Strength Characteristics of Concrete Mix by Replacing Fine Aggregates with Industrial Sand

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Abstract- Presently large amount of industrial sand are generated from metal industries. The Disposal of Industrial Sand is an important issue as it has direct impact on environment. In the present study the feasibility of using Industrial sand (I.S.) as a partial replacement of fine aggregates for the production of concrete has been explored.

The present study is conducted to investigate the effects of replacement of fine aggregates with the percentage of industrial sand from 0% to 50% in steps of 10% on the compressive strength, splitting tensile strength and flexural strength of concrete M20. In the present study 72 cube specimens (150mm x 150mm x 150mm), 72 cube specimens (150mm x 150mm x 150mm), 72 cylindrical specimens (150mm x 300mm) and 72 beams specimens (100mm x 100mm x 500mm) have been cast to determine compressive strength, splitting tensile strength (cylindrical and cubical specimens) and flexural strength of concrete mixes at curing age of 7 days, 14 days, 28 days and 56 days. A total of 288 specimens have been cast to determine compressive

Index Terms- Industrial sand, Compressive strength, splitting tensile strength and flexural strength.

I. INTRODUCTION

The three basic ingredients of concrete are aggregate, cement, water. Cement is the fixture that binds the ingredients together, water gives the concrete viscosity in order to be molded and react with the ingredients, and the aggregates are what adds bulk to the concrete, but are not involved in the chemical processes.

The compressive strength, splitting tensile strength and flexural strength is often considered as the sole criterion for approving a concrete mix. With increasing incidences of concrete deterioration, and increasing demand for durable structure, compressive strength alone cannot be considered as the sole criterion for evaluating the quality of concrete. Concrete is now specified in terms of both strength and durability. It is assumed that higher the compressive strength of concrete, better would be its durability. However, this assumption is not always true. A concrete mix satisfying the required strength may not necessarily be durable.

In the industry whenever there will be a relative motion between the casted products i.e. (cast iron) and grinding wheel i.e. (aluminum oxide). There will be a fine clips will came out as residue of the process that will acts as a waste and I just want to use this industrial sand as binding material.

Industrial sand is fine mixture of Cast iron and grinding wheel. Cast iron is iron or a ferrous alloy which has been heated until it liquefies, and is then poured into a mould to solidify. It is usually made from pig iron. Grinding wheel is made up of natural or synthetic minerals bonded together in a matrix to form a wheel. It is a finely divided residue combined fine product of cast iron and grinding wheel collected or precipitated from the metal factory

II. LITERATURE REVIEW

1) Siddique (2003) used mix design M-20 grade of concrete to study the effect of the results of an experimental investigation carried out to evaluate the mechanical properties of concrete mixtures in which fine aggregate (sand) was partially replaced with Class F fly ash.
2) Aggarwal etal.(2007)studied the effect of the experimental investigations carried out to study the effect of use of bottom ash (the coarser material, which falls into furnace bottom in modern large thermal power plants and constitute about 20% of total ash content of the coal fed in the boilers) as a replacement of fine aggregates.
3) Phani Madhavi, Sampathkumar and Gunasekaran (2010) used mix design M-30 grade of concrete to study to find out the effectiveness of the fly ash and glass aggregate based concrete. In this investigation it was proposed that the use fly ash as cement replacement material and glass aggregate as fine aggregate material partially in Concrete.
4) Chandrasekar and Kumar (2010) studied the effect of Disposal of used Plastics is a major problem in the present era, as the usage of plastics is growing day by day and it takes hundreds of years for plastic material to degrade.
5) Brindra and Nagan (2010) studied the potential use of granulated copper slag from Sterlite Industries as a replacement for sand in concrete mixes. The effect of replacing fine aggregate by copper slag on the compressive strength and split tensile strength are attempted in this work.
6) Gautam, Srivastava and Agarwal (2012) studies that the use of recycled glass helps in energy saving. The increasing awareness of glass recycling speeds up inspections on the use of waste glass with different forms in various fields. One of its significant

contributions is to the construction field where the waste glass was reused for concrete production.

7) Deshpande, Kulkarni and Pachpande (2012) used mix design M-25 grade of concrete to study the effect of a Recycled aggregates as fine aggregates in place of sand. They made an attempt to utilize recycled concrete aggregates and artificial sand (machine made sand) in concrete, using IS10262:2009 as guideline for designing the concrete with grade M25.

III. Experimental Program

3.3.1 Cement

The cement use for the experimental studies was ACC 43 Grade OPC as per the specifications of Indians Standards Code IS: 8112-1989. It was fresh and without any lumps. The various test performed on the cement and their values are shown in the Table 3.1 Cement was carefully stored to prevent deterioration in its properties due to contact with the moisture.

Table 3.1: Physical properties of cement.

S. No.	Properties	Observation	Codal Requirements IS:8112-1989 (Part 1)
1	Fineness (90 micron IS Sieve)	2 %	10% (Maximum)
2	Specific gravity	3.12	3.15
3	Soundness	2 mm	
4	Initial setting time	65 minutes	30 (Minimum)
4	Final setting time	370 minutes	600 (Maximum)
6	Standard consistency	34 percent	
7	3-days compressive strength	24.70 MPa	23 (Minimum)
	7-days compressive strength	35.90 MPa	33 (Minimum)
	28-days compressive strength	44.85 MPa	43 (Minimum)

3.3.3 Fine aggregate

River sand was used as fine aggregate. The particle size distribution and other physical properties of the fine aggregates are listed in Table 3.2 respectively. Lumps of clay and other foreign matter were separated out before using it in concrete.

Table 3.2 Sieve Analysis of Fine Aggregates (as per IS: 383- 1970)

S.NO	I.S. Sieve (mm)	Weight Retained	Cumulative retained	%age Cumulative retained	%age passing	Limit
1	10	----	----	----	100	100
2	4.75	52	52	2.6	97.40	90-100
3	2.36	60	112	5.6	94.4	85-100
4	1.18	192	304	15.2	84.8	75-100
5	600 μ	212	516	25.8	74.2	60-79
6	300 μ	992	1508	75.4	24.6	12-40
7	150 μ	444	1952	97.6	2.4	0-10
8	Pan	48	2000	----	$\sum$ 2.22	
Fineness modulus of fine sand = 2.22						

The Fine aggregates belongs to Zone III as per Table 3.2, I.S. 383-1970

Table 3.3 Physical properties of fine aggregates

Specific Gravity of Fine Aggregates	2.727
Water Absorption	1%

3.3.4 Coarse aggregate

Coarse Aggregates used was a mixture of two crushed stones of 10mm and 20mm size in 50:50 proportions. The sieve analysis properties of coarse aggregates satisfied the requirement of IS: 383-1970 and the results are given in table 3.4 and table 3.5 respectively.

Total weight of 10mm aggregates = 2000gm

Table 3.4: Proportioning of Coarse aggregates

S.NO	IS Sieve Designation	Cumulative %age passing of 10mm aggregates	Cumulative %age passing of 20mm aggregates	Proportion 50:50 (10mm:20mm)	IS:383-1970
1	80	100	100	100	100
2	40	100	100	100	100
3	20	100	97.5	98.75	95-100
4	10	82.5	.25	41.375	25-55
5	4.75	7.5	.2	3.85	0-10

Table 3.5: Physical Properties of Coarse Aggregates

Specific Gravity of Coarse Aggregates	2.76
Free Moisture Content	Nil
Water Absorption	0.5%
Fineness Modulus (20mm)	7.02
Fineness modulus (10mm)	6.1

3.3.6 Industrial waste

Industrial waste is fine mixture of Cast iron and grinding wheel Cast iron is iron or a ferrous alloy which has been heated until it liquefies, and is then poured into a mould to solidify. It is usually made from pig iron. Grinding wheel is made up of natural or synthetic minerals bonded together in a matrix to form a wheel. It is a finely divided residue combined fine product of cast iron and grinding wheel collected or precipitated from the metal factory. In present study the Fine aggregates has been replaced with 0%, 10%, 20%, 30%, 40% and 50% of Industrial sand content. Specific gravity of Industrial waste calculated is 2.85.

Table 3.6: Sieve analysis of industrial waste.

S.NO	IS Sieve Designation	Wt retained On Sieve (gm)	Cumulative weight (gm)	Cumulative% age Retained	%age Passing	IS:383-1970
1	10	0	……..	……	100	
2	4.75	60	60	3	97	
3	2.36	220	280	14	86	
4	1.18	320	600	30	70	
5	600 mic	480	1080	54	46	
6	300mic	530	1610	80.5	19.5	
7	150	140	1750	87.5	12.5	
8	pan	250	2000	2.69…….		
Fineness modulus of industrial waste = 2.69						

Table 3.7 Chemical properties of Cast iron

Constituents of Cast iron	Constituents present in Cast iron %
Grade	HT 100
Carbon (C)	3.4-3.9%
Manganese (Mn)	0.5-0.8%
Silicon (Si)	2.1-2.6%
Phosphorus (P)	0.3%
Sulphur (S)	0.15%

3.4 MIX DESIGN

The design mix involves determination of the proportions of the given constituents namely cement, water, coarse aggregates and fine aggregates , if any which produce concrete possessing specified properties both in the fresh and hardened states with maximum overall economy. Workability is specified as the important property of concrete in fresh state; for hardened state compressive strength durability are important. The mix design is therefore, generally carried out for a particular compressive strength of concrete with adequate workability so that fresh concrete can be properly placed and compacted, and achieves the required durability.

Table 3.9 Values of Different Materials Used (Kg/m^3)

Mix Name	Cement kg	Industrial Waste(kg)	Water (L)	Fine Aggregate (kg)	Coarse Aggregate(kg)	W/C ratio
MX0	358.1	Nil	197.16	695	1196	0.55
MX10	358.1	69.5	197.16	625.5	1196	0.55
MX20	358.1	139	197.16	556	1196	0.55
MX30	358.1	208.5	197.16	486.5	1196	0.55
MX40	358.1	278	197.16	417	1196	0.55
MX50	358.1	347.5	197.16	347.5	1196	0.55

3.5 SPECIMEN DETAILS

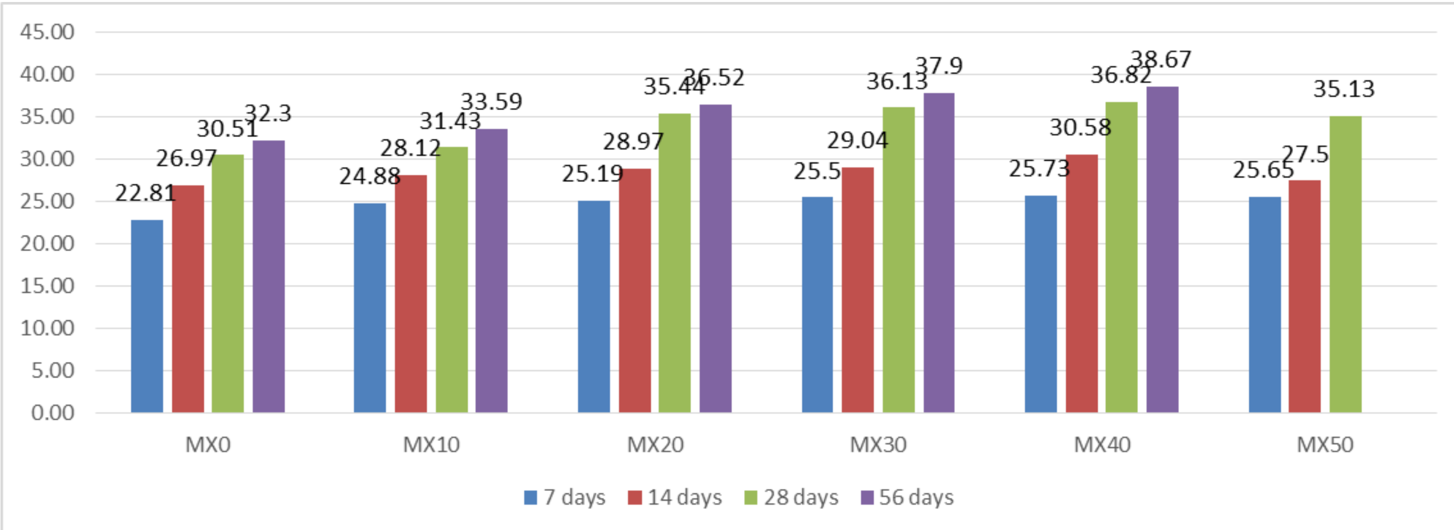
Cube specimens of size 150 mm x 150 mm x 150 mm were used for Compressive strength of concrete and also for split tensile strength of cubes, whereas cylinder specimens with 150 mm diameter and 300 mm depth used split tensile strength and beams of size 100 mm x 100 mm x 500 mm were used for flexural strength.

3.6 CASTING AND CURING

The casting of the specimens was done under laboratory conditions using standard equipment (Fig. 3.2). Each batch consisted of three standard cubes for compression Test, three cylinders of 150 mm diameter and 300 mm depth for split tensile strength, and three beams of 100*100*450mm for flexural strength of concrete.144 standard cubes for determination of 7 days, 14 days, 28 days, and 56 days compressive strength and split tensile strength of cube, 72 cylinders for determining of 7 days, 14 days,28days, and 56 days tensile strength and 72 beams for determining of 7 days, 14 days, 28days, and 56 days flexural strength of each batch respectively.

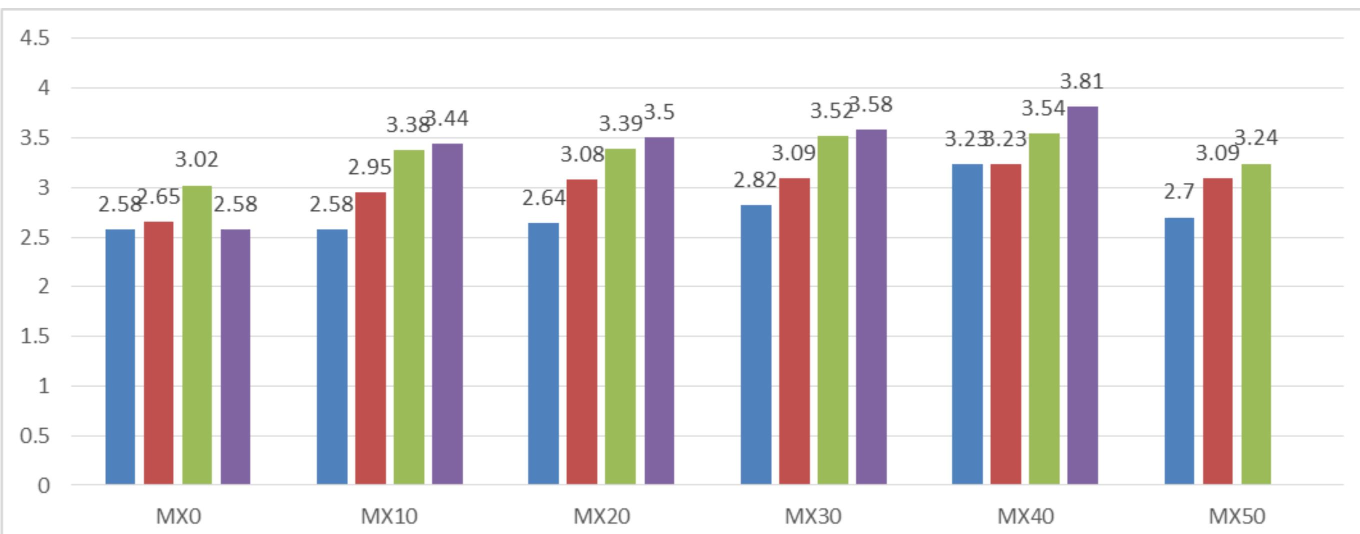
COMPRESSIVE STRENGTH TEST RESULTS

The results of the compressive strength tests conducted on concrete specimens of different mixes cured at different ages are presented and discussed in this section. The compressive strength test was conducted at curing ages of 7, 14, 28, and 56days. The compressive strength test results of all the mixes and different curing ages are shown in Table-4.2-4.5.Variation of compressive strength of all the mixes cured at 7, 14, 28, and 56 days is also shown in Figs. 4.2 to Fig. 4.5.



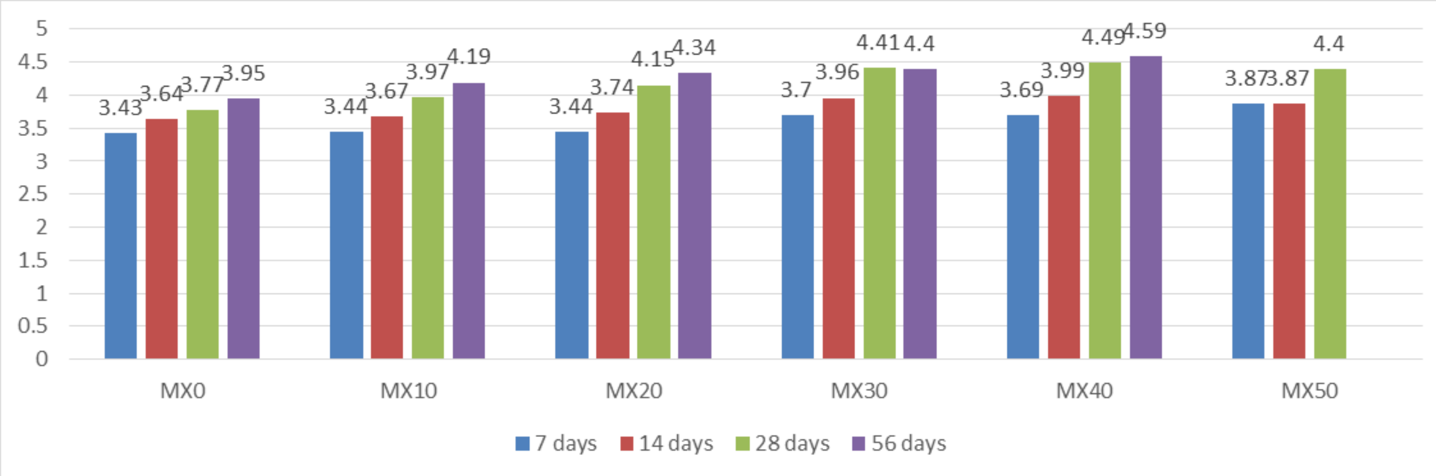
SPLITTING TENSILE STRENGTH TEST RESULTS

The results of the splitting tensile strength tests conducted on concrete specimens of different mixes cured at different ages are presented and discussed in this section. The splitting tensile strength test was conducted at curing ages of 7, 14, 28 and 56 days. The splitting tensile strength test results of all the mixes and different curing ages are shown in Table-4.6-4.9.Variation of splitting tensile strength of all the mixes cured at 7, 14, 28 and 56 days is also shown in Figs. 4.8 to 4.13.



FLEXURAL STRENGTH TEST RESULTS

The results of the flexural strength tests conducted on concrete specimens of different mixes cured at different ages are presented and discussed in this section. The flexural strength test was conducted at curing ages of 7, 14, 28, and 56 days respectively. The Flexural strength test results of all the mixes and different curing ages are shown in Table-4.9-4.12.Variation of splitting tensile strength of all the mixes cured at 7, 14, 28 and 56 days is also shown in Figs. 4.10 to 4.13.



IV. CONCLUSION

1. The results obtained in the present investigation that it is feasible to replace the fine aggregates by industrial waste for improving the strength characteristics of concrete, thus the industrial waste can be used as an alternative material for the production of concrete to address the waste disposal problems and to minimize the cost of construction with usages industrial waste which almost freely available in metal factory.
2. With the partial replacement of sand by industrial waste the compressive strength of concrete increased up to 40% replacement at curing age of 7 days, 14 days, 28 days and 56 days. The compressive strength of concrete containing MX0% MX10%, MX20% and MX30% increase in the range of 3 %, 16% 18 % and 20% compared to the compressive strength of reference mix. However for the mixes containing MX50% the compressive strength was comparable to the compressive strength of control mix. The increase in compressive strength due to replacement of sand by industrial waste at the constant cement content is attributed to the contribution of industrial waste to the hydration process and thus enhancing the compressive strength of concrete.
3. The split tensile strength of concrete mixes containing with the additions of industrial waste of upto 40% replacement at curing age of 7 days, 14 days, 28 days and 56 days. The split tensile strength of concrete containing MX0% MX10%, MX20% and MX30% increase in the range of 11.9%, 12%, 16.5% and 17% compared to the split tensile strength of reference mix further addition of industrial waste resulted in decrease in split tensile strength. However the split tensile strength for the mixes containing 50% was found to be comparable to the split tensile strength of control mix.
4. The flexural strength of concrete mixes containing with the additions of industrial waste of upto 40% replacement at curing age of 7 days, 14 days, 28 days and 56 days. The flexural strength of concrete containing MX0% MX10%, MX20% and MX30% increase in the range of 5.3%, 10.07%, 16.9% and 19% compared to the flexural strength of reference mix further addition of industrial waste resulted in decrease in flexural strength. However the flexural strength for the mixes containing 50% was found to be comparable to the flexural strength of control mix
5. The split tensile strength of concrete cubes mixes containing with the additions of industrial waste of upto 40% replacement at curing age of 7 days, 14 days, 28 days and 56 days. The split tensile strength of concrete containing MX0% MX10%, MX20% and MX30% increase in the range of 12%, 12.4%, 16.2% and 17.4% compared to the split tensile strength of reference mix. further addition of industrial waste resulted in decrease in split tensile strength. However the split tensile strength for the mixes containing 50% was found to be decrease as comparable to the split tensile strength of control mix.

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