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A Brief Study on Effect of Used Foundry Sand and Mineral Admixtures on Strength Properties of Concrete

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ABSTRACT

Sand has been used for centuries as a moulding material in ferrous and non-ferrous metal casting industries because of its thermal conductivity. Foundries successfully recycle and reuse the sand many times in a foundry. When the sand can no longer be reused in the foundry, it is removed from the foundry and is termed as USED FOUNDRY SAND (UFS) or WASTE FOUNDRY SAND (WFS). This used foundry sand waste can be utilized for the preparation of concrete as partial replacement of sand. In order to explore the possibility of utilizing the used foundry sand as partial replacement to fine aggregate, an experimental investigation has been carried out. The strength properties such as Compressive, Split tensile and Flexural strengths of M25 grade concrete are studied with different percentage replacement of fine aggregate by used foundry sand for 0%, 10%, 20%, 30%, 40%, and 50%. The optimum percentage of used foundry sand in concrete corresponding to maximum strength will be identified. Keeping this optimum percentage of used foundry sand replacement as constant, cement replacement study with admixtures such as silica fume (5%,7.5%,10%,12.5%)and fly ash (5%,10%,15%,20%,) are carried out separately on strength properties of concrete. With the above study, the maximum strength of concrete corresponding to replacement of silica fume and fly ash are identified. It was observed that the maximum increase in strength properties compared to conventional concrete was achieved at 40% replacement of used foundry sand. Based on the results obtained, the replacement of 40% used foundry sand with silica fume showed better performance than with Fly ash .Among all the mixes the maximum increase in strengths were observed in a mix which consist of 40% used foundry sand with 10% silica fume. The details of the investigation along with the results are present in this report.
Keywords: Rapid Development, Effectiveness, Assessment, Monitoring, Management, Planning

I. INTRODUCTION

Fundamentally, concrete is economical, strong, and durable. Although concrete technology across the industry continues to rise to the demands of a changing market place. The construction industry recognizes that considerable improvements are essential in productivity, product performance, energy efficiency and environmental performance. The industry will need to face and overcome a number of institutional competitive and technical challenges. One of the major challenges with the environmental awareness and scarcity of space for land-filling is the wastes/by products utilization as an alternative to disposal. Throughout the industrial sector, including the concrete industry, the cost of environmental compliance is high. Use of industrial by-products such as foundry sand, fly ash, bottom ash and slag can result in significant improvements in overall industry energy efficiency and environmental performance.

The consumption of all type of aggregates has been increasing in recent years in most countries at a rate far exceeding that suggested by the growth rate of their economy or of their construction industries. Artificially manufactured aggregates are more expensive to produce, and the available source of natural aggregates may be at a considerable distance from the point of use, in which case, the cost of transporting is a disadvantage. The other factors to be considered are the continued and expanding extraction of natural aggregates accompanied by serious environmental problems. Often it leads to irremediable deterioration of the country side.

Quarrying of aggregates leads to disturbed surface area etc., but the aggregates from industrial wastes are not only adding extra aggregate sources to the natural and artificial aggregate but also prevent environmental pollution. Over 70% of the total by-product material consists of sand because moulds usually consist of moulding sand, which is easily available, inexpensive, resistance to heat damage, easily bonded with binder, and other organic material in mould. Foundry industry use high quality specific size silica sand for their moulding and casting process. This is high quality sand than the typical natural sand. Foundries successfully recycle and reuse the sand many times in foundry. When it can no longer be reused in the foundry, it is removed from the industry, and is termed as used foundry sand (UFS). It is also known as spent foundry sand (SFS) and waste foundry sand (WFS).

Used foundry sand are by-products which appears to possess the potential to partially replace regular sand as a fine aggregate in concretes, providing a recycling opportunity for them. If such types of materials can be substituted partly/fully for natural sand (fine aggregates) in concrete mixtures without sacrificing or even improving strength and durability, there are clear economic and environmental gains. Currently, very limited literature is available on the use of these by products in concrete. Used foundry sand is one of the major issues in the management of foundry waste. Used foundry sand are black in colour and contain large amount of fines. The typical physical and chemical property of Used foundry sand is dependent upon the type of metal being poured, casting process, technology employed, type of furnaces (induction, electric arc and cupola furnace) and type of finishing process (grinding, blast cleaning and coating).

II. METHODS AND MATERIAL

A. Literature Review

Gurpreet Singhel at (1998) have studied the strength and durability properties of concrete mixtures, in which natural sand was replaced with five percentage (0%, 5%,10%, and 15%and20%) of waste foundry sand(WFS)by weight. Compression test and splitting tensile strength test were carried out at the age of 7, 28 and 91 days and Modulus of elasticity, ultrasonic pulse velocity and Rapid Chloride Permeability test were conducted at the age of 28 and 91 days. The abrasion resistance of concrete containing WFS was also investigated. Based on the results obtained they concluded that (i)Maximum increase in compressive strength, splitting tensile strength and modulus of elasticity of concrete was observedwith15% WFS, both at28and91 days;(ii)WFS increases the ultrasonic pulse velocity values and decreased the chloride ion penetration in concrete;(iii) Abrasion resistance of concrete increased with the increase in WFS content. They also added that WFS can be suitably used in making structural grade concrete, as well as for applications where abrasion is also important parameter.

Khati and Ellis (2001) studied the influence of three types of foundry sand as a partial replacement of fine aggregate on the compressive strength of concrete, up to the age of 90 days. Three types of sand used in foundries were; the white fine sand without the addition of clay and coal, the foundry sand before casting (blended) and the foundry sand after casting (waste). The standard sand (Class M) was partially replaced by (0, 25, 50, 75 and 100%) these sands. They concluded that (i) with the increase in the replacement level of standard sand with foundry sand, the strength of concrete decreased; (ii) the concrete containing white sand showed somewhat similar strength to those containing waste sand at all replacement levels; (iii) presence of high percentage of blended sand in the concrete mixture caused a reduction in strength as compared with concrete incorporating white sand or waste sand; (iv) increase in strength was not observed at low replacement levels (less than 50%).

Kumbharetal (2003) investigated the various mechanical properties of concrete containing used foundry sand. Concrete was produced by replacing natural sand with UFS in various percentages (10%,20%,30%and40%).Based on the test results they concluded that(i)workability goes on reducing with increase in UFS content; (ii)At28-days,Compressive strength, splitting tensile strength for different replacement levels of UFS is increased whereas flexural tensile strength goes on reducing for UFS contentmorethan20%;(iii)At28-days,themodulus of elasticity values increases with replacement of UFS upto 20%.Theyalsoconcluded that the UFS can be utilized as a replacement to regular sand in concrete upto about 20%.

B. Experimental Programme

The materials used in the present investigation are as fallows

1. Cement
2. Aggregates
3. Water
4. Super plasticizer
5. Silica Fume

1. Cement

In this work ZUARI cement of 53 grade was used for all concrete mixes. The cement was of uniform colour i.e. grey with alight greenish shade and was free from any hard lumps. The various tests conducted once ment are initial and final setting time, specific gravity, fineness and compressive strength etc. Testing of cement was done as per IS:12269 -1987

2. Aggregate

Locally available coarse aggregates having the maximum size of 20mm were used in the present work. Testing on coarse aggregates was done as per IS:383-1970.They were then washed to removed us and dirt and were dried to surface dry condition. There sults of various tests conducted on coarse aggregate are given in Table 5 andTable6.

Coarse Aggregate: Locally available coarse aggregates having the maximum size of 20mm were used in the present work. Testing on coarse aggregates was done as per IS:383-1970.They were then washed to removed us and dirt and were dried to surface dry condition. There sults of various tests conducted on coarse aggregate are given in Table 5 andTable6.

Fineaggregate

The sand used for the experimental programme was locally procured and conformed to grading zone II as per IS:383-1970.The sand was first sieved through 4.75 mm sieve to remove any particles greater than 4.75mm and then was washed to remove the dust.

Used Foundry Sand

Used Foundry sand obtained from SHIVAANI ALLOY STEEL CASTINGS LTD, Hyderabad is used in the present work. The physical Properties of the used foundry sand and Sieve Analysis of Used Foundry Sand are shown in Table 9 and Table 10 respectively.

Silica fume

Silica fume obtained from MEHTABPVT.LIMITED, CHANDIGARH, issued in this work. It was grey in colour.Silica Fume mixed with cementis shown in Fig. 6Silica fume particles are extremely small, with more than 95%of the particles finer than1µ m.

Fly Ash

The Fly Ash used in this study is of class F , obtained from Mahasakthi cement, Banaganapalli. Fly Ash mixed with cementis shown in Fig. 7.Fly ash is usually a fine grained substance consisting largely of spherical particles. Many ashes additionally contain abnormal of angular particles. The length of particles varies according to the places. Many ashes could possibly be finer or maybe coarser in comparison with Portland cement particles. A few of these particles seems to be solid, while a few much larger particles seems to be levels of thin, hollow spheres containing several small particles. Its typical physical properties are given in Table12.

Water

In this project, casting and curing of specimens were done using potable water which shall be free from deleterious materials. It helps in the hydration of the mix.

Silica Fume

The oxide fume was utilized in these experiments conforms to ASTM C 1240 and IS 15388:2003. The oxide fume is extraordinarily fine particle that exists in white color powder kind. Oxide fume has been procured from Astrra chemicals Ltd-Chennai.

III. BATCHING, MIXING AND CASTING OF SPECIMENS

Concrete cubical moulds of size150mm³ werecastforthe determination of compressive strength of concrete. Care was taken during casting and table vibrator was used for proper compaction. Cylinder moulds of size 150mm x 300mm were cast for determination of Spilt tensile strength of concrete. Beam moulds of size 100 x 100 x 500 mm cast for the determination of Flexural strength of concrete. with Indian standard specification IS: 516-1959.

All the specimens were prepares in accordance

Mix No	M0	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13
Cement (Kg/m^3)	419.14	419.14	419.14	419.14	419.14	419.14	398.183	377.23	356.27	335.32	398.19	387.79	377.23	366.74
Sand (kg)	643.12	578.81	514.5	450.18	385.87	321.56	385.87	385.87	385.87	385.87	385.87	385.87	385.87	385.87
Foundry sand (%)	0	10	20	30	40	50	40	40	40	40	40	40	40	40
Foundry sand (Kg)	0	64.31	128.62	192.93	257.25	321.56	257.25	257.25	257.25	257.25	257.25	257.25	257.25	257.25
C.A 20mm (Kg)	806.28	806.28	806.28	806.28	806.28	806.28	806.28	806.28	806.28	806.28	806.28	806.28	806.28	806.28
C.A 10mm (kg)	230.37	230.37	230.37	230.37	230.37	230.37	230.37	230.37	230.37	230.37	230.37	230.37	230.37	230.37
Water (kg/m^3)	197	197	197	197	197	197	197	197	197	197	197	197	197	197
Water/cement	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47
Fly Ash (%)	0	0	0	0	0	0	5	10	15	20	0	0	0	0
Fly Ash (Kg)	0	0	0	0	0	0	20.97	41.91	62.87	83.82	0	0	0	0
Silica fume (%)	0	0	0	0	0	0	0	0	0	0	5	7.5	10	12.5
Silica fume (Kg)	0	0	0	0	0	0	0	0	0	0	20.95	31.35	41.91	52.39

All the moulds were cleaned and oil ed properly. These were securely tightened to correct dimensions be forecasting. Care was taken that there is no gaps left from where there is any possibility of leakage of slurry

A careful procedure was adopted in the batching, mixing and casting operations. The mixing of concrete was done by using pan mixture.OPChaving53 grades was used in casting. Fine aggregates along with used foundry sand are thoroughly mixed in mixer. After that coarse aggregates are added to it. Then water was added carefully so that no water was lost during mixing. For each mix cubes(150 x 1 5 0 x 1 5 0 mm,Beams (150 x150 x 150mm), cylinders (300x150mm) were cast to determine the compressive strength , flexural strength, split tensile strength of concrete .

Vibrations moulds were kept on table Vibrator and stopped as soon as the cement slurry appeared on the top surface of the Mould. The specimens were allowed to remain in the steel mould for the first 24 hours at ambient condition**.**

In this gift investigation it is aimed to study the strength characteristics of concrete such as compressive strength, split durability and flexural strengths of M40 and M50 grade concretes, by modifying standard concrete with totally different percentages of oxide fume (0%, 5%, 7.5%, 100 percent& 15%) and nano oxide (1%, 1.5%, 2%, & 2.5) by partial replacement of cement by weight. Various mix proportions of M40 and M50 grade concretes with nano silica, small oxide, combinations of nano silica and micro silica find out for for M40 and M50 grade concretes.

Compaction Factor Test

Compaction factor test is based on the definition, that workability is that property of the concrete that determines the amount of work required to produce full compaction. The test consists essentially of applying a standard amount of work to standard quantity of concrete and measuring the resulting compaction as shown in Fig.8.The workability of different mixes obtained are as shown in table 16. It is observed that as percentage of used foundry sand increases, compaction factor value decreases and is due to finer particles present in used foundry sand.

IV. RESULTS AND DISCUSSION

A. Tests Conducted on Strength Properties of Concrete

Compressive Strength Test

The compressive strength of reference mix (M0) and all other mixes prepared, using used foundry sand, fly ash and silica fume are as represented in Table 17.

It was observed that the increase in compressive strength was observed gradually up to 40% replacement of fine aggregates by used foundry sand and then decreased. The maximum compressive strength was obtained 38.70 N/mm^2 at 40% used foundry sand. Maximum compressive strength was obtained with mix

(M4) 40% used foundry sand38.70 N/mm^2 which was 17.14% more compared reference mix (33.03 N/mm^2).

Compressive strength of M25 grade were studied with combination of 40% used foundry sand (because at 40% used foundry sand replacement maximum compressive strength obtained) and 10%,15%,20% fly ash replaced with cement. Mix with M25 grade with 40% used foundry sand and 5 % fly ash obtained maximum strength among all fly ash replacements. It was observed that as fly ash percentage in concrete increased, its compressive strength decreased. Mix which was replaced by 40% of used foundry sand and 5% fly ash (M6) obtained a compressive strength 37.12 N/mm^2 which was 12.36% more than the reference mix (M0).But it was -4.25% less strength than mix with 40% replacement by used foundry sand (M4).

Compressive strength of M25 grade were also studied with combination of 40% used foundry sand and 5%,7.5%10% silica fume replaced with cement. Mix with M25 grade with 40% used foundry sand and 10% silica fume obtained maximum strength among all silica fume replacements. It was observed that silica fume percentage in concrete increased, its compressive strength also increased. Mix with 40% replacement used foundry sand and 10% silica fume (M11) replacement, obtained compressive strength 42.96N/mm^2 which was 30.04 % more than the reference mix (M0).

Split Tensile Strength Test

The split tensile strength of reference mix (M0) and all other mixes prepared, using used foundry sand, fly ash and silica fume areas represented in Table 18.
It was observed that the increase in split tensile strength was observed gradually up to 40% replacement of fine aggregates by used foundry sand and then decreased. The maximum split tensile strength was obtained 3.40 N/mm2 at 40% used foundry sand. Maximum split tensile strength was obtained with mix (M4) 40% used foundry sand which was 23.64% more compared with reference mix (2.275 N/mm2). Variation of split tensile strength of M25 grade with different percentage replacement of fine aggregate by used foundry sand is as represented in figure 15.

Split tensile strength of M25 grade were studied with combination of 40% used foundry sand and 10%,15%,20% fly ash replaced with cement. Mix with M25 grade with 40% used foundry sand and 5% fly ash obtained maximum strength among all fly ash replacements. It was observed that as fly ash percentage in concrete increased, its split tensile strength decreased. Mix which was replaced by 40% of used foundry sand and 5% fly ash (M6) obtained a split tensile strength 3.10N/mm^2 which was 12.73% more than the reference mix (M0).But it was -9.667% less strength than mix with 40% replacement by used foundry sand (M4). Variation of split tensile strength of concrete with 40% used foundry sand and a different percentage of fly ash is as represented in figure 16.

Split tensile strength of M25 grade were studied with combination of 40% used foundry sand and 5%,7.5%10% silica fume replaced with cement. Mix with M25 grade with 40% used foundry sand and 10% silica fume obtained maximum strength as all silica fume replacements. It was observed that silica fume percentage in concrete increased, its split tensile strength increased. Mix with 40% replacement used foundry sand and 10% silica fume (M11) replacement obtained split tensile strength 3.74N/mm^2 which was 36% more than the reference mix. Variation of split tensile strength of concrete with 40% used foundry sand and different percentage of silica fume

Flexural Strength Test

The flexural strength of reference mix (M0) and all other mixes prepared, using used foundry sand, fly ash and silica fume are as represented in Table 19.
It was observed that the increase in flexural strength was observed gradually up to 40% replacement of fine aggregates by used foundry sand and then decreased. The maximum flexural strength was obtained 3.34 N/mm^2 at 40% used foundry sand. Maximum flexural strength was obtained with mix (M4) 40% used foundry sand which was 29.96% more compared with reference mix (2.57N/mm^2). Variation of flexural strength of M25 grade with different percentage replacement of fine aggregate by used foundry sand is as represented in figure 18.

Flexural strength of M25 grade were studied with combination of 40% used foundry sand and 10%,15%,20% fly ash replaced with cement. Mix with M25 grade with 40% used foundry sand and 5% fly ash obtained maximum strength among all fly ash replacements. It was observed that as fly ash percentage in concrete increased, its flexural strength decreased. Mix which was replaced by 40% of used foundry sand and 5% fly ash (M6) obtained a flexural strength 2.98 N/mm^2 which was 15.56% more than the reference mix (M0).But it was -12.08% less strength than mix with 40% replacement by used foundry sand (M4). Variation of flexural strength of concrete with 40% used foundry sand and different percentages of fly ash is as represented in figure 19.

Flexural strength of M25 grade were studied with combination of 40% used foundry sand and 5%,7.5%10% silica fume replaced with cement. Mix with M25 grade with 40% used foundry sand and 10% silica fume obtained maximum strength as all silica fume replacements. It was observed that silica fume percentage in concrete increased, its flexural strength increased. Mix with 40% replacement used foundry sand and 10% silica fume (M11) replacement obtained flexural strength 3.52N/mm^2 which was 36.96% more than the reference mix. Variation of flexural strength of concrete with 40% used foundry sand and different percentage of silica fume is as represented in figure 20.

V. RESULTS AND DISCUSSION

Compressive Strength

The compressive strength of reference mix (M0) and all other mixes prepared, using used foundry sand, fly ash and silica fume are as shown in Table 17. It was observed that the increase in compressive strength was observed gradually up to 40% replacement of fineaggregates by used foundry sand and then decreased. The maximum compressive strength was obtained 38.70 N/mm^2 at 40% used foundry sand. Maximum compressive strength was obtained with mix (M4) 40% used foundry sand38.70 N/mm^2 which was 17.14% more compared reference mix (33.03 N/mm^2). Variation of compressive strength of M25 grade with different percentage replacement of fine aggregate by used foundry sand is as shown in figure 12.

Compressive strength of M25 grade were studied with combination of 40% used foundry sand (because at 40% used foundry sand replacement maximum compressive strength obtained) and 10%,15%,20% fly ash replaced with cement. Mix with M25 grade with 40% used foundry sand and 5 % fly ash obtained maximum strength among all fly ash replacements. It was observed that as fly ash percentage in concrete increased, its compressive strength decreased. Mix which was replaced by 40% of used foundry sand and 5% fly ash (M6) obtained a compressive strength 37.12 N/mm^2 which was 12.36% more than the reference mix (M0).But it was -4.25% less strength than mix with 40% replacement by used foundry sand (M4). Variation of compressive strength of concrete with 40% used foundry sand and different percentages of fly ash are as shown in figure 13.

Mix No	**Percentage of Used foundry sand**	**Percentage of Fly ash**	**Percentage of silica fume**	**Compressive strength**	**Percentage increased or decreased (Wrt to reference mix)**
M0	0	0	0	33.037	-
M1	10	0	0	34.98	5.88
M2	20	0	0	36.6	10.78
M3	30	0	0	37.88	14.66
M4	**40**	**0**	**0**	**38.7**	**17.14**
M5	50	0	0	36.13	0.28
M6	**40**	**5**	**0**	**37.12**	**12.36**
M7	40	10	0	35.11	6.27
M8	40	15	0	33.85	2.46
M9	40	20	0	31.29	-5.29
M10	40	0	5	39.82	20.53
M11	40	0	7.5	40.71	23.23
M12	**40**	**0**	**10**	**42.96**	**30.04**
M13	40	0	12.5	40.85	23.65

Compressive strengths of different concrete mixes at 28 days

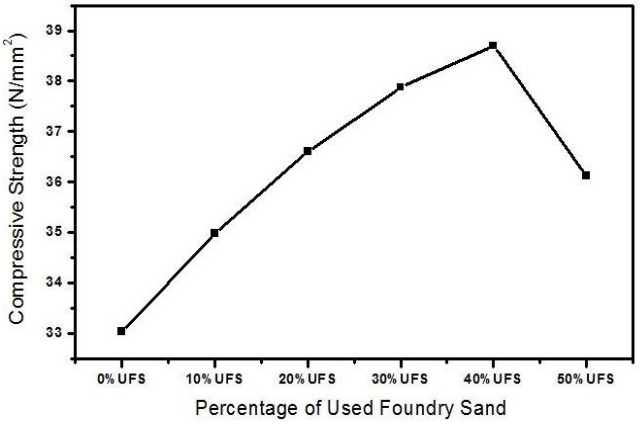

Figure 1. Relation between the percentage of used foundry sand and compressive strength

Compressive strength of M25 grade were also studied with combination of 40% used foundry sand and 5%,7.5%10% silica fume replaced with cement. Mix with M25 grade with 40% used foundry sand and 10% silica fume obtained maximum strength among all silica fume replacements. It was observed that silica fume percentage in concrete increased, its compressive strength also increased. Mix with 40% replacement used foundry sand and 10% silica fume (M11) replacement, obtained compressive strength 42.96N/mm^2 which was 30.04 % more than the reference mix (M0). Variation of compressive strength of concrete with 40% used foundry sand and different percentage of silica fume is as shown in figure 14.

SPLIT TENSILE STRENGTH

The split tensile strength of reference mix (M0) and all other mixes prepared, using used foundry sand, fly ash and silica fume areas shown in Table 18.

It was observed that the increase in split tensile strength was observed gradually up to 40% replacement of fineaggregates by used foundry sand and then decreased. The maximum split tensile strength was obtained 3.40 N/mm^2 at 40% used foundry sand. Maximum split tensile strength was obtained with mix (M4) 40% used foundry sand which was 23.64% more compared with reference mix (2.275 N/mm^2).

Split tensile strength of M25 grade were studied with combination of 40% used foundry sand and 10%,15%,20% fly ash replaced with cement. Mix with M25 grade with 40% used foundry sand and 5% fly ash obtained maximum strength among all fly ash replacements. It was observed that as fly ash percentage in concrete increased, its split tensile strength decreased. Mix which was replaced by 40% of used foundry sand and 5% fly ash (M6) obtained a split tensile strength 3.10N/mm^2 which was 12.73% more than the reference mix (M0).But it was -9.667% less strength than mix with 40% replacement by used foundry sand (M4).

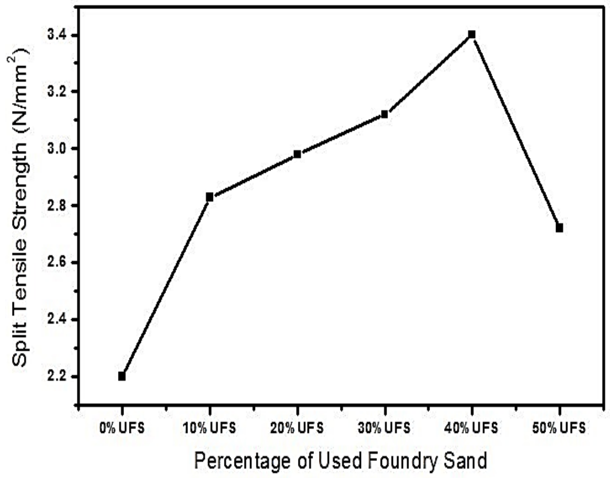

Figure 13. Relation between the percentages of used foundry sand and Split tensile strength

Mix No	**Percentage of Used foundry sand**	**Percentage of Fly ash**	**Percentage of silica fume**	**Split tensile strength**	**Percentage increased or decreased (Wrt to reference mix)**
M0	0	0	0	2.75	-
M1	10	0	0	2.83	2.91
M2	20	0	0	2.98	8.36
M3	30	0	0	3.12	13.45
M4	**40**	**0**	**0**	**3.4**	**23.64**
M5	50	0	0	3.12	13.45
M6	**40**	**5**	**0**	**3.1**	**12.73**
M7	40	10	0	3.04	10.55

M8	40	15	0	2.97	8
M9	40	20	0	2.91	5.82
M10	40	0	5	3.61	31.27
M11	40	0	7.5	3.67	33.45
M12	**40**	**0**	**10**	**3.74**	**36**
M13	40	0	12.5	3.64	32.72

Split tensile strengths of different concrete mixes at 28 days.

Split tensile strength of M25 grade were studied with combination of 40% used foundry sand and 5%,7.5%10% silica fume replaced with cement. Mix with M25 grade with 40% used foundry sand and 10% silica fume obtained maximum strength as all silica fume replacements. It was observed that silica fume percentage in concrete increased, its split tensile strength increased. Mix with 40% replacement used foundry sand and 10% silica fume (M11) replacement obtained split tensile strength 3.74N/mm^2 which was 36% more than the reference mix.

VI. CONCLUSION

Based on above study, the following observation are made regarding the strength properties of concrete on partial replacement of fine aggregate by used foundry sand and cement by minerals admixture such as fly ash and silica fume.

1. As percentage replacement of used foundry sand by fine aggregate is increased in concrete, its workability decreases.
2. The maximum compressive strength of 38.70 N/mm^2 (M4) was obtained with respect to M25 grade concrete when 40% fine aggregate replaced by used foundry sand. Maximum compressive strength was obtained with mix (M4) 40% used foundry sand which was 17.14% more compared with reference mix M0 (33.03 N/mm^2).
3. The maximum compressive strength was obtained with 40% of used foundry sand and 5 % fly ash (M6) obtained a compressive strength 37.12 N/mm^2 which was 12.36% more than the reference mix .
4. The maximum compressive strength was obtained with 40% replacement used foundry sand and 10% silica fume (M11) replacement obtained compressive strength 42.96N/mm^2 which was 28.738% more than the reference mix.
5. The maximum split tensile strength was obtained 3.40 N/mm^2 (M4)at 40% used foundry sand. Maximum split tensile strength was obtained with mix (M4) 40% used foundry sand which was 23.64% more compared with reference mix (2.275 N/mm^2).
6. The maximum split tensile strength was obtained with 40% of used foundry sand and 5% fly ash (M6) obtained a split tensile strength 3.10N/mm^2 which was 12.73% more than the reference mix .
7. The maximum split tensile strength was obtained with 40% replacement used foundry sand and 10% silica fume (M11) replacement obtained split tensile strength 3.74N/mm^2 which was 36% more than the reference mix.
8. The maximum flexural strength was obtained 3.34 N/mm^2(M4)at 40% used foundry sand. Maximum flexural strength was obtained with mix (M4) 40% used foundry sand which was 29.96% more compared with reference mix (2.57N/mm^2).
9. The maximum flexural strength was obtained with 40% of used foundry sand and 5 % fly ash (M6) obtained a flexural strength 2.98 N/mm^2 which was 15.56% more than the reference mix.
10. The maximum flexural strength was obtained with 40% replacement used foundry sand and 10% silica fume (M11) replacement obtained flexural strength 3.52N/mm^2 which was 36.96% more than the reference mix.
11. Based on experimental results, it is observed that there is significance improvement in the strength properties of concrete with used foundry sand and silica fume combination when compared to used foundry sand and fly ash.

A. MIX DESIGN FOR M_{25} GRADE OF CONCRETE (IS: 10262-2009)

M_{25} Design Mix

Data

a) Grade designation = M25

b) Type of cement = OPC 53 grade

c) Maximum nominal size of aggregate = 20mm

d) Maximum water-cement ratio = 0.47

f) Exposure condition = good

e) Workability = 100 mm (slump)

g) Type of aggregate = Crushed angular aggregate

h) Maximum cement content = 450 kg/m^3

TEST DATA FOR MATERIALS

a) Cement used = Zuari cement OPC 53 grade

b) Specific gravity of cement = 3.12

c) Specific gravity of

1) Coarse aggregate = 2.825

2) Fine aggregate = 2.57

B. TARGET STRENGTH FOR MIX PROPORTIONING

$F_{ck} = f_{ck} + 1.65\ S$
$= 25 + 1.65 x 4$
$= 31.6\ N/mm^2$

Where:-
F_{ck} is target average compressive strength at 28 days,
f_{ck} is characteristic compressive strength at 28 days, and
s is standard deviation.
From Table - 1 of IS 456, standard deviation, s = 5 N/mrn^2

C. SELECTION OF WATER-CEMENT RATIO

From Table - 5 of IS 456, maximum water-cement ratio = 0.5.
Based on experience, adopt water-cement ratio as 0.47.
0.47 < 0.50, hence O.K.

D. SELECTION OF WATER CONTENT

Using 20mm maximum size coarse aggregates
Water content = 186 litre
Increase water content by 6 %
For 100mm Slump = $186 + \frac{6}{100}$ x 186
= 197 Litre.

E. CALCULATION OF CEMENT CONTENT

$\frac{Water}{Cement}$ ratio = 0.47
Cement content = $\frac{197}{0.47}$ = 419.14 Kg/m^3

F. PROPORTION OF VOLUME OF COARSE AGGREGATE AND FINE AGGREGATE CONTENT

From Table - 3 of IS 456. volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate (Zone II)for water-cement ratio of 0.50 = 0.60.

In the present case water-cement ratio is 0.47.Therefore. Volume of coarse aggregate is required to be increased to decrease the fine aggregate content. As the water-cement ratio is lower by 0.10. The proportion of volume of coarse aggregate is increased by 0.02 (at the rate of -/+ 0.01 for every ± 0.05 change in water-cement ratio).Therefore. Corrected proportion of volume of coarse aggregate for the water-cement ratio of 0.47 = 0.626.

Volume of Coarse aggregates = 0.626
Volume of Fine aggregates = 1 - 0.626 = 0.374

G. MIX CALCULATIONS

Mix proportion M_{25}

Volume of Cemen = 1m^3

Volume of Cement = $\frac{419.14}{3.13}$ x $\frac{1}{1000}$
= 0.1339 Kg/m^3

Volume of Water = $\frac{197}{1000}$

Volume of all aggregates = 1 - [0.1339 + 1.197]

Mass of coarse aggregates = 0.6691 x 0.626 x 1000 x 2.75 = 1151.8556 Kg

Mass of fine aggregates = 0.6691 x 0.374 x 2.57 x 1000 = 643.125 Kg

Unit of Batch	Cement (kg/m^3)	FA (Kg)	CA (Kg)	Water (kg/m^3)
Cubic meter content	419.14	643.125	1151.8556	197
Ratio of ingredient	1	1.53	2.748	0.47

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