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"Experimental Investigation of Mineral Admixtures on Ternary Blend Concrete with different Water Binder Ratios"

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ABSTRACT:

The present study is carried out on the partial replacement of cement with fly ash / micro silica for the development of Blended Concrete. Previous studies have led to the development of binary, ternary, quaternary blended concrete (depending on the number CCM and their combinations). Compressive strength of ternary blended concrete at the ages of 7, 14, 21 and 28 days for various combinations of micro silica and fly ash mixes was investigated. Micro silica of 0%, 5%, and 10% and15% along with fly ash by 10%, 20% 30% and 40% were used as replacement materials and were studied at different water cement ratios.

Keywords*:* Micro Silica, Fly ash, CCM, Compressive Strength.

I. INTRODUCTION

As our needs for different types of construction are continuously increasing in the present era, we also require different types of construction materials to fulfill these needs. In conventional concrete, portland cement is frequently used as the primary ingredient. The heating of limestone releases carbon dioxide into the atmosphere directly, and the use of fossil fuels to heat the kiln indirectly emits carbon dioxide into the atmosphere.

Cement conservation, aggregate conservation, water conservation, and concrete durability are a few of the various strategies that can be considered in order to lessen these negative consequences in the production of cement. As a result, it has become important to combine various ingredients. Fly ash, a byproduct of thermal power plants, is the most widely used mineral ingredient in concrete

globally. The addition of fly ash to concrete improves the workability of plastic concrete as well as the strength and durability of hardened concrete. Fly ash utilization is also cost-effective. If fly ash is included, the amount of portland cement in the concrete may be reduced. Scientists from all over the world are creating ternary blended concrete by adding a superfine mineral addition, such as micro silica, to the binary blended concretes of fly ash. Micro silica is an excellent additive for concrete because it has outstanding technical properties. This study's objective is to assess and contrast the performance of fly ash and silica-containing concretes to that of conventional concrete.

II. LITERATURE REVIEW

Some of the recent researchers have examined the use of micro silica and fly ash in concrete.

Jung and Choi (2017) The effectiveness of a newly created ternary blended concrete mix in preventing thermal cracking in large concrete structures was assessed, as well as its field viability. According to their findings, changes in temperature and strain in the test member were greatly decreased by the ternary mix's lower heat of hydration.

Jafari and Javad (2019) Portland cement can be substituted for pozzolanic materials, according to research, which found that doing so is almost always advantageous. The use of ternary blended mixes can help achieve the best possible fire resistance outcomes and offset the environmental costs associated with using inferior pozzolana across all damage categories.

Padavala Siva and Anjaneya Babu (2021) Cement is partially substituted with the mixture of fly ash (FA) and silica fume (SF) to generate a ternary blended mix concrete.) examined the reduction impacts of large amount of energy in the manufacture and releases a lot of CO_2. Their research centred on the mechanical properties and behaviour of ternary mixed concrete mix of M30 grade. For the creation of blended concrete mix, various percentage substitutions of cement by FA (20%, 30%, 40%) and SF (5%, 7.5%, 10%) were used. The best compressive, split tensile, and flexural properties were demonstrated by a ternary mix consisting of 62.5% cement, 30% FA, and 7.5% SF.

Prasad Ravella (2022) His research was primarily concerned with the performance of very effective self-compacting concretes mixed with ternary cementitious systems incorporating fly ash and silica fume. Along with the findings of the experimental tests, a system for determining the ideal mix proportions for ternary blended cement concretes was created.

III. EXPERIMENTAL INVESTIGATION

The current study's objective is to determine how mineral admixtures affect the compressive strength of ternary concrete, which is a mixture of micro silica and fly ash that helps to generate the strongest concrete possible. In the Ternary mixes, the cement was substituted to a maximum of 30%. Five different combinations in total were looked at. By weight of cement with different w/b ratios of 0.55,0.45 and 0.35, 5% micro silica + 15% fly ash, 5% micro silica + 20% fly ash, 10% micro silica + 15% fly ash, 10% micro silica + 20% fly ash, and 0% micro silica + 0% fly ash were examined. At 7,14,21 and 28 days old, the compressive strength was calculated.

IV. MATERIALS

a) **Materials Used** Cement, fine aggregate, and coarse aggregate are the three ingredients that make up concrete. Each of these three raw components is crucial in the production of concrete. The characteristics of concrete alter as the qualities and amounts of various components change. Cement, fine aggregate, coarse aggregate, mineral admixtures, and chemical admixtures make up the bulk of the raw materials employed in this innovative effort.

b) **Silica fume** It is pozzolanic, like metakaoline, which is made of rice husk ash. Cement made using Portland Pozzolanic is made using these (PPC). The cement is strengthened by silica. If there is an excess, cement takes longer to set but gains in strength.

c) **Cement** Cement is the main ingredient in manufacturing of concrete. The characteristics of concrete was affected by changing the cement content. The cement used in this project is Ordinary Portland cement of 53 grade conforming to IS 12269 – 1987.

d) **Fine Aggregate** The local market sells natural river sand that has a specific gravity of 2.62 and goes through a 4.75mm filter.

e) **Coarse Aggregate:** In this investigation, crushed granite that complies with IS 383 - 1970 is used. Used was coarse aggregate with a specific gravity of 2.82 that passed through a 20 mm sieve but was held on a 16 mm sieve.

f) **Water** Water is a crucial component of concrete since it actively participates in the chemical reaction with cement; our college campus has access to clean portable water, which is used. Concrete specimens were mixed with water that complied with IS: 456-2000, and they were

then allowed to cure.

Quantity of material required are shown below from table no. 1 to table no. 4

Table 1: Quantities of material required for ternary blended concrete (per m^3)

S.No	W/B	Cement	Micro silica (5%)	Fly ash (15%)	Fine Aggregate	Coarse Aggregate	Water
1	0.55	259	16.20	48.6	736.0	1084.0	178
2	0.45	312	`19.55	58.65	697.0	1070.0	176
3	0.35	397	24.85	74.55	629.0	1050.0	174

Table 2: Quantities of material required for ternary blended concrete (per m^3)

S.No	W/B	Cement	Micro (silica 5%)	Fly ash (20%)	Fine Aggregate	Coarse Aggregate	Water
1	0.55	243	16.20	64.8	736.0	1084.0	178
2	0.45	293	19.55	78.2	697.0	1070.0	176
3	0.35	373	24.85	99.4	629.0	1050.0	174

Table 3: Quantities of material required for ternary blended concrete (per m^3)

S.No	W/B	Cement	Micro silica (10%)	Fly ash (15%)	Fine Aggregate	Coarse Aggregate	Water
1	0.55	243	32.4	48.6	736.0	1084.0	178
2	0.45	293	39.1	58.65	697.0	1070.0	176
3	0.35	373	49.7	74.55	629.0	1050.0	174

Table 4: Quantities of material required for ternary blended concrete (per m^3)

S.No	W/B	Cement	Micro silica (10%)	Fly ash (20%)	Fine Aggregate	Coarse Aggregate	Water
1	0.55	227	32.4	64.8	736.0	1084.0	178
2	0.45	274	39.1	78.2	697.0	1070.0	176
3	0.35	348	49.7	99.4	629.0	1050.0	174

V. RESULT AND DISCUSSION

a. Workability of Ternary Blended Concrete

When fly ash and micro silica are combined, the positive impact of fly ash on fluidity can be used to make up for the workability loss caused by the addition of micro silica. In terms of water to binder ratios, 5% micro silica + 20% fly ash requires the least amount of water cement, whereas 10% micro silica + 15% fly ash requires the most amount of water cement. It was found that the fly ash content rises when the water to binder ratio falls. More fly ash content is needed to adsorb on the surface of cement and mineral additive particles to increase the fluidity of the mix as the water to binder ratio declines.

Fig 1: Slump cone test

b. Compressive Strength of Ordinary and Ternary Blended Concrete

For convenience mineral admixture replace nomenclature reference table are given below

Reference table: Mineral admixture replace nomenclature

1C	Combination of 0% Micro Silica + 0% Fly Ash
2C	Combination of 5% Micro Silica + 15% Fly Ash
3C	Combination of 5% Micro Silica + 20% Fly Ash
4C	Combination of 10% Micro Silica + 15% Fly Ash
5C	Combination of 10% Micro Silica + 20% Fly Ash

In comparison to control mix proportions shown in tables 1.0 to 5.0, the addition of micro silica and fly ash increases compressive strength at ages 7,14,21 and 28 days, regardless of water to binder ratios. The best mix of the four examined for all the water to binder ratios is composed of 5% micro silica, 15% fly ash, and 80% cement. It was observed that mineral admixtures tended to perform less effectively when cement was replaced by more than 20%. The strength of the other combinations, consisting of 5% micro silica + 20% fly ash and 10% micro silica + 15% fly ash, which used 25% of mineral admixtures in place of cement, did not significantly improve. For w/b ratios of 0.55 and 0.45, 0.35, the mixture of 10% micro silica and 20% fly ash demonstrated a reduction in strength compared to control concrete at the age of 28 days.

From Table 5, it can be seen that the compressive strength ranges from 28.95 to 60.04 MPa for ordinary concrete, 33.67 to 83.78 MPa for ternary blended concrete (TBC) (5% Micro Silica + 15% Fly Ash), 31.78 to 77.88 MPa for ternary blended concrete (TBC) (5% Micro Silica + 20% Fly Ash), 32.91 to 81.08 MPa for ternary blended concrete (TBC) (10% Micro Silica+ 20% Fly Ash) , 27.20 to 67.30MPa for Ternary Blended Concrete(TBC) (10% Micro Silica + 20% Fly Ash) with W/B ratios of 0.55, 0.45,

0.35 respectively.

Table 5: Compressive strength of ordinary and ternary blended concrete at different w/b ratio

S. No.	Compressive strength (MPa)											
	w/b ratio											
	0.55				0.45				0.35			
	7 Days	14 Days	21 Days	28 Days	7 Days	14 Days	21 Days	28 Days	7 Days	14 Days	21 Days	28 Days
1C	28.95	31.42	33.44	35.20	32.57	35.61	38.42	42.32	40.57	46.72	53.24	60.04
2C	33.67	38.87	40.81	43.64	40.25	47.00	51.73	56.22	54.77	65.00	72.70	83.78
3C	31.78	36.35	38.80	41.47	37.07	42.90	46.84	52.00	49.89	60.04	67.00	77.88
4C	32.91	37.56	39.64	42.11	38.88	45.51	49.63	54.75	53.45	63.14	70.82	81.08
5C	27.20	32.60	34.00	37.10	31.58	37.78	41.98	44.12	41.30	52.20	59.12	67.30

c. Increase of compressive strength of ternary blended concrete (5% micro silica + 15% fly ash) compared with ordinary concrete

Figure 2 shows that the improvement in compressive strength of ternary blended concrete from 7 days to 28 days compared to ordinary concrete is 16% to 40% for all w/b ratios. At 0.35 w/b ratio, the percent gain in compressive strength was determined to be the highest.

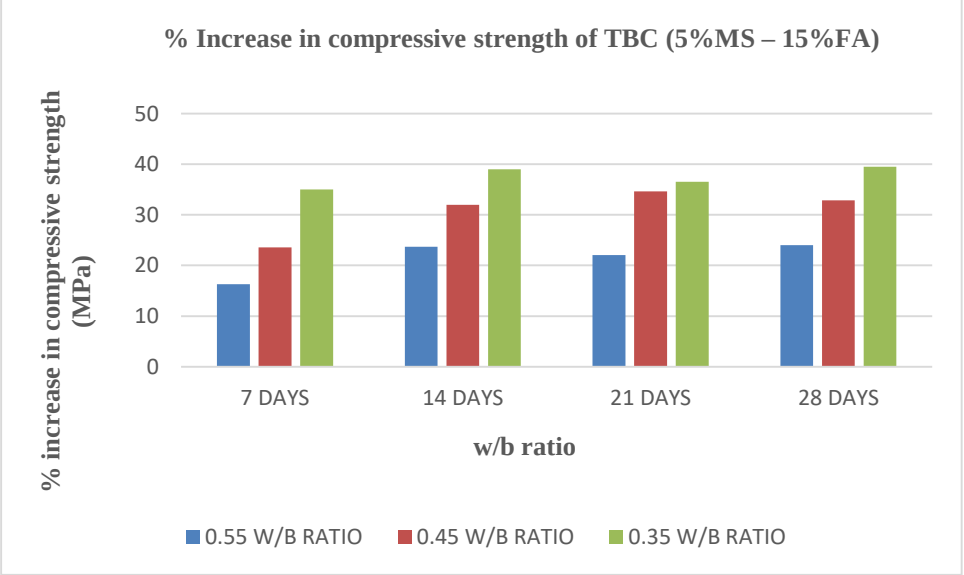

Fig 2: Percentage increase in compressive strength of ternary blended concrete (5% MS + 15% FA) with respect to ordinary concrete at the age of 7,14,21 and 28 days.

d. Increase of compressive strength of ternary blended concrete (5% micro silica + 20% fly ash) compared with ordinary concrete

From Fig. 3, it can be shown that the ternary blended concrete increases its compressive strength from 7 days to 28 days by 9% to 30% for all w/b ratios. Maximum percentage growth in compressive strength was discovered at 0.35 w/b ratio.

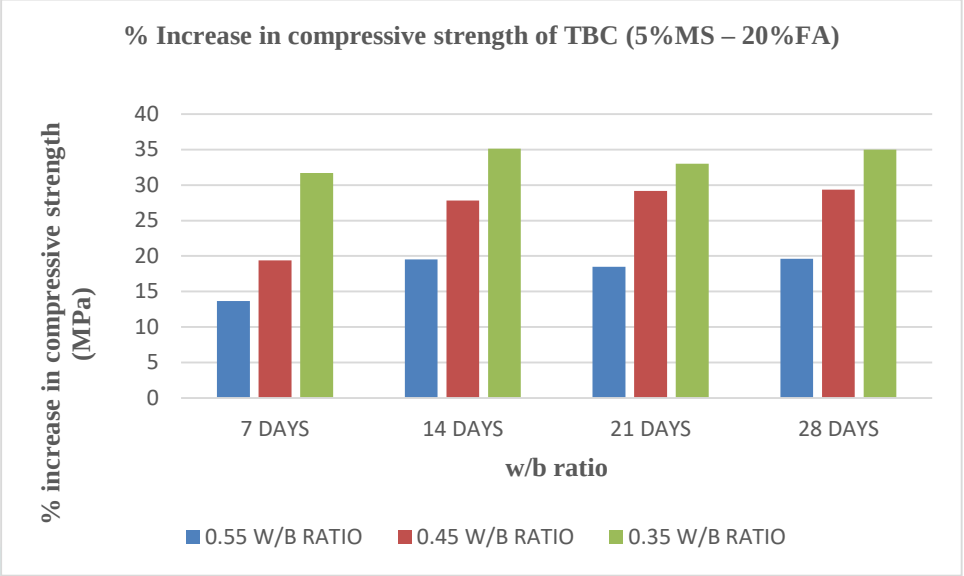

Fig 3: Percentage increase in compressive strength of ternary blended concrete (5% MS + 20% FA) with respect to ordinary concrete at the age of 7,14,21 and 28 days.

e. Increase of compressive strength of ternary blended concrete (10% micro silica + 15% flyash) compared with ordinary concrete

According to Fig. 4, for all w/b ratios, the increase in compressive strength of ternary blended concrete over conventional concrete from 7 days to 28 days is 13% to 35%. Maximum percentage growth in compressive strength was discovered at 0.35 w/b ratio.

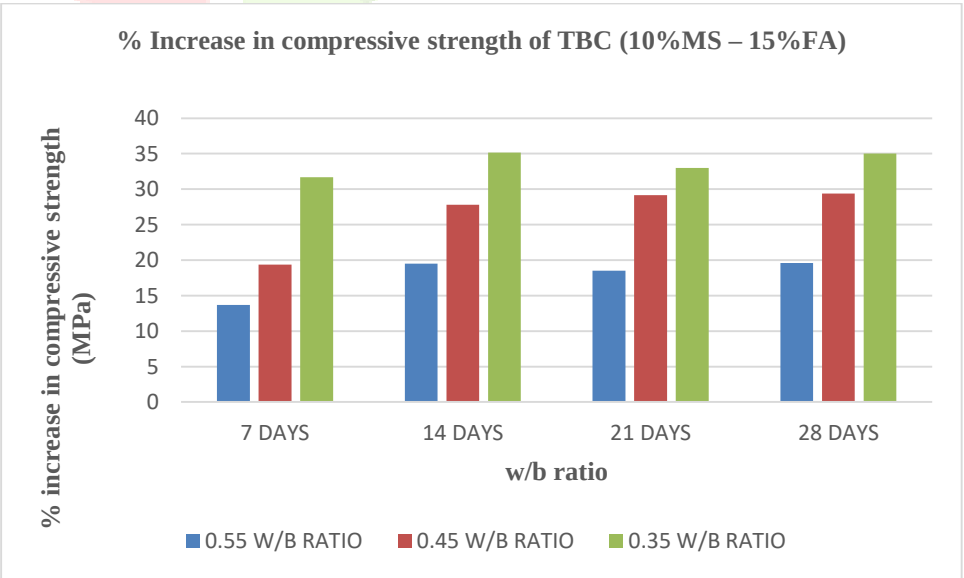

Fig 4: Percentage increase in compressive strength of ternary blended concrete (10% MS + 15% FA) with respect to ordinary concrete at the age of 7,14,21 and 28 days.

f. Increase of compressive strength of ternary blended concrete (10% micro silica + 20% fly ash) compared with ordinary concrete

From Fig. 5, it can be shown that ternary blended concrete exhibits a -6.0% to 12.0% increase in compressive strength from 7 days to 28 days when compared to regular concrete.

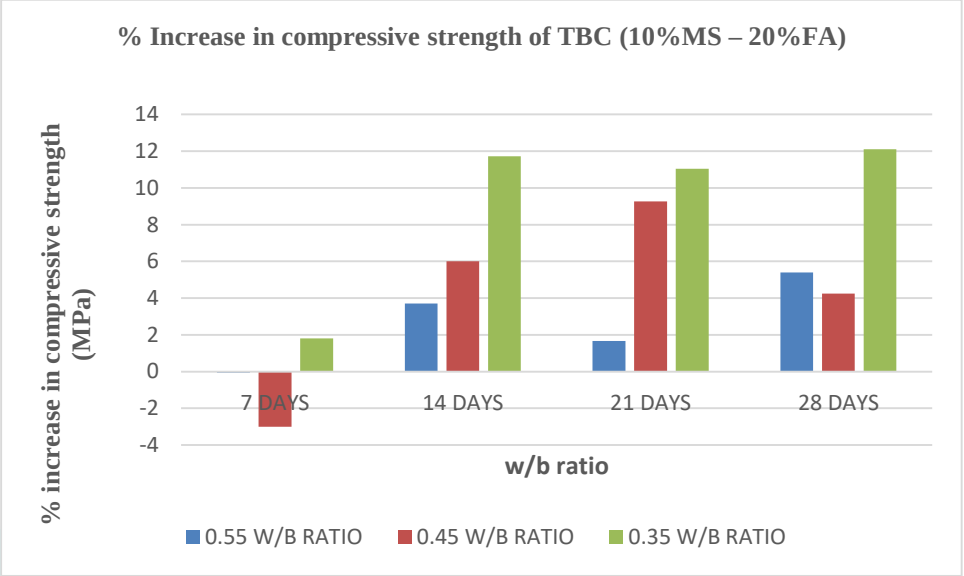

Fig 5: Percentage increase in compressive strength of ternary blended concrete (10% MS + 20% FA) with respect to ordinary concrete at the age of 7,14,21 and 28 days.

VI. CONCLUSION

1) Out of the three w/b ratios, the combination of 5% micro silica and 20% fly ash offers the best workability.
2) In terms of compressive strength, the blend of 5% micro silica + 15% fly ash outperformed all other combinations at all ages and w/b ratios examined.
3) Among all the ternary mixes, the 10% micro silica + 20% fly ash combination had the lowest compressive strength at all w/b ratios and varied ages.
4) For various w/b ratios, it is discovered that ternary blended concrete (5% micro silica + 15% fly ash) increases compressive strength by 16% to 40% compared to regular concrete (4.72 MPa to 23.74 MPa).The percentage increase in compressive strength of ternary blended concrete is found to be higher at higher ages for all water to binder ratios.
5) According to the results, ternary blended concrete has a number of advantages over control concrete. When these components are employed separately, such concretes exhibit usually favorable characteristics and mitigate the drawbacks of using fly ash and micro silica. The

creation of new cement types that combine different cementitious materials in ternary cementitious systems needs to receive more focus.

6) Fly ash and micro silica are a good combination. Fly ash consistently enhances the qualities of hardened concrete as it ages, while micro silica enhances the performance of concrete at young ages.

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