the economic development of any country. In IndiaConstruction industry is the second largest after agriculture, contributes about 11% in the GDP. Construction industry is directly related with the consumption of cement in the world. India is the second largest cement producer in the world after China. Sand is a major material used for preparation of mortar and concrete and plays a important role in mix design. Sand is required about two times the volume of cement used in concrete construction. Hence the demand of natural sand is very high in developing countries to satisfy the rapid infrastructure growth. As demand of natural sand isincreasing day by day there is a need to find the new alternative material to replace the river sand, such that excess river erosion and harm to environment is prevented.

In this study alternatives of natural sand, blast furnace slag were evaluated for their suitability of replacing natural sand for making mortar and concrete. Blast furnace slag as by– product, which is a non–biodegradable waste material from that only a small percentage of it is used by cement industries to manufacture cement.. Mortar with proportions (1:4) for 0%, 25%, 50%, 75% and 100% replacement and concrete of M-20 and M-30 grades for 0%, 25%, 50%, 75% and 100% replacement cube were also prepared respectively. From this study it is observed that Blast furnace slag can be used as an alternative to natural sand up to 60% and 75% in mortar and concrete respectively.

2.3 POLYPROPYLENE FIBER
Performance of Polypropylene Fibre Reinforced Concrete
Milind V. Mohod

The paper deals with the effects of addition of various proportions of polypropylene fibers on the properties of High strength concrete (M30and M40 mixes). An experimental program was carried out to explore its effects on compressive, tensile, flexural strength under different curing condition. The main aim of the investigation program is to study the effect of Polypropylene fiber mix by varying content such as 0% ,0.5%,1%,1.5% & 2% and finding the optimum Polypropylene fibre content.

The concrete specimens were tested at different age level for mechanical properties of concrete, namely, cube compressive strength, split tensile strength, flexural strength. A detailed study was carried out for curing conditions. Half of the concrete specimens were left exposed to the surrounding to cure by themselves and the remaining half were cured in a curing tank. Initially the concrete specimen's shows appreciable strength for irregular curing but as the days advances the curing specimens gave satisfactory strength. A notable increase in the compressive, tensile and flexural strength was observed. However, further investigations were highly recommended and should be carried out to understand more mechanical properties of fibre reinforced concrete

Strength Prediction of Polypropylene Fiber Reinforced Concrete

Rana A. Mtasher, Dr.Abdulnasser M. Abbas &Najaat H. Nema (2011)

The main purpose of this investigation is to study the effects of polypropylene fiber on the compressive and flexural strength of normal weight concrete. Four mixes used polypropylene fiber weight with 0.4, 0.8, 1.0 and 1.5% of cement content. To provide a basis for comparison, reference specimens were cast without polypropylene fiber. The test results showed that the increase of mechanical properties (compressive and flexural strength) resulting from the addition of polypropylene fiber was relatively high. The increase in the test was about 64 percent for compressive strength, while, in flexural strength was about 55.5 percent.

Experimental Study for Flexure Strength on Polypropylene Fiber Reinforced Concrete

Miss KomalBedi

The study mainly involves in finding the flexure strength of a concrete mix when polypropylene fibers are added in it. The experimental programmed was under taken to test standard concrete beam of size 150 X 150 mm with a span 700 mm for studying strength in flexure. The sample were compared without any fiber and with polypropylenes fiber of intensity 0.89 kg per cum of concrete. To provide a basis for flexure, reference specimens were cast without polypropylene fiber. The test results showed that the mechanical properties of flexural strength resulting from added of polypropylene fiber was relatively high.

Comparative Study of Polymer Fibre Reinforced Concrete with Conventional Concrete Pavement

S.A Kanalli ,RamuPalankar , Bharath Kumar , Praveen Kumar , Prakash

A preliminary study on compressive strength, tensile strength and flexural using different proportions of polypropylene fibers resulted in a varying ratio of fiber dosage of 0.25 percent by volume of concrete. Concrete cubes of size 150mm x 150mm, having thickness of 150mm and cylinder of diameter 150mm and height of 300mm, both with PCC (plain cement concrete) and OPFRC (optimum fibre reinforced concrete) with experimental fibers were cast and tested for compression, tensile for 7 and 28 days of curing.

The short term compressive strength test was carried out to study if there is any reduction in strength due to possible degradation of the fibers in the concrete's alkaline environment. A concrete beam of size 150mm x 150mm x 700 mm were casted and tested for flexural strength after 7 and 28 days.

PFRC can be used advantageously over normal concrete pavement. Polymeric fibers such as polyester or polypropylene are being used due to their cost effective as well as corrosion resistance. PFRC requires specific design considerations and construction procedures to obtain optimum performance. The higher initial cost by 15-20% is counterbalanced by the reduction in maintenance and rehabilitation operations, making PFRC cheaper than flexible pavement by 30-35%. In a fast developing and vast country like India, road networks ensure mobility of resources, communication and in turn contribute to growth and development. Resistance to change though however small disturbs our society hence we are always reluctant to accept even the best. It's high time that we overcome the resistance and reach for the peaks.

Strength Properties of Polypropylene Fiber Reinforced Concrete

Kolli.Ramujee

The interest in the use of fibers for the reinforcement of composites has increased during the last several years. Acombination of high strength, stiffness and thermal resistance favourably characterizes the fibres. In this study, the results ofthe Strength properties of Polypropylene fiber reinforced concrete have been presented. The compressive strength, splittingtensile strength of concrete samples made with different fibers amounts varies from 0%, 0.5%, 1% 1.5% and 2.0% werestudied. The samples with added Polypropylene fibers of 1.5 % showed better results in comparison with the others.

Study on Residual Properties of Polypropylene Fiber Reinforced Concrete under Elevated Temperatures

Sheba Sam, M. Perarasan, Dr. D. Suji

High temperature can cause the development of cracks which may eventually cause loss of structural integrity and shorting of service life. As the concrete used for special purpose, the risk of exposing it to high temperature also increases. Polypropylene fibre reinforced concrete is one such innovation that an experimental program is carried out using different volume fraction of 0%, 0.2%, 0.4%, and 0.6% to find the fire resistance characteristics. Beams of size 500x100x100 mm size where used to find the flexural behaviour change under 1000C, 2000C, 3000C. Experiment shows that addition of polypropylene fibres enhances the flexural behaviour of concrete compared to concrete without fibres. In this paper the results of fractural resistance of PPFRC is presented.

Applications and Properties of Fibre Reinforced Concrete
Amit Rai1, Dr. Y.P Joshi

In conventional concrete, micro-cracks develop before structure is loaded because of drying shrinkage and other causes of volume change. When the structure is loaded, the micro cracks open up and propagate because of development of such micro-cracks, results in inelastic deformation in concrete. Fibre reinforced concrete (FRC) is cementing concrete reinforced mixture with more or less randomly distributed small fibres. In the FRC, a numbers of small fibres are dispersed and distributed randomly in the concrete at the time of mixing, and thus improve concrete properties in all directions.

The fibers help to transfer load to the internal micro cracks. FRC is cement based composite material that has been developed in recent years. It has been successfully used in construction with its excellent flexural-tensile strength, resistance to spitting, impact resistance and excellent permeability and frost resistance. It is an effective way to increase toughness, shock resistance and resistance to plastic shrinkage cracking of the mortar thus increasing its durability and workability property of concrete mix.

These fibers have many benefits. Steel fibers can improve the structural strength to reduce in the heavy steel reinforcement requirement. Freeze thaw resistance of the concrete is improved. Durability of the concrete is improved to reduce in the crack widths. Polypropylene and Nylon fibers are used to improve the impact resistance. Many developments have been made in the fiber reinforced concrete in order to use it in concrete mix to increase its workability and strength property in present situation of tremendous usage of concrete mix globally day to day.

Improvements in Concrete Properties by Polymer Fibers are:

- ✓ **Compressive strength** –Increased about 16 %
- ✓ **Split strength** –It is improved up to 23%
- ✓ **Flexural Strength** – Increased about 30%
- ✓ **Abrasion resistance–** Increased up to 20 – 50%
- ✓ **Toughness-** Increases of 15%
- ✓ **Permeability -** Improved, permeability decreases of 33% to45%by inclusion of fiber.

Some considerable facts found are:

- ✓ Fiber addition improves ductility of concrete and its post-cracking load-carrying capacity.
- ✓ Fibre reinforced concrete requires large quantities of fibres in order to make a difference regarding resistance.
- ✓ Fiber addition improves ductility of concrete and its post-cracking load-carrying capacity.
- ✓ There has been significant interest and development in the use of continuous fiber reinforcement for improving the behaviour of concrete.
- ✓ Fiber Reinforced Polymers (FRP) or sometime also referred to as Fiber Reinforced Plastic are increasingly being accepted as an alternative for uncoated and epoxy-coated steel reinforcement for pre-stressed and non-Pre-stressed concrete applications.
- ✓ The most important contribution of fiber reinforcement in concrete is not to strength but to the flexural toughness of the material.
- ✓ Plain concrete fails suddenly once the deflection corresponding to the ultimate flexural strength is exceeded, on the other hand, fiber-reinforced concrete continue to sustain considerable loads even at deflections considerably in excess of the fracture deflection of the plain concrete.
- ✓ In FRC crack density is increased, but the crack size is decreased.The addition of any type of fibers to plain concrete reduces the workability.
- ✓ Fiber-reinforced concrete is generally made with a high cement content and low water/cement ratio.

Mechanical properties of polypropylene hybrid fiber-reinforced concrete

Machine Hsie, ChijenTu, P.S. Song

The investigation on mechanical properties for polypropylenehybridfiber-reinforced concrete. Thereare two forms of polypropylene fibers including coarse monofilament, and staple fibers. The content of theformer is at 3 kg/m^3, 6 kg/m^3, and 9 kg/m^3, and the content of the latter is at 0.6 kg/m^3. The experimentalresults show that the compressive strength, splitting tensile strength, and flexural properties of thepolypropylene hybrid fiber-reinforced concrete are better than the properties of single fiber-reinforcedconcrete. These two forms of fibers work complementarily. The staple fibers have good fineness anddispersion so they can restrain the cracks in primary stage. The monofilament fibers have high elasticmodulus and stiffness. When the monofilament fiber content is high enough, it is similar to the functionof steel fiber. Therefore, they can take more stress during destruction. In addition, hybrid fibers dispersethroughout concrete, and they are bond with mixture well, so the polypropylene hybrid fiber-reinforced concrete can effectively decrease drying shrinkage strain.

Polypropylene hybrid fiber-reinforced concrete utilizes twocomplementary fibers to improve the properties of concrete, andthe performance of hybrid fiber-reinforced concrete is betterthan that of single fiber-reinforced concrete. Comparing with thestrengths of pure concrete, the compressive strength of polypropylenehybrid fiber-reinforced concrete increased by 14.60–17.31%;the splitting tensile strength did by 8.88–13.35%; modulus of rupturedid by 8.99–24.60%.Adding polypropylene hybrid fibers to concrete can increasetoughness index, and the more the fiber content is, the highertoughness index is. Adding monofilament fibers at 9 kg/m3 tohybrid fiber-reinforced concrete, the values of respective mixes are3.58, 6.91, and 15.23, respectively. In addition, polypropylene hybridfiber-reinforced concrete also can lower drying shrinkage strain andranged from 0.862 to 0.871.

III. METHODS AND MATERIAL

This chapter explains about the materials and its properties. It also includes mix proportions and mixing.

3.1 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.

Figure 3.1. Cement

3.2 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.

3.2.1 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.

Figure 3.2 Coarse Aggregate

3.2.2 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.

Figure 3.2.1 Fine Aggregates

3.3 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.

Figure 3.3 Ferrous Slag

3.4 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.

Figure 3.4 Polypropylene Fibre

3.5 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 3.1: 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 3.2: Chemical Properties of Cement

S.no	Particulars	Test results	Specification as per IS:12269:1987
1	LSF(Lime Saturation factor)	0.89	0.8-1.02
2	Alumina Modulus	0.83	Min 0.66
3	Insoluble residue (%)	1.48	Max 3.0
4	Magnesia (%)	1.46	Max 6.0
5	Sulphuric Anhydride (%)	2.06	Max 3.0
6	Loss on Ignition (%)	1.58	Max 4.0
7	Chloride Content (%)	0.009	Max 0.1

Table 3.3: 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 3.4: 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 3.5: 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

Table 3.6: Chemical Properties of Ferrous Slag

Sl.no	Particulars	Percentage
1	Cao	36.35
2	Mgo	9.59
3	Al_2O_3	16.21
4	SO_3	1.78
5	SiO_2	35.20
6	Fe_2O_3	0.56

Ferrous slag content is an industrial waste product obtained after the smelting process of the cast iron. As there is a tremendous increase in demand of construction activites now a days , the demand for cement and aggregates usage also increases day to day. So natural aggregates such as river sand usage increases which resulting to have a depletion of sand.

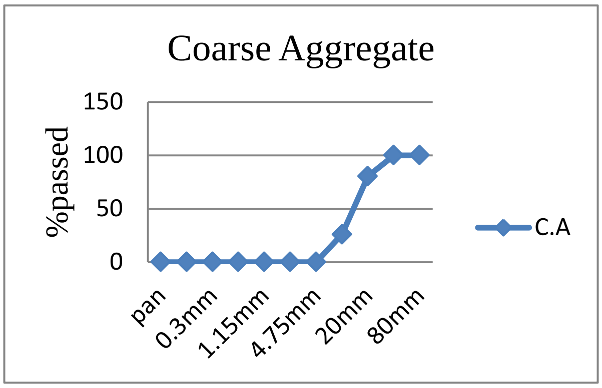
By considering the properties of ferrous slag as shown in table 3.5 & 3.6 the grading will falls under zone -2, with a fineness modulus of 3.06, specific gravity of 3.4 and it was having a water absorption property of 4 %.

Table 3.7: Sieve analysis of coarse aggregates
Weight of sample taken = 5000 gm

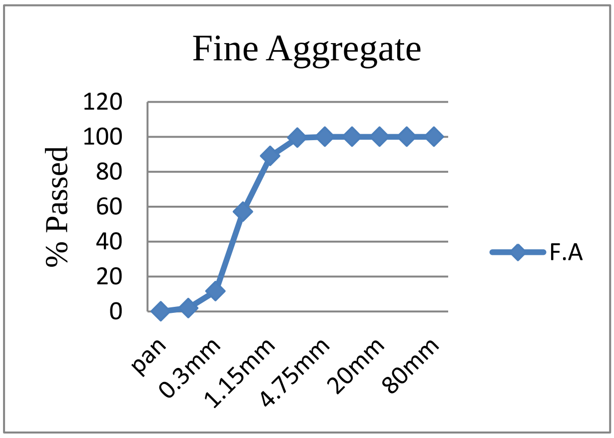
S. no	I.S .Sieve designation	Weight of sample retained	Cumulative weight retained	Cumulative % age retained	%age passed.
1	80 mm	0	0	0	100
2	40 mm	0	0	0	100
3	20 mm	980	980	19.6	80.4
4	10 mm	2972	3952	79.04	25.96
5	4.75 mm	1048	5000	100	0
6	2.36 mm	-	-	100	0
7	1.18 mm	-	-	100	0
8	0.6mm	-	-	100	0
9	0.3mm	-	-	100	0

10	0.15mm	-	-	100	0
11	Pan	-	-	100	0
Total			798.6		

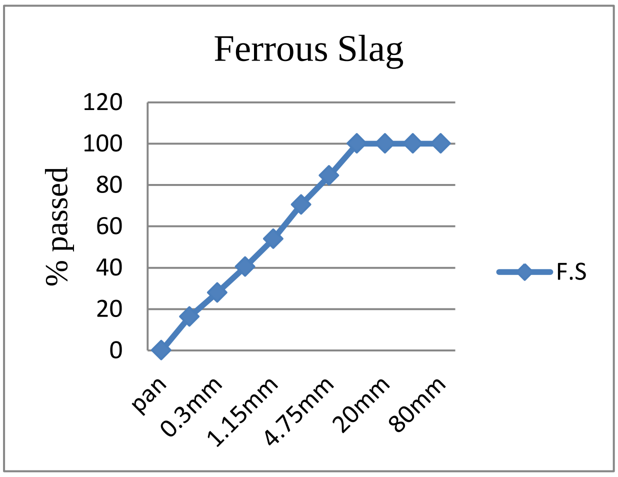
Graph 3.1: Sieve Analysis for Coarse Aggregates



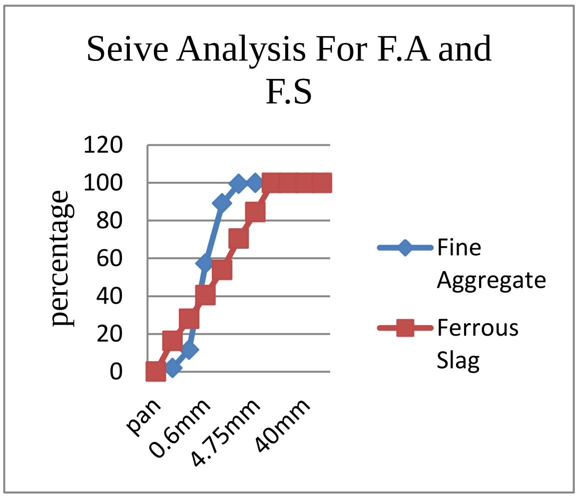
Graph 3.2: Sieve Analysis for Fine Aggregates



Graph 3.3: Sieve Analysis for Ferrous Slag



Graph 3.4: Sieve Analysis for Ferrous Slag and Fine Aggregates



When we come across the graph that showing the comparision between sieve analysis of river sand and ferrous slag we can notice some important things. They are:

A. As it indicates that the river sand is lower than the ferrous slag initially in yne curve.
B. The presence of the percentage of fines is more in the ferrous slag that the curve is in the same angle where river sand has crossed at 300 microns.
C. When the fines are more in the aggregate that we use commonly the water absorption also increases
D. So more water is to be used, as in this study we had got the water absorption percentage as 4%.
E. Similarly we can notice the increase in the density and specific gravity of the slag than the normal sand.
F. The more fines will combine with the granulars and gives a good grading.
G. So there will not be any gaps and cracks occurring possibility.

3.6 Mix proportioning :

There are various methods of mix proportioning .Mix proportioning was based on the water cement ratio (water/cement) and the density of the concrete is 2400kg/m^3. Quantity of water is taken according to slump of concrete 0.5 for economical purpose. The quantity of cement i.e, 350 kg/m^3 used. Therefore quantity of water should be 175kg/m^3. For fine and coarse aggregate absorption of water in additional 1 % and 0.8% of water was used. The quantity of aggregates is taken based on the aggregate grading curve is selected. The quantity of fine aggregates used is 646kg/m^3, coarse aggregates is 1229kg/m^3, the quantity of 20mm and 12mm are 502kg/m^3 and 727kg/m^3.

For the investigation purpose the fine aggregates replaced with Ferrous Slag and in percentage relatively 0, 0, 20, and 50 percent for the mixes M_1, M2, M3 andM4respectively and to the weight of cement 0.5% of Polypropylene Fiber are added to Mixes M2, M3, and M4.

Table 3.10: Mix Proportions:

Mix	**Cement**	**C.A 12 mm**	**C.A 20 mm**	**FineAggregate**	**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

3.7 Specimen Details:

The specimens like cubes, cylinders and beams that are used to conduct the strength tests are taken according toIS10086-1982.

Compression strength = cube moulds of 150mmX150mmX150mm are used.

Split tensile strength = cylindrical moulds of 100dia at 200mm height are used.

3.8 Casting of specimens:

After completion of the workability tests, the concrete has been placed in the standard metallic moulds in three layers and has been compacted each time by tamping rod. Before placing the concrete inside faces of the mould are coated with the machine oil for easy removal afterwards. The concrete in the moulds has been finished smoothly. The casted specimens are shown in Figure 3.7.

Figure 3.5 Cube moulds

3.9 Curing Procedure:

After casting the cubes and cylinders the specimens the moulds are kept in air curing for one day and the specimen are removed from the moulds after 24 hours of casting of concrete specimens. Markings have been done to identify the different percentages of ferrous slag specimens. Then specimens were kept for normal water curing until testing age.

Figure 3.6 Cubes CastedFig 3.7Cylinders Casted

IV. RESULTS AND DISCUSSION

co In this chapter it is detailed about the tests conducted on the concrete. Mainly they explain the basic strength properties and the transportation properties. The tests conducted in our investigation are:

1. Compressive Strength Test
2. Split Tensile Strength Test
3. Evaporation test.
4. Absorption test.
5. Moisture migration test.

4.1 COMPRESSIVE STRENGTH TEST:

Compression test is done confirming to IS: 516-1953. All the concrete specimens that are tested in a 2000KN capacity Compressive-testing machine. Concrete cubes of size 150mm x 150mm x150mm and cylinders of size 100mm diameter& 200mm height were tested for crushing strength, crushing strength of concrete was determined by applying load at the rate of 1400 N/cm^2/min till the specimens fail. The maximum load applied to the specimens was recorded and divided the failure load with cross-sectional area of the specimens for compressive strength has been calculated.

Compressive Strength of concrete=**Load/Area** ------→ Equ.1

Compressive strength test was conducted on cubes of 150mmX150mmX150mm cubes for the various mixes M1, M2, M3 and M4 of concrete. The details about the loading and strength of the specimens are given in the table 4.1 and 4.2.

Figure 4.1Compression Test

Table 4.1: Compressive strength load details

Compressive Load details of specimen of various mixes in KN							
Mix	cubes	3 days		7 days		28 days	
		Load	avg	Load	avg	Load	avg
M1	1	260	260.33	530	531.66	620	645
	2	255		545		650	
	3	266		520		665	
M2	1	287	275.33	575	555	680	673.33
	2	272		545		650	
	3	272		545		690	
M3	1	267	277.66	535	556.66	590	643.33
	2	264		530		690	
	3	302		605		650	
M4	1	267	238.66	535	478.33	550	496.66
	2	199		400		480	
	3	250		500		460	

4.2 SPLIT TENSILE STRENGTH TEST:

The cylinders were subjected to split tensile tension by replacing them horizontally on the failure in the 2000KN CTM. The load is applied uniformly at a constant rate until failure by splitting along the vertical diameter takes place load at which the specimens failed is recorded and the splitting tensile stress is obtained using the formula based on *IS: 5816-1970.*

$F_t = 2P/\pi DL$ -------------→Equ.2

Where P = Compressive load on the cylinder

L = Length of the cylinder D = Diameter of the cylinder

Split tensile strength has done for the mixes M1, M2, M3, and M4 of concrete for 1 day, 7 days and 28 days. The test has conducted on the cylinder of 100mmX200mm. The details about the loading and strength of the specimens are given in the table 4.3 and 4.4.

5.1 COMPRESSIVE STRENGTH

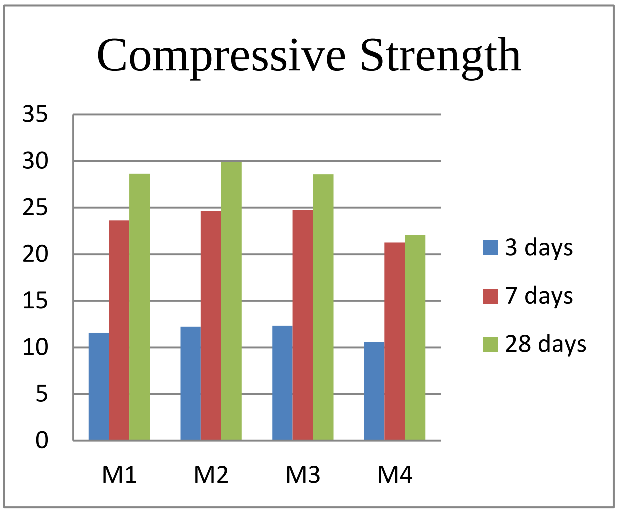
Table 5.1 Compressive Strength of different mixes

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 5.1 Compressive Strength of different mixes

Compression test is most commonly conducted test as it is the most desirable characteristic property of the concrete that is to be acheived.In this investigation totally 36 cube moulds of size 150*150*150 were tested for knowing compressive strength of different mixes at 3 days , 7days, and 28 days.

Comparision between the strengths of different mix proportions:



- In the 3 days strength results the compressive strength has been increasing till the 20% of the ferrous slag mix.
- At 0% of ferrous mix the strengths were 11.57 and 12.23 and when it was 20% then it increased to 12.34.
- The strength has been reduced when 50% slag is added. This has been repeated in all the periods of testing.
- As the strength parameters in the 7 days test had been increasing till the slag was 20% and then the strength reduced when the slag had replaced by 50%.
- The results at 7 days for 0% and 20% have increased the strength from 24.66 mpa to 24.75 mpa.
- In this investigation it shows that the strength parameters of the 28 days had been finally made small variations in the mix proportions 0% and 20%.
- The results at 28 days for 0% and 20% have increased the strength from 28.66 mpa to 29.92 mpa.
- As the 28 days strength should achieve 20mpa and in the results we can observe that the strength of all the mix ratio of slag has been achieved the strength of the M20 grade mix.
- So we can make the proportion of all the mentioned mix ratios of the slag as the replacement of the Fine aggregates.

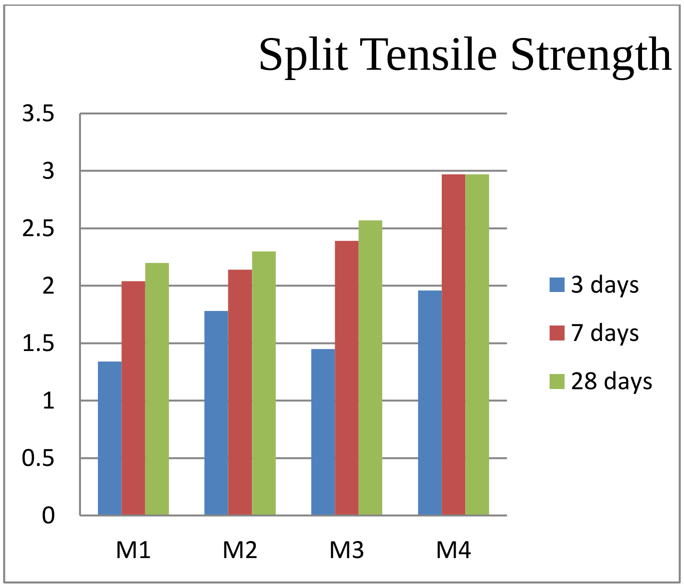
- As it is mentioned as slag as an inert material it can be used as the replacement to the fine aggregate at the places where the slag is available.

5.2 SPLIT TENSILE STRENGTH

Table 5.2 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 5.2 Split Tensile Strength of different mixes



Direct measuring of the tensile strength of concrete is difficult. Neither specimen nor testing apparatus have been designed which can assure uniform distribution of pull is applied to the concrete. Many tests are made by finding out the flexural strength by making the beam moulds. In the present case the tensile strength is found by and indirect method that is Cylinder Split Tension Test.

Split Tensile test is conducted on the cylinders of the sizes in ratio 1:2 to the diameter and length of the specimen. In this investigation totally 36 cylindrical moulds of size 100mm x 200 mm were tested for knowing Split tensile strength of different mixes at 3 days , 7days, and 28 days.

Comparision between the strengths of different mix proportions:

- As we know that concrete is strong in compression and weak in tension.
- Generally it is noted that Tensile strength must achieve 10% of compressive strength, as all the results have achieved the result.
- At 0% of fiber mix the strength is 1.74 when it was 0.5 then it increased rapidly 1.78 in the 3 days result.
- As the strength parameters in the 7 days test had been increasing constantly in the slag has been increased the tensile strength increased from 2.04 to 2.97.
- The results at 7 days for 0% and 0.5% have increased the strength from 2.04 to 2.14.
- In this investigation it shows that the strength parameters of the concrete can be increased by adding the fiber content to the concrete.
- In all the periods and when the fiber is added to the concrete the split tensile strength has been increased.
- As there are many fibers present in the present world and many of they are produced by the waste of the plastics and resins.
- We can make use of the fibers to increase the tensile property of the concrete and it can also serve as the substitute material for the steel provided in the reinforced cement concrete.

V. 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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