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EFFECT OF FOUNDRY SAND AND MINERAL ADMIXTURES ON MECHANICAL PROPERTIES OF CONCRETE

DR K.V.S.GOPALA KRISHNA SASTRY[1], A.RAVITHEJA[2*],
DR.T.CHANDRA SEKHARA REDDY[3]

Abstract: Foundry sand waste can be utilized for the preparation of concrete as a partial replacement of sand. The strength properties of M25 grade concrete are studied with different percentages of replacement of fine aggregates by foundry sand at 0%, 10%, 20%, 30%, 40%, and 50%. The optimum percentage of foundry sand replacement in the concrete corresponding to maximum strength will be identified. Keeping this optimum percentage of foundry sand replacement as a constant, a cement replacement study with mineral admixtures such as silica fume (5%, 7.5%, 10%) and fly ash (10%, 15%, 20%,) is carried out separately. The maximum increase in strength properties as compared to conventional concrete was achieved at 40% foundry sand replacement. Test results indicated that a 40% replacement of foundry sand with silica fume showed better performance than that of fly ash. The maximum increase in strengths was observed in a mix consisting of 40% foundry sand and 10% silica fume. SEM analysis of the concrete specimens also reveals that a mix with 40% foundry sand and 10% silica fume obtained the highest strength properties compared to all other mixes due to the creation of more C-H-S gel formations and fewer pores.

Keywords: Foundry sand, Fly ash, Silica fume, Strength properties, SEM analysis

1. INTRODUCTION

Fundamentally, concrete should be economical, strong, and durable. 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 concerning

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[1] Professor, G. Pulla Reddy Engineering College, Kurnool, Andhra Pradesh, India

[2*] Research Scholar, Civil Engineering Department, G. Pulla Reddy Engineering College, Kurnool, Andhra Pradesh, India (Corresponding author. Tel.: +91 9493135331 and E-mail addresses: ravithejahp@gmail.com)

[3] Professor, G. Pulla Reddy Engineering College, Kurnool, Andhra Pradesh, India

environmental awareness and scarcity of space for land-filling is waste/by-product repurposing as an alternative to disposal.

Consumption of all types 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 construction industries. Artificially manufactured aggregates are more expensive to produce and the available source of natural aggregates may be located at a considerable distance from point of manufacture, in which case the cost of transport is also a disadvantage. The foundry industry produces a large amount of by-product materials during the casting process. Commonly, foundry sand is used for mould-making and consists of a mixture of silica sand (80–95%), bentonite clay (4–10%), a carbonaceous additive (2–10%), and water (2–5%). Over 70% of the total by-product material is sand, as moulds usually consist of moulding sand, which is easily available, inexpensive, resistant to heat damage, and easily bonded with a binder and other organic materials in the mould. The foundry industry uses high-quality specific size silica sand for their moulding and casting process. Foundries successfully recycle and reuse the sand multiple times, and when it can no longer be reused in the foundry, it is removed from the manufacturing process and is then termed 'foundry sand' (**FS**). It is also known as spent foundry sand (**SFS**) and waste foundry sand (**WFS**).

2. LITERATURE REVIEW

Rafat Siddique et al. [1] investigated the mechanical properties of concrete mixtures in which fine aggregate was partially replaced by foundry sand at different weight percentages (10%, 20%, 30%). Tests were performed to find various properties of concrete like its compressive, split tensile, and flexural strengths, and its modulus of elasticity at 28, 56, 91, and 365 days. Test results showed that the increase in compressive strength varied between 8% and 19%, splitting tensile strength between 6.5% and 14.5%, flexural strength between 7% and 12%, and the modulus of elasticity between 5% and 12%.

Khatib and Baig et al. [2-3] studied fresh and hardened properties of concrete containing waste foundry sand (WFS) replaced with fine aggregate at 0 to 100%, maintaining the W/C ratio constant throughout the study. Testing on the hardened properties of concrete was conducted at 14, 28, and 56 days. Results showed that the incorporation of waste foundry sand in concrete causes a decrease in workability, ultrasonic pulse velocity, and strength, but an increase in water absorption and the shrinkage of concrete. They also reported that an acceptable concrete strength can be achieved using foundry sand.

Kumbhar et al. [4] investigated the various mechanical properties of concrete containing used foundry sand. The concrete was produced by replacing natural sand with UFS in various percentages (10%, 20%, 30%, and 40%). Based on the test results they concluded that (i) workability decreases with an increase in UFS content, (ii) at 28-days, the compressive and splitting tensile strengths for different replacement levels of UFS increased, whereas flexural tensile strength decreased for a UFS content of more than 20%, (iii) at 28-days, the modulus of elasticity values increase with a replacement of UFS up to 20%. They also concluded that UFS can be utilized in place of regular sand in concrete in up to about 20%.

Ranjitham et al. [5] investigated strength properties like compressive, split tensile, and flexural strengths of M75 grade of mixtures at 10% to 30% replacement of fine aggregate by foundry sand, along with cement replacement by mineral admixtures such as fly ash and GGBS slag at a water-binder ratio of 0.3. Based on the results shown, a replacement of 30% UFS with 3% super plasticiser exhibited superior strength characteristics. They conclude that by varying the super plasticizer dose, workability can be reached. Mixes with 30% fly ash and 30% GGBS replacement showed better workability compared to other percentage replacements. The use of foundry sand and mineral admixtures improves the strength properties of concrete. A combination of UFS+GGBS showed better overall performance than UFS and fly ash.

Jay Pandya et al. [6] investigated durability of concrete using supplementary materials such as foundry sand & slag. The alccofine is used in 10% and 15% by replacement of cement, and, the same time, the sand will be replaced with foundry sand at 10%, 20%, 30%, 40%, and 50% for all experimental work. Durability tests like RCPT, sulfate attack, sorptivity, rebound hammer, UPV, and compressive strength tests were carried out at 7, 28, and 56 days. Results showed that foundry sand increases the strength up to 20% replacement; as the percentage of foundry sand then increases, the strength and durability of the concrete decreases.

Konapure et al. [7] researched M20 & M30 grade concrete with mix proportions of 1:2.09:3.02 & 1:1.98:3.88 with respective water-cement ratios of 0.45 & 0.42 when evaluating basic fundamental properties of concrete (compressive strength, split tensile strength, flexural strength). The data obtained from their research can be analyzed & a comparative study can be done with mixes using foundry sand [FS]. This relationship is governed by workability, compressive strength, split tensile strength, and flexural strength, hence this data can be represented both mathematically & graphically. Test results showed that a 20% substitution of foundry sand results in an increase in compressive strength for both the M20 & M30 grade concrete when compared to mixes with natural sand, and then decreases as the replacement percentage increases.

Gurumoorthy et al. [8] investigated and found that UFS in concrete without proper treatment will reduce the binding and strength properties. In order to minimize iron content, the UFS was treated with acid. From this treatment, the silica in the foundry sand had been enriched - this is called Treated Used Foundry Sand (TUFS). This paper presents the results of an experimental investigation carried out to evaluate the microstructural and mechanical properties of concrete mixtures in which fine aggregate (river sand) was partially replaced with TUFS. Test results indicate a marginal increase in the strength properties and good microstructural properties of plain concrete with this inclusion of TUFS as a partial replacement of fine aggregate (sand). This will pave the way for making high-quality concrete and convenient disposal of the UFS safely without disturbing the environment.

Pranita Bhandari et al. [9] investigated how to produce low-cost concrete. An experimental investigation was carried out on concrete containing waste foundry sand at 0%, 10%, 20%, 30%, 40%, 60%, 80%, and 100% replacement by weight for M25 grade concrete. Concrete containing foundry sand was tested and compared against conventional concrete in terms of workability, compressive strength, and acid attack performance. Cubes were cast and a compression test was performed on 3-, 7-, and 28-day old specimens for a mix of 1:1.01:2.5 at a w/c of 0.4. Through the obtained experimental results we conclude that after a 20% partial replacement of foundry sand compressive strength decreases with each increase in the percentage of replacement. The aim of this research is to evaluate the mechanical properties of concrete after adding an optimum quantity of WFS in different proportions. Per this study, maximum compressive strength was obtained at 20% replacement of fine aggregate by waste foundry sand.

Jayanthi Singaram et al. [10] investigated masonry units which are extensively used nowadays to reduce CO_2 emissions and embodied energy rates. Long-term performance of such structures has become essential for sustaining construction technologies. This study aims to assess the strength and durability properties of concrete prepared with unprocessed bagasse ash (BA) and silica fume (SF). A mix proportion of 1:3:3 was used to cast concrete cubes 100 mm in size. Results showed that there was a slight difference in mass loss before and after exposure to a chemical attack in all the cases examined. Though the appearance was slightly different than the normal concrete, residual weight was not affected. The compressive strength for 10% bagasse ash (BA) replacement with 10% SF as an admixture resulted in better strength than that of normal concrete.

Mahdi Mahdikhani et al. [11] experimented with how mineral admixtures such as silica fume affect the mechanical properties and durability of cementitious materials. In addition, the superior performance of self-consolidating concrete (SCC) and self-consolidating mortars (SCM) over conventional concrete is generally related to their ingredients. This study investigates the effects of nanosilica and silica fume on the compressive strength and chloride permeability of self-consolidating mortars. Tests included compressive strength, the rapid chloride permeability test, a water permeability test, a capillary water absorption test, and surface electrical resistance testing, all which were carried out on twenty mortar mixtures containing 0-6% nanosilica and silica fume. Results show that SCMs incorporating nanosilica had higher compressive strengths at various ages. In addition, results show that nanosilica enhanced the durability of the SCMs and reduced their chloride permeability.

3. EXPERIMENTAL STUDY

3.1. MATERIALS

Ordinary 53 grade Portland cement (Zuari brand) confirming to IS 12269 -1987 norms was used; its properties are given in Table 1. The properties of the fly ash (FS) and silica fume (SF) are given in Table 2. Locally available river sand was used as a fine aggregate. Foundry sand was used as a fine aggregate replacement in this study. Physical properties of the fine aggregate, foundry sand, and coarse aggregate are given in Table 3.

Table 1. Properties of Cement

Characteristics	Values obtained	Standard value per IS code 12269 -1987
Initial setting time	42 min	No less than 30 min
Final setting time	310 min	No greater than 600 min
Fineness (%)	4.9	<10
Specific gravity	3.12	-
Compressive strength	56 N/mm^2	No less than 53 N/mm^2

Table 2. Properties of Silica Fume and Fly Ash

Characteristics	Fly ash	Silica Fume
Colour	grey	white
Specific gravity	2.3	2.1
Size (µm)	5.9	<1
Bulk density (kg/m^3)	994	130-430
Surface area (m^2/kg)	8900	20000

Table 3. Properties of Aggregates

Characteristics	Specific gravity	Fineness modulus	Bulk density (kg/m^3)
Fine Aggregate	2.57	2.64	1753
Foundry Sand	2.2	1.89	2589
Coarse Aggregate (10 mm)	2.704	6.45	1670
Coarse Aggregate (20mm)	2.825	7.68	1630

3.2 PREPARATION AND CASTING OF SPECIMENS

Various concrete specimens - cubes (150mm X 150mm X 150mm) to determine compressive strength, cylinders (150mm in diameter and 300mm in length) to determine split tensile strength, and beams (10mm X 10mm X 50mm) to determine flexural strength - were cast. All specimens were prepared in accordance with Indian Standard Specifications IS 516-1959. Care was taken that no gaps were left in areas where any possibility of slurry leakage could occur. Vibrations were stopped as soon as cement slurry appeared on the top surface of the mould. For each mix, 3 cubes, 3 beams, and 3 cylinders were cast and tested for their respective strengths. The average of 3 measurements for each sample is considered as the final value for their respective strengths.

3.3 EXPERIMENTAL PROCEDURE

An experimental investigation was carried out with reference to a concrete mix of M25 grade concrete. Twelve mixes were prepared. A reference mix (RC) was prepared for M25 grade of concrete per IS: 10262-2009. Five concrete mixes (RC, FS10, FS20, FS30, FS40, FS50) were prepared where the fine aggregate was replaced with 10%, 20%, 30%, 40%, and 50% foundry sand by mass, respectively. It was observed that concrete with 40% FS replacement attains maximum strength properties. Hence, the 40% FS replacement was kept constant, and a cement replacement study was carried out separately; mineral admixtures such as fly ash at 10%, 15%, 20% (FA10+FS40, FA15+FS40, FA20+FS40) and silica fume at 5%, 7.5%, 10% (SF5+FS40+SF7.5+FS40,SF10+FS40) were added in. A number of trial mixes were prepared for the available materials such as cement, coarse aggregate, and fine aggregate, starting with a water-cement ratio of 0.5. Finally, we arrived at the target strength of M25 grade mix at a water-cement ratio of 0.47. Hence, a water-cement ratio of 0.47 was used throughout the study. Component proportions of all mixes are shown in Table 4**.**

4. RESULTS AND DISCUSSIONS

4.1 FRESH CONCRETE PROPERTIES

The workability of fresh concrete is a composite property which includes the diverse requirements of stability, mobility, compatibility, place ability, and finishability. A compaction factor test is based on the definition that workability is a property of concrete which determines the amount of work required to produce full compaction. Compaction factor tests were performed per BIS: 1199-1959. These tests were conducted on different mixes and their results are shown in Table 4. It was observed that as the percentage of foundry sand replacement increased, its workability decreased.

Table 4. Different Mixes Cast

Mix No.	RC	FS10	FS20	FS30	FS40	FS50	FA10+ FS40	FA15+ FS40	FA20+ FS40	SF5+ FS40	SF7.5+ FS40	SF10+ FS40
Cement (kg/m^3)	419.14	419.14	419.14	419.14	419.14	419.14	377.23	356.27	335.32	398.19	387.79	377.23
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
Foundry sand (%)	0	10	20	30	40	50	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
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
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
Water (kg/m^3)	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
Fly ash (%)	0	0	0	0	0	0	10	15	20	0	0	0
Fly ash (kg)	0	0	0	0	0	0	41.91	62.87	83.82	0	0	0
Silica fume (%)	0	0	0	0	0	0	0	0	0	5	7.5	10
Silica fume (kg)	0	0	0	0	0	0	0	0	0	20.95	31.35	41.91
Compaction factor	0.959	0.942	0.931	0.914	0.87	0.83	0.951	0.948	0.942	0.961	0.958	0.952

4.2. COMPRESSIVE STRENGTHS OF CONCRETE

The compressive strength of the reference mix (RC) and all other mixes prepared using foundry sand, fly ash, and silica fume is shown in Table 5.

An increase in compressive strength was observed gradually up to 40% fine aggregate replacement, but then compressive strength decreased. A maximum compressive strength of 38.70 N/mm^2 was obtained at 40% replacement. Maximum compressive strength was obtained with the FS40 mix (40%

foundry sand), which was 17.1% higher when compared to the reference mix. Variations of the compressive strengths of the different M25 grade mixes is shown in Figure 1.

The compressive strength of M25 grade concrete was studied with a combination of 40% foundry sand and 10%, 15%, and 20% fly ash replaced with cement. The mix of M25 grade concrete with 40% foundry sand and 10% fly ash obtained the highest maximum strength value among all fly ash replacements. It was observed that as the fly ash percentage in concrete increased, its compressive strength decreased. A mix with 40% foundry sand and 10% fly ash (FA10+FS40) obtained a compressive strength 35.11N/mm^2, which was 5.1% more than the reference mix (RC), though it was still lower than the FS40 mix.

The compressive strength of M25 grade concrete was studied with a combination of 40% foundry sand and 5%, 7.5%, 10% silica fume replaced with cement. The mix with 40% foundry sand and 10% silica fume obtained the highest maximum strength when compared to the other silica fume replacements. It was observed that as the silica fume percentage in concrete increased, its compressive strength also increased. The mix with 40% FS and 10% silica fume (SF10+FS40) replacement obtained a compressive strength of 42.96N/mm^2, which was 28.7% more than the reference mix. Variations of the compressive strengths of the mixes with 40% foundry sand and different percentages of fly ash and silica fume are shown in Figure 2.

Table 5. Strength Properties of Concrete

Mix No.	Compressive strength in N/mm^2	% Improvement in compressive strength	Split tensile strength in N/mm^2	% Improvement of split tensile strength	Flexural strength in N/mm^2	% Improvement of split tensile strength
RC	33.03	----	2.75	-----	2.57	----
FS10	34.98	5.9	2.83	2.9	2.67	3.9
FS20	36.60	10.8	2.98	8.4	2.90	12.8
FS30	37.88	14.7	3.12	13.5	3.20	24.5
FS40	38.70	17.1	3.40	23.6	3.34	30
FS50	36.13	9.4	3.12	13.5	3.01	17.1
FA10+FS40	35.11	5.2	3.04	10.6	2.90	12.8
FA15+FS40	33.85	1.4	2.97	8.0	2.87	11.7
FA20+FS40	31.29	-6.2	2.91	5.8	2.71	5.4
SF5+FS40	39.82	19.3	3.61	31.3	3.42	33.1
SF7.5+FS40	40.71	22	3.67	33.5	3.47	35.0
SF 10+FS40	42.96	28.7	3.74	36.0	3.52	37

4.3 SPLIT TENSILE STRENGTHS OF CONCRETE

The split tensile strengths of the reference mix (RC) and all the other mixes prepared using foundry sand, fly ash, and silica fume are shown in Table 5.

It was observed that an increase in split tensile strength was observed gradually up to 40% fine aggregate replacement, and then the strength values decreased. A maximum split tensile strength of 3.40 N/mm^2 was obtained at 40% foundry sand replacement. The maximum split tensile strength obtained with the FS40 mix (40% foundry sand) was 23.6% more than the reference mix. Variations of the split tensile strengths are shown in Figure 3.

The split tensile strengths were studied with a combination of 40% foundry sand and 10%, 15%, and 20% fly ash replaced with cement. The mix with 40% foundry sand and 10% fly ash obtained the maximum strength value among all fly ash replacements. It was observed that as the fly ash percentage in concrete increased, its split tensile strength decreased. A mix with 40% foundry sand and 10% fly ash (FA10+FS40) obtained a split tensile strength 3.04N/mm^2, which was 10.5% more than the reference mix (RC), but it was a lower strength value than that of the mix with 40% foundry sand alone (FS40).

The split tensile strength of M25 grade concrete was studied with a combination of 40% foundry sand and 5%, 7.5%, 10% silica fume replaced with cement. The mix with 40% foundry sand and 10% silica fume obtained the maximum strength value among all silica fume replacements. It was observed that as the silica fume percentage in concrete increased, its split tensile strength increased as well. The mix with 40% FS replacement and 10% silica fume (SF10+FS40) replacement obtained a split tensile strength of 3.74N/mm^2, which was 36% more than the reference mix. Variations of the split tensile strengths of concrete with 40% foundry sand and different percentages of fly ash and silica fume are as shown in Figure 4.

4.4 Flexural Strengths of Concrete

The flexural strength of the reference mix (RC) and all other mixes is shown in Table 5. It was observed that an increase in flexural strength was observed gradually up to 40% replacement, but it then decreased. The maximum flexural strength obtained was 3.34 N/mm^2 at 40% foundry sand replacement. Maximum flexural strength was obtained with the FS40 mix (40% foundry sand) which was 29.9% higher than the reference mix. Variations of the flexural strengths of the different percentages of replacement are shown in Figure 5.

Flexural strengths of the mixes were studied with a 40% foundry sand additive and 10%, 15%, 20% fly ash replaced with cement. The mix with 40% foundry sand and 10% fly ash obtained the maximum strength value among all the fly ash replacements. It was observed that as the fly ash percentage in concrete increased, its flexural strength decreased. A mix with 40% foundry sand and 10% fly ash (FA10+FS40) obtained a flexural strength of 2.9N/mm^2, which was 12.8% more than the reference mix (RC), but it was a lower strength than the mix with 40% foundry sand alone (FS40).

The flexural strength of M25 grade concrete was studied with a combination of 40% foundry sand and 5%, 7.5%, and 10% silica fume replaced with cement. The mix with 40% foundry sand and 10% silica fume obtained the highest maximum strength over all remaining silica fume replacements. It was observed that as the silica fume percentage in concrete increased, its flexural strength increased as well. The mix with 40% foundry sand and 10% silica fume (SF10+FS40) obtained a flexural strength of 3.52N/mm^2, which was 36.9% more than the reference mix. Variations of the flexural strengths of concrete with 40% foundry sand and different percentages of fly ash and silica fume are shown in Figure 6.

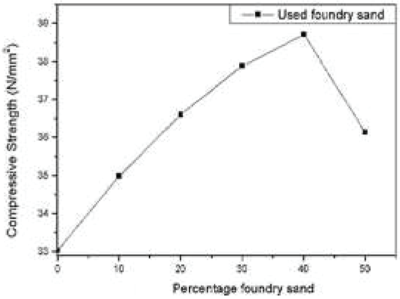

Figure 1. Relation between the percentage of foundry sand and compressive strength

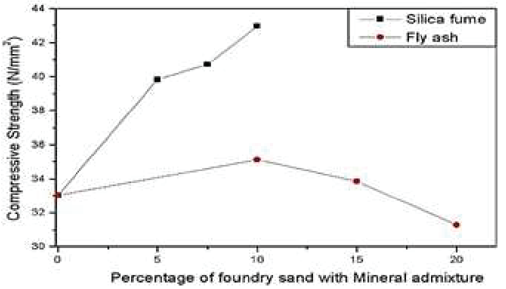

Figure 2. Relation between the percentages of foundry sand with fly ash and silica fume and compressive strength

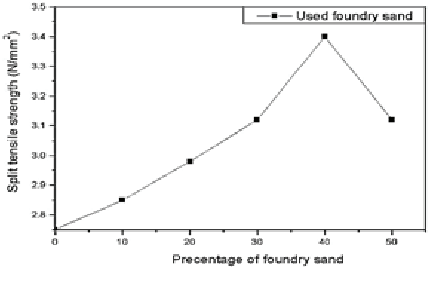

Figure 3. Relation between the percentage of foundry sand and split tensile strength

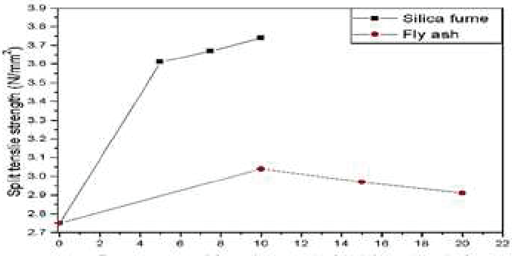

Figure 4. Relation between the percentages of foundry sand with fly ash and silica fume and split tensile strength

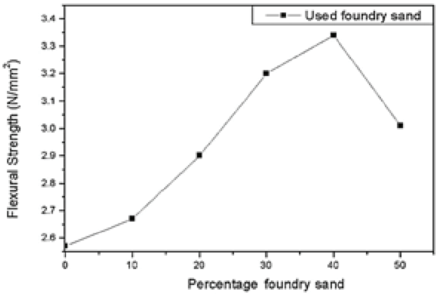

Figure 5. Relation between the percentages of foundry sand and flexural strength

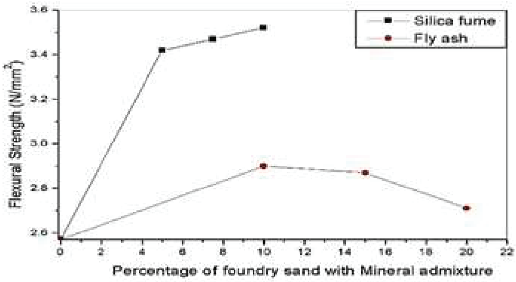

Figure 6. Relation between the percentages of foundry sand with fly ash and silica fume and flexural strength

4.5. SEM ANALYSIS

To study the effects of foundry sand replacement along with mineral admixtures like fly ash and silica fume on concrete specimens, SEM analysis was conducted to identify the changes in the microstructures of the concrete. Specimens were examined at 2 µm and 3 µm microstructural images.

Figures 7 and 8 represent SEM images of the specimen produced with the reference mix (RC) and a mix with 40% foundry sand replacement (FS40).

Figure 7 represents a 3 µm micrograph of the reference mix specimen which depicts the formation of a uniform the C-S-H gel and evenly distributed pores of longer sizes.

Figure 8 represents a 2 µm micrograph of the concrete sample prepared with 40% foundry sand (FS40) which shows a uniform distribution of the C-S-H gel with a lower number of pores of smaller size.

In Figures 8 and 9 SEM images of the sample cast with 40% foundry sand and 10% fly ash (FA10+FS40) and 40% foundry sand with 10% silica fume (SF10+FS40) can be seen.

Figure 9 indicates a 3 µm micrograph of the concrete sample with 40% foundry sand and 10% fly ash in cement (FA10+FS40) showing the number of C-H-S gel with large small pores resulting in increased strength as compared to the other mixes.

Figure 10 indicates a 2 µm micrograph of the concrete sample made with 40% foundry sand with 10% silica fume (SF10+FS40) depicting a densely formed C-H-S gel with a lower number of small pores leading to maximum strength among all mixes evaluated in the present study.

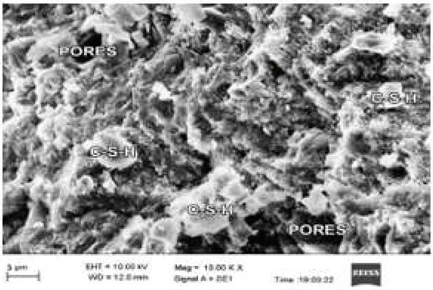

Figure 7 Micrograph of reference mix (RC)

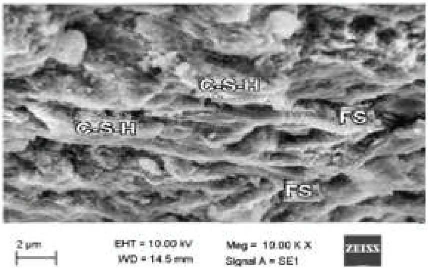

Figure 8 Micrograph of replacement of 40% Foundry sand (FS40)

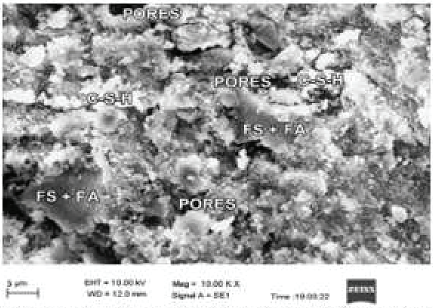

Figure 9 Micrograph of replacement of 40% FS with 10% FA

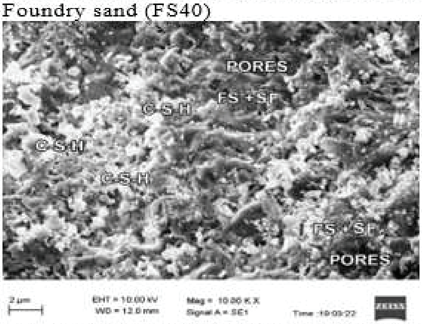

Figure 10 Micrograph of replacement of 40% FS with 10% SF

5. CONCLUSION

Based on the above research, the following observations are made regarding the strength properties of concrete with partial replacement of fine aggregate by foundry sand and of cement by mineral admixtures such as fly ash and silica fume:

- As the percentage of foundry sand increased, its workability decreased.
- As the percentage of foundry sand increased, strength properties like compressive strength, split tensile strength, and flexural strength all increased up to the 40% replacement ratio, and then decreased.
- Keeping 40% as the optimum percentage of FS replacement in further experiments, mineral admixtures like fly ash (10%, 15%, 20%) and silica fume (5%, 7.5%, 10%) were tested.
- The concrete mix with 40% foundry sand and 10% silica fume obtained the highest strength properties compared to all other mixes.
- The concrete mix with 40% foundry sand and 10% fly ash obtained higher strength properties than the reference mix.

- Based on experimental results it is observed that there is more improvement in the strength properties of concrete when incorporating foundry sand and silica fume than when using a combination of foundry sand and fly ash.
- SEM analysis of the concrete samples reveals that the concrete sample with 40% foundry sand replacement and 10 % silica fume replacement obtained the highest strength properties due to the densely formed C-S-H gels and a meagre number of smaller pores.

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WPŁYW PIASKU ODLEWNICZEGO I DOMIESZEK MINERALNYCH NA WŁAŚCIWOŚCI MECHANICZNE BETONU

Słowa kluczowe: piasek odlewniczy, popiół lotny, pył krzemionkowy, właściwości wytrzymałościowe, analiza SEM

STRESZCZENIE:

Ze względu na swoją przewodność cieplną, piasek jest używany od wieków jako materiał formierski w przemyśle odlewniczym wykorzystującym metale żelazne i nieżelazne. Odlewnie z powodzeniem wielokrotnie przetwarzają i ponownie wykorzystują piasek. Jeśli piasek nie może być ponownie użyty w odlewni, wówczas jest on usuwany z odlewni i określany jako ŻUŻYTY PIASEK ODLEWNICZY (UFS) lub ODPADOWY PIASEK ODLEWNICZY (WFS). Takie odpady zużytego piasku odlewniczego mogą być wykorzystywane w procesie przygotowywania betonu w ramach częściowej wymiany piasku. W celu zbadania możliwości wykorzystania zużytego piasku odlewniczego jako częściowego zamiennika dla drobnego kruszywa, przeprowadzono badanie eksperymentalne.

Właściwości wytrzymałościowe, takie jak wytrzymałość na ściskanie, wytrzymałość na rozciąganie i wytrzymałość na zginanie betonu klasy M25 są badane z zastosowaniem różnego procentowego zastąpienia drobnego kruszywa zużytym piaskiem odlewniczym, przy wartościach 0%, 10%, 20%, 30%, 40% i 50%. Określona zostanie optymalna zawartość procentowa zużytego piasku odlewniczego w betonie, odpowiadająca maksymalnej wytrzymałości. W celu utrzymania takiej optymalnej zawartości procentowej w odniesieniu do takiej wymiany zużytego piasku odlewniczego przeprowadzane są badania wymiany cementu z domieszkami, takimi jak popiół lotny (10%, 15%, 20%) oraz pył krzemionkowy (5%, 7,5%, 10%), oddzielnie dla właściwości wytrzymałościowych betonu. W ramach powyższych badań, określono maksymalną wytrzymałość betonu odpowiadającą wymianie pyłu krzemionkowego i popiołu lotnego. Zaobserwowano, że maksymalny wzrost właściwości wytrzymałościowych w porównaniu do konwencjonalnego betonu został osiągnięty przy 40% zastąpieniu zużytego piasku odlewniczego. Maksymalny wzrost wytrzymałości zaobserwowano w mieszaninie składającej się z 40% piasku odlewniczego z 10% zawartością pyłu krzemionkowego. Analiza SEM próbek betonu pokazuje również, że mieszanina z 40% zawartością piasku odlewniczego oraz 10% zawartością pyłu krzemionkowego uzyskała najwyższe właściwości wytrzymałościowe w porównaniu do wszystkich innych mieszanin, ze względu na tworzenie większej ilości form żelowych C-H-S i mniejszej ilości porów.