COMPARATIVE STUDY ON STRENGTH PROPERTIES OF CONCRETE BY REPLACING CEMENT WITH COMBINATIONS OF MINERAL ADMIXTURES

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Abstract: **In a growing country like India a huge amount of usage of cement is polluting the Environment. With reference to the statement, this study aims at utilization of industrial by product such as GGBS, fly ash, silica fume, rice husk ash, metakolian etc, for value added application. In addition the waste used can improve the properties of construction materials. The fly ash, GGBS, silica fume, rice husk ash, metakolian has been used in this project. The mentioned materials were tested as concrete ingredients. Cement was replaced by fly ash, silica fume, rice husk ash, metakolian and GGBS with different mix proportions along varying percentage of fly ash, silica fume, rice husk ash, metakolian and GGBS for concrete with suitable water cement ratio. The compressive strength, split tensile strength, shear test, impact test and flexural strength were conducted for the above replacements.**

Index Terms **– Metakaolin, Silica Fumes, Rice Husk Ash, Fly Ash, GGBS, Compressive Strength, Flexural Strength, Split Tensile Strength.**

1. INTRODUCTION

Concrete's versatility, durability, sustainability, and economy have made it the world's most widely used construction material. The term concrete refers to a mixture of aggregates, usually sand, and either gravel or crushed stone, held together by a binder of cementitious paste. The paste is typically made up of Portland cement and water and may also contain supplementary cementing materials, such as fly ash, GGBS, rice husk ash, silica fume, metakaolin or slag cement, and chemical admixtures. High Performance concrete (HPC) is achieved by utilizing the mineral admixtures. In the present experimental work fly ash, GGBS, rice husk ash, silica fume, and metakaolin type of mineral admixtures is mixed with the replacement of cement .HPC posse's greater strength parameters which include compression, tensile, flexure, and impact makes stronger than conventional concrete. Admixtures are added in concrete to improve the quality of concrete. Mineral admixtures include fly ash (FA), silica fume (SF), ground granulated blast furnace slag (GGBS), metakaolin (MK), and rice husk ash (RHA) which possess certain characteristics through which they influence the properties of concrete differently. The reported benefits of mineral admixtures are often associated with the harden properties of concrete; however, mineral admixtures may also influence the properties of wet concrete between the time of mixing and hardening in one or more of the following ways such as they may affect water demand, heat of hydration, setting time, bleeding, and reactivity. Deterioration due to storage is less in HPC. It can be cast into beams and slab. Chemical reaction occurs after few hours of mixing makes the mixtures hardened and solidifies. Quality of concrete increases with age. Ordinary Portland cement may not give good strength and durability hence to overcome this HPC can be used. With the advent of admixture, it has now been possible to produce the concrete of much higher strength than the normal concrete. Concrete of strength approximately 138 MPa is commercially available as High Performance Concrete (HPC). High performance high strength concrete is very commonly used in building column, bridge super structures and decks. High performance concrete (HPC) is a specialized series of concrete designed to provide several benefits in the construction of concrete structures that cannot always be achieved routinely using conventional ingredients, normal mixing and curing practices. In the other words a high performance concrete is a concrete in which certain characteristics are developed for a particular application and environment, so that it will give excellent performance in the structure in which it will be placed, in the environment to which it will be exposed, and with the loads to which it will be subjected during its design life.

2. OBJECTIVES

Approach to this current project is to appraise the strength and behavior of HPC. At the investigation an effort had been made to improve the concrete strength by adding supplementary cementitious materials like (fly ash, GGBS, rice husk ash, silica fume, metakaolin).

The cubes, cylinders, beams specimens are casted with concrete comprising of primary ingredients and cementitious materials. To check the compressive, split tensile and flexural strength tests of the specimens are conducted after a curing period of 28 days.

3.LITERATURE REVIEW

General

There are various experimental investigation that have been done in0the field of High performance concrete (HPC), some of the papers have been discussed or reviewed here in order to support the objective of the present project work.

Literature survey:

[1] **Dr.H.M. Somasekharaiah et.al.** In this thesis, a study had been made for the development of High Performance Concrete using mineral admixtures such as Fly-ash, Silica-fume and Metakaolin. The compressive strength, split tensile strength and flexural strength of the plain concrete specimens without any mineral admixture have been compared with that of compressive-strength, split-tensile strength and flexural-strength of composite concrete made up of mineral admixtures for different W/B ratios.

[2] **Barham Haidar Ali et.al.** This paper deals with the outcomes of an experimental research on mechanical properties of conventional concrete and a concrete incorporated metakaolin (MK) without steel fibre. One of the ingredients of the concrete mixture was metakaolin; Portland cement was partially substituted with metakaolin (MK) as 10% by weight of the total binder content. Value of water/binder ratios (w/b) was 0.35. To know the impacts of MK, the mechanical behaviors of the concrete were investigated such as: compressive, flexure, and bonding strength of the concretes.

[3] **Prodosh.kDinaker.P and Sriram.G [4].** Represented that plastic density of mix reduces by the use of cement replaced with metakaolin fine particles of metakaolin filled in the pores which tends to decrease the concrete porosity. Strength parameter tends to increase in the investigation.

[4] **ThavasumonyD et.al, (2014)** To produce high strength concrete these Ground Granulated Blast Furnace Slag is used. It is obtained by quenching molten iron Slag (a by-product of iron and steel making) from blast Furnace in water or steam. GGBS is used to make durable concrete structure in combination with ordinary Portland cement and (or) other pozzolona materials. Concrete containing GGBS cement has a higher ultimate strength than concrete made with Portland cement. It has a higher portion of the strength enhancing calcium silicate hydrates than concrete made with Portland cement only and a reduce content of free lime which does not contribute to concrete strength, concrete made with GGBFS continues to gain strength overtime, and has been shown to double its 28-day-strength over periods of 10 to 12 years. Our project is a testing project compared with the compressive strength of PCC and GGBS, used concrete. Here the amount of cement is reduced and that amount is replaced with GGBS.

4.WORKABILITY TEST ON FRESH CONCRETE

General

Slump test is the test conducted on fresh concrete to examine the workability of concrete. To know the workability, following are the steps to conduct slump test for fresh concrete.

Fig No: 01 Slump Test

Table No: 01 Recommended slump of concrete

SL.NO	CONCRETE MIXES	SLUMP RANGE IN mm
1	Columns, Retaining walls	75-150 mm
2	Beams and slab	50-100 mm
3	CC Pavements	20-30 mm
4	Decks of bridge	30-75 mm
5	Huge mass construction	25-50 mm

- In slump test, mould is used having the shape of frustum of cone, the height of the mould is 300 mm, base diameter is 200 mm and top diameter is 100 mm.
- The mould should be clean and the inner surface is greased with oil for easy separation of fresh concrete.
- The mould is placed on smooth surface which should not be undulated and should be cleaned and leveled.
- Then three layer of fresh concrete is filled in slump cone or container
- After pouring of concrete, each layer should be tamped 25 times with tamping rod.
- The top surface of slump cone should be struck off by utilizing tamping rod in screeding or rolling motion.
- Immediately after struck off at the top surface of concrete, cone or mould lifted slowly in vertical direction, after lifting measure the slump value nearest to 5mm.
- If concrete is level at top without falling down is called true slump, the concrete is felled with slided one side is called shear slump and if it is fell down completely is called collapsed slump.

5.RESULTS AND DISCUSSION

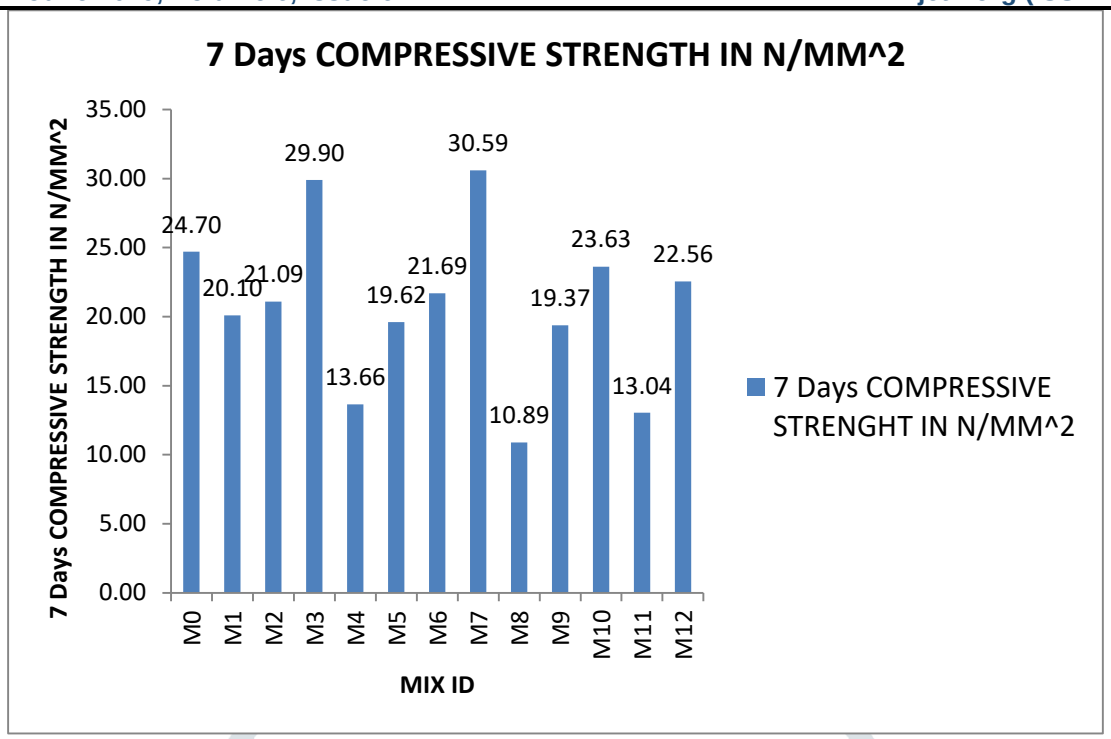
5.1Compressive strength:-

Fig No: 02 Compressive test on Cubes

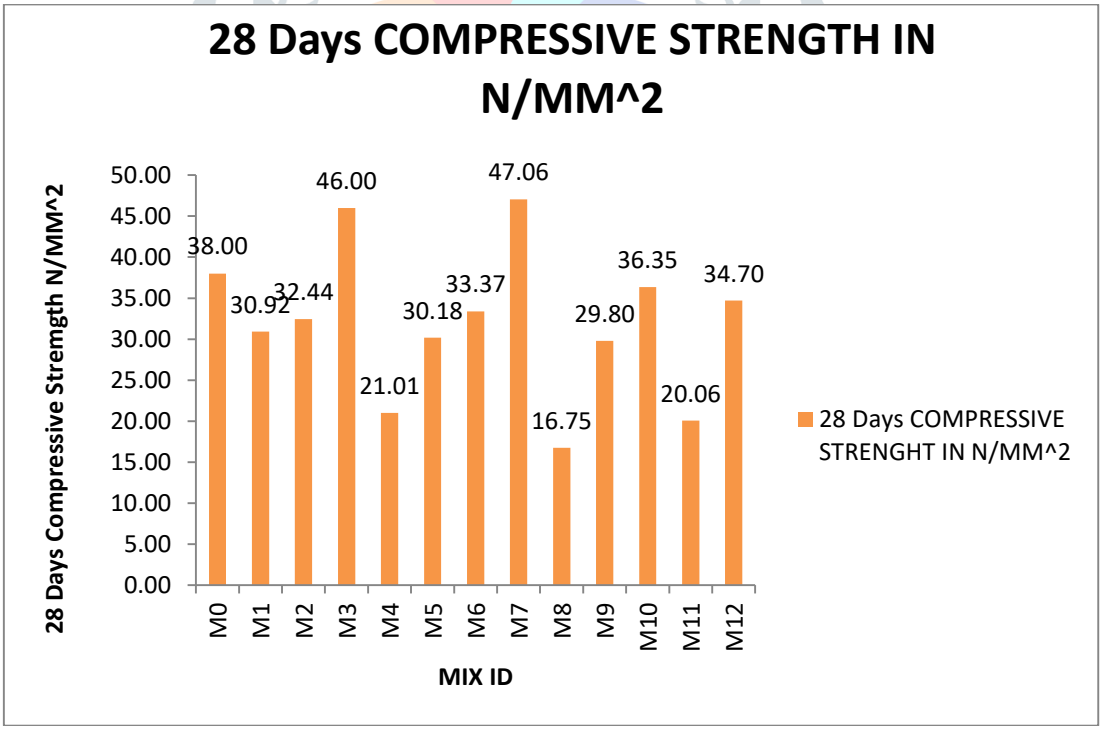
Fig No: 03 Compression Failure of Cubes

Table No: 02 Strength results

SL No.	MIX ID	7 DAY'S COMPRESSIVE STRENGTH IN N/MM2	28 DAY'S COMPRESSIVE STRENGTH IN N/MM2	SPLIT TENSILE IN N/MM2	FLEXURAL N/MM2 (Size=100X 100X500)mm	IMPACT TEST (Size=150mm Dia & 60mm thick		SHEAR TEST N/MM2 L-Shape (90mm x 60 mm)
						Avg No. of Drops at First Crack (N1)	Avg No. of Drops at Failure Crack (N2)	
1	M0	24.70	38.00	4.18	6.68	302	314	25.00
2	M1	20.10	30.92	3.70	6.37	280	325	21.29
3	M2	21.09	32.44	3.60	5.94	300	350	23.70
4	M3	29.90	46.00	3.80	6.15	487	497	28.14
5	M4	13.66	21.01	1.90	3.85	87	95	19.07
6	M5	19.62	30.18	3.85	6.72	338	385	20.18
7	M6	21.69	33.37	4.17	7.29	410	425	22.22
8	M7	30.59	47.06	4.02	6.94	385	397	29.25
9	M8	10.89	16.75	2.01	4.25	142	167	21.11
10	M9	19.37	29.80	3.38	5.30	240	262	23.70
11	M10	23.63	36.35	3.51	6.07	350	368	25.56
12	M11	13.04	20.06	2.54	4.96	218	223	21.85
13	M12	22.56	34.70	3.63	6.31	310	323	26.11



Graph No: 01 7 Days Compressive Strength Test



Graph No: 02 28 Days Compressive Strength Test

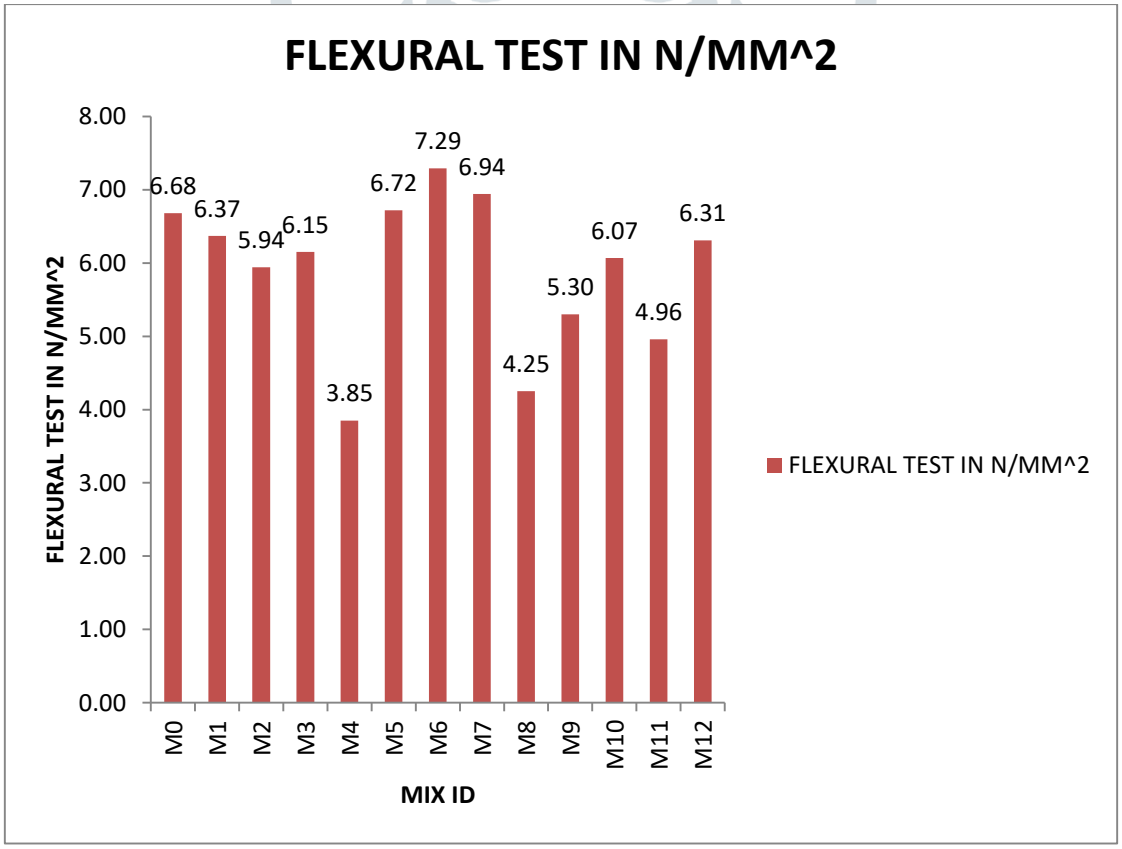
- As we can observe from the above graph that the mix M7 (Cement: Flyash: Metakolian=70%:20%:10%) and mix M3 (Cement: Metakolian=90%:10%) shows the high 7 Days Compressive Strength when compared to the other mixes.
- We can also see that the mix M8 (Cement: Fly ash: Rice husk ash=70%:20%:10%) shows the lower Compressive Strength when compared to the other mixes and the addition of Rice husk ash in any mix leads to the lower Compressive Strength.
- So it is better to adopt M7 and M3 mix for higher strength.

- As we can observe from the above graph that the mix M7 (Cement: Flyash: Metakolian=70%:20%:10%) and mix M3 (Cement: Metakolian=90%:10%) shows the high 28 Days Compressive Strength when compared to the other mixes.
- We can also see that the mix M8 (Cement: Fly ash: Rice husk ash=70%:20%:10%) shows the lower Compressive Strength when compared to the other mixes and the addition of Rice husk ash in any mix leads to the lower Compressive Strength. So it is better to adopt M7 and M3 mix for higher strength.

5.2 Flexural strength:-

Fig No: 04 Flexural test on Concrete

Fig No: 05 Flexural Failure of Concrete



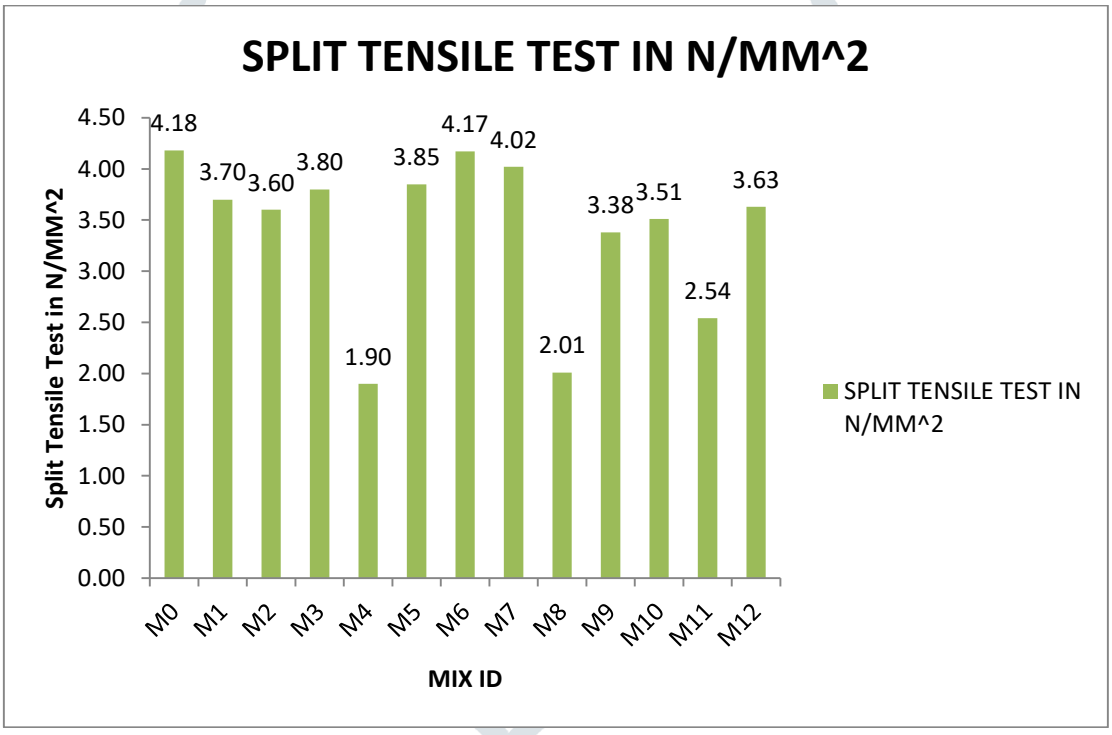
Graph No: 03 Graph showing flexural strength Results

- As we can observe from the above graph that the mix M6 (Cement:Flyash:Silica fume=70%:20%:10%) shows the high flexural strength when compared to the other mixes.
- We can also see that the mix M4 (Cement:Rice husk ash=90%:10%) shows the lower flexural strength when compared to the other mixes and the addition of Rice husk ash in any mix leads to the lower shear strength.
- So it is better to adopt M6 mix for higher strength.

5.3 Split Tensile strength:-

Fig No: 06 Split tensile test on Cylinder

Fig No: 07 Split Tensile Failure of Cylinder

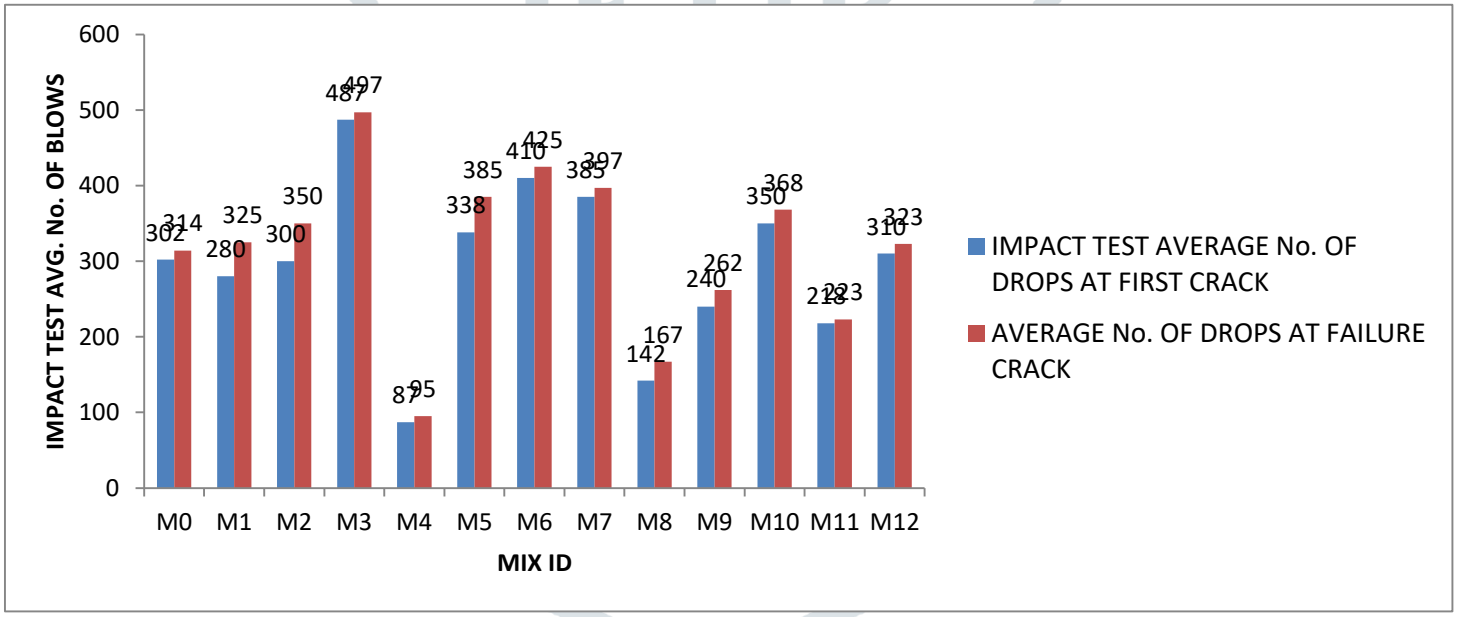


Graph No: 04 Graph showing split tensile strength

- As we can observe from the above graph that the mix M0 (cement =100%) and mix M6 (Cement:Flyash:Silica fume=70%:20%:10%)M7 (Cement: Flyash: Metakolian=70%:20%:10%) and mix M3 (Cement: Metakolian =90%:10%) shows the high Split Tensile Test when compared to the other mixes.
- We can also see that the mix M4 (Cement:Rice husk ash=90%:10%) and M8 (Cement: Fly ash: Rice husk ash=70%:20%:10%) shows the lower Split Tensile Test when compared to the other mixes and the addition of Rice husk ash in any mix leads to the lower Split Tensile Test.
- So it is better to adopt M0,M6 and M7 mix for higher strength.

5.4 Impact test

Fig No: 08 Impact Test



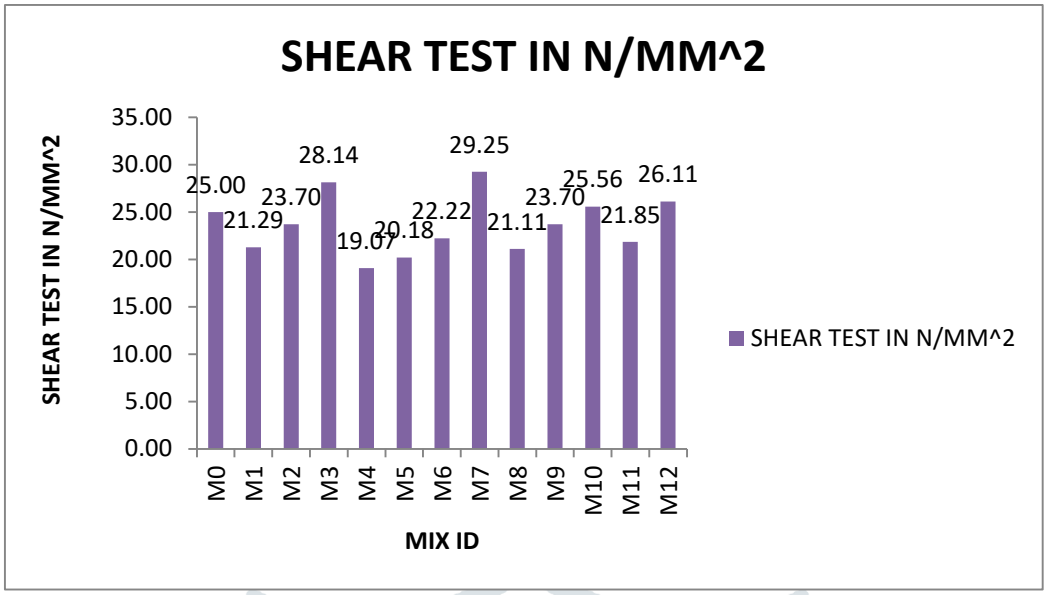
Graph No: 05 Graph showing Impact test

- As we can observe from the above graph that the mix M3(Cement: Metakolian=90%:10%) shows the high Impact strength when compared to the other mixes.
- We can also see that the mix M4 (Cement:Rice husk ash=90%:10%) shows the lower Impact strength when compared to the other mixes and the addition of Rice husk ash in any mix leads to the lower shear strength.
- So it is better to adopt M3 mix for higher strength.

5.5 Shear test

Fig No: 09 Graph showing Impact test

Fig No: 10 Graph showing Impact test



Graph No: 06 Graph showing Shear test

- As we can observe from the above graph that the mix M7 (Cement: Flyash: Metakolian=70%:20%:10%) and mix M3 (Cement: Metakolian=90%:10%) shows the high Shear Strength when compared to the other mixes.
- We can also see that the mix M4 (Cement:Rice husk ash=90%:10%) shows the lower Shear Strength when compared to the other mixes and the addition of Rice husk ash in any mix leads to the lower Compressive Strength.
- So it is better to adopt M7 and M3 mix for higher strength

6. CONCLUSION

Based on the review, it is quite clear that mineral admixtures may be categorized into two groups, namely, chemically active mineral admixtures (highly reactive pozzolan) and microfiller mineral admixtures (low to moderate reactive pozzolan). SF and MK are chemically active mineral admixtures, whereas FA, GGBS, and RHA are microfiller mineral admixtures.

The mineral admixture like Metakolin are product of industrial waste & they have no further use in any production process, Which remains as waste & should be disposed off, But these products have high cementitious properties which can replace cement to some extent.

Metakaolin type of mineral admixtures is used which increases the strength at the early ages.

- As we can observe from the graph 5.1 that the mix M7 (Cement: Flyash: Metakolian=70%:20%:10%) and mix M3 (Cement: Metakolian=90%:10%) shows the high 7 Days Compressive Strength when compared to the other mixes.
- We can also see that the mix M8 (Cement: Fly ash: Rice husk ash=70%:20%:10%) shows the lower Compressive Strength when compared to the other mixes and the addition of Rice husk ash in any mix leads to the lower Compressive Strength.
- As we can observe from the graph 5.1(a) that the mix M7 (Cement: Flyash: Metakolian=70%:20%:10%) and mix M3 (Cement: Metakolian=90%:10%) shows the high 28 Days Compressive Strength when compared to the other mixes.
- We can also see that the mix M8 (Cement: Fly ash: Rice husk ash=70%:20%:10%) shows the lower Compressive Strength when compared to the other mixes and the addition of Rice husk ash in any mix leads to the lower Compressive Strength.
- As we can observe from the graph 5.2 that the mix M0 (cement =100%) and mix M6 (Cement:Flyash:Silica fume=70%:20%:10%)M7 (Cement: Flyash: Metakolian=70%:20%:10%) and mix M3 (Cement: Metakolian=90%:10%) shows the high Split Tensile Test when compared to the other mixes.
- We can also see that the mix M4 (Cement:Rice husk ash=90%:10%) and M8 (Cement: Fly ash: Rice husk ash=70%:20%:10%) shows the lower Split Tensile Test when compared to the other mixes and the addition of Rice husk ash in any mix leads to the lower Split Tensile Test.

- As we can observe from the graph that the 5.3 mix M6 (Cement:Flyash:Silica fume=70%:20%:10%) shows the high flexural strength when compared to the other mixes.
- We can also see that the mix M4 (Cement:Rice husk ash=90%:10%) shows the lower flexural strength when compared to the other mixes and the addition of Rice husk ash in any mix leads to the lower shear strength.
- As we can observe from the graph 5.4 that the mix M3(Cement: Metakolian =90%:10%) shows the high Impact strength when compared to the other mixes.
- We can also see that the mix M4 (Cement:Rice husk ash=90%:10%) shows the lower Impact strength when compared to the other mixes and the addition of Rice husk ash in any mix leads to the lower shear strength.
- As we can observe from the graph 5.5 that the mix M7 (Cement: Flyash: Metakolian=70%:20%:10%) and mix M3 (Cement: Metakolian=90%:10%) shows the high Shear Strength when compared to the other mixes.
- We can also see that the mix M4 (Cement:Rice husk ash=90%:10%) shows the lower Shear Strength when compared to the other mixes and the addition of Rice husk ash in any mix leads to the lower Compressive Strength.

7. REFERENCES

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