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Enactment Of Mineral Admixtures As Supplementary Cementitious In Concrete

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Abstract: This study investigates the incorporation of mineral admixtures as supplementary cementitious materials in concrete to enhance its properties and sustainability. The research delves into the impact of mineral mixes including silica fume, flyash and slag, on the mechanical strength, durability, and environmental performance of concrete. Through a comprehensive review of relevant literature and experimental analyses, this study aims to provide insights into the optimal utilization of mineral mixes in concrete mix designs. The findings contribute to the ongoing efforts in advancing environmentally friendly and high-performance concrete technologies for sustainable construction practices. In conclusion, the enactment of mineral mixes as additional cementitious materials within concrete offers significant potential for improving its performance and sustainability. Nonetheless, great thought needs to be paid to their incorporation into concrete mixtures to ensure that desired benefits are achieved without compromising overall performance. Adherence to relevant standards and guidelines is essential to ensure that resulting concretes meet specified requirements for strength, durability, and sustainability.

***Index Terms* - Concrete, Mineral admixtures, Physical & Mechanical properties**

I. INTRODUCTION

Concrete is one of the building materials most frequently utilized construction materials; it is usually associated with Portland cement as the main component for making concrete. The demand for concrete as a construction material is rising. According to estimates, the production of cement will increase from about from 1.5 billion tonnes in 1995 to 2.2 billion tonnes in 2010.On the other hand, the climate change due to global warming, one of the greatest environmental issues has become a major concern during the last decade. The global warming is caused by the emission of greenhouse gases, such as CO_2, to the atmosphere by human activities. Among the greenhouse gases, CO_2 contributes about 65% of global warming. The cement industry is responsible for about 6% of all CO_2 emissions, because the creation of one metric tonne of Portland cement emits approximately one tonne of CO_2 into the atmosphere. Despite the fact that Portland cement use in concrete is still inevitable for the foreseeable future, numerous attempts are being undertaken to minimise its use. Using additional cementing elements including fly ash, silica fume, granulated blast furnace slag, rice husk ash and metakaolin, as well as looking for substitute binders for Portland cement, are some of these attempts.

Now, the production of Portland cement involves high energy intensive process and flaming of non-renewable resources which discharge large quantities of greenhouse gas like carbon dioxide (CO2) into the atmosphere. About 2.9T of raw materials including fuels and catalyst are required to produce Portland cement. It is estimated de-carbonation of lime in producing 1T of Portland cement generates about 1T of greenhouse gas. Utilizing eco-friendly green construction products of waste or industrial by-products containing aluminosilicates as source materials. This special concrete has shown a remarkable potential as an alternative to Portland cement by lowering global warming due to greenhouse gas emission. They not only exhibit outstanding qualities of durability and strength but they also have high resistance to fire and acids.

II. LITERATURE REVIEW

In Standard concrete with a very low water/binder ratio, hydration stops within the extremely low water/binder concrete, hydration ceases in the concrete well before the 28-day mark because of a shortage of water or when the partial pressure of water vapour in the pores reaches the 80% threshold, below which hydration is severely slowed down by adding mineral admixtures.(M.V Fayaz and R.V Krishnaiah (2023)).

Dheeresh Kumar Nayak and P.P. Abhilash (2022) found that the impact of adding flyash and recycled aggregates from waste demolition to concrete mixtures on the material's compressive strength was investigated. 16 The prepared mixed's workability and compressive strength were measured and contrasted with those of standard concrete. According to the results, the slump value decreases with each increase in fly ash dose; as a result, more mechanical effort must be put into compaction or additive application for the concrete to remain workable. The lowest drop in compressive strength (about 11%) among all the mixes under study is achieved with a 5% fly ash dosage, according to the findings of the compressive strength test. Although the concrete can be used in newly constructed areas, it is suggested that it be used in low-load areas first.

Bianca R.S. Calderón-Morales (2021) found thatThe industry occasionally sales the product at low price but mainly use for land filling. Testing different fresh and hardened qualities of cement paste, mortar, and concrete revealed encouraging results when phosphogypsum was added in amounts of 5–10% with Portland cement clinker. The field sample was first cleaned, and then it was dried. Phosphogypsum processing often produced better results across all media. When 10% addition level was added to paste, mortar, and concrete, the processed sample performed better, or at least similarly, as the control samples (100% clinker). 3. This suggested that the natural gypsum, which is typically used to make 5% of the total cement, might be replaced by the industrial by-product in cement production in a sustainable manner. The cement industry may then lessen its reliance on naturally occurring gypsum in its manufacturing. Environmental concern is an important issue in this regard. A more detailed research and development work might help to ensure better use of this material in construction industry.

III. EXPERIMENTAL STUDY

MATERIALS:

Cement: The cement used in this experimental investigation is Portland Pozzolanic Cement of 53 grade confirming to IS:1489 (part:1): 1991.

Fine aggregate: In the present investigations fine aggregate is natural sand obtained from near river is used

Coarse aggregate: The coarse Aggregateused in this experimental investigation is crushed granite of 12.5 mm maximum size, which was obtained from the nearby crusher facility.

Water: To mix concrete, potable tap water that complied with IS: 456 - 2000 standards and had a pH value of 7.0±1 was available in the lab.

Fly Ash: The fly ash (Class F) used in this investigation was obtained from S.I.E.L. located at Muthukuru, SPSR Nellore, Andhra pradesh.

Phosphogypsum: Phosphogypsum is a reactive product obtained from phosphoric acid production process from phosphate rock it is converted to insoluble salt calcium sulphate [$caso_4$] Gypsum .

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Preliminary tests are conducted for all the materials used for concrete composition. Physical tests were conducted on Cement of PPC 53 grade, Flyash and Phosphogypsum according to IS 4031 (Part 5) – 1988. Fly ash and Phosphogypsum also exhibits cement properties so used as Mineral admixtures in our study. Fine aggregate and coarse aggregates physical tests were conducted to exhibit their properties.

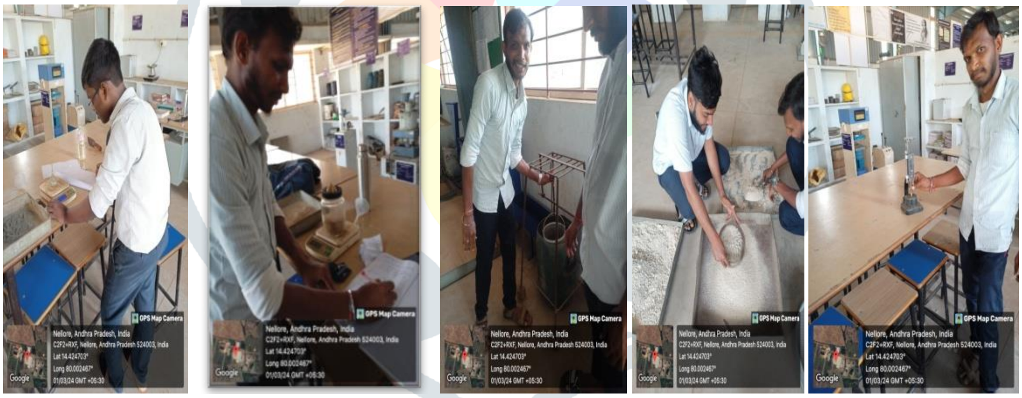

Fig 3.1.1 preliminary tests conducted for concrete composition

From the preliminary tests conducted to concrete composition fresh concrete property tests were conducted to know the workability of fly ash-infused concrete and Phosphogypsum which will be used for Mix design of M50 grade concrete.

Fig 3.1.2 Workability tests conducted for concrete composition

IV. CONCRETING PROCESS

Concrete mixes were designed for M50 to study the compressive strength at different w/c ratios. The w/c ratios of 0.35 were adopted. fly ash (class F) and Phosphogypsum content were varied as 0%, 5%, 10% ,15% , 20%, 25% and 30% by weight of cement. The cementitious material was taken as 450 kg/m3 and Sand content was650kg/m3. The quantity of coarse aggregate was calculated by allowing 2% air entrainment. All the materials are weighted as per mix proportion of 1:1.65:2.65. Concrete with different content of fly ash infused and Phosphogypsum was studied at different ages, namely days 7, 14 and 28. Destructive tests were conducted to cube and cylindrical specimens to test achieve maximum strength value.

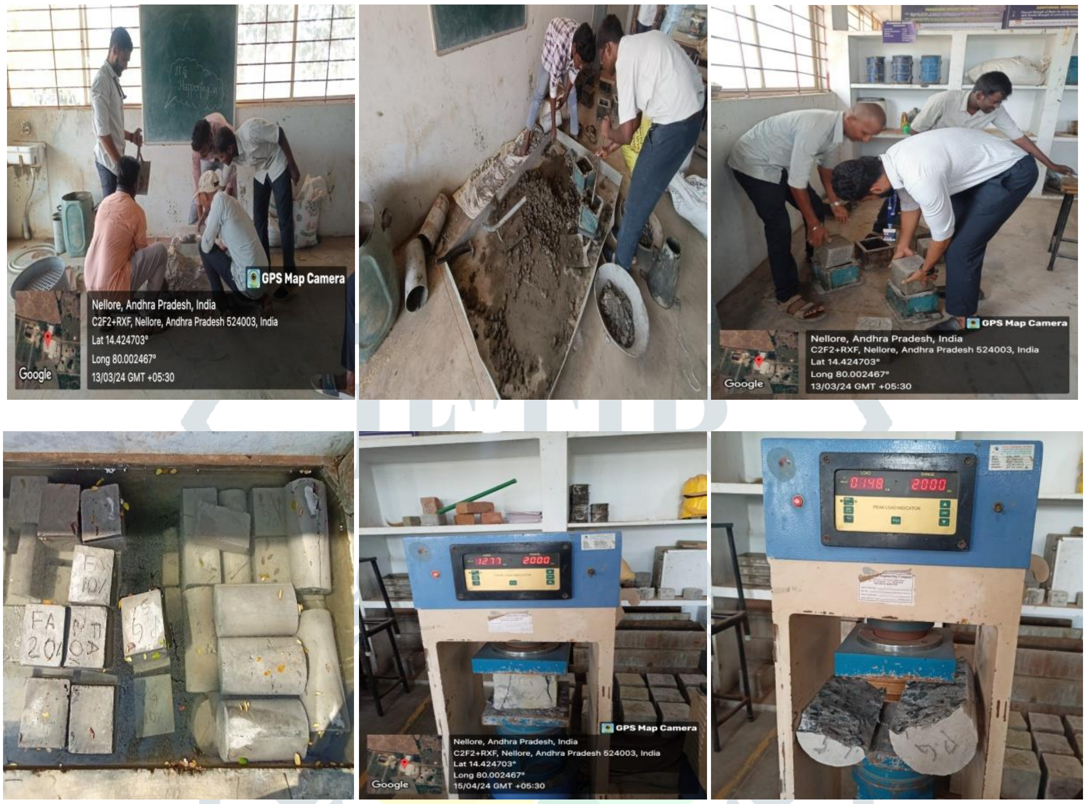

Fig 4.1 Concreting process and destructive tests

IV. RESULTS AND DISCUSSION

4.1 Results of Preliminary Tests for Concrete composition

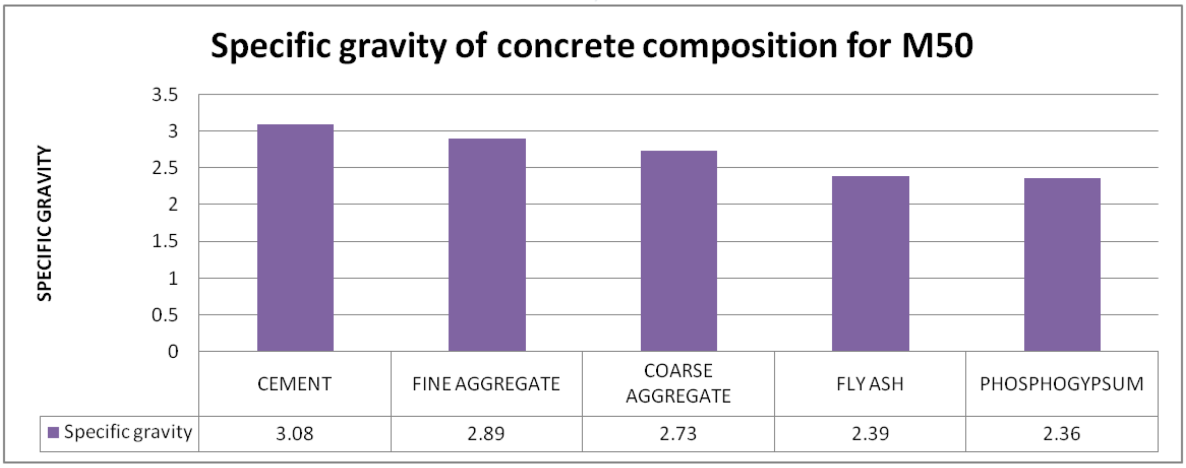

Figure 4.1.1 Specific gravity test of concrete composition

Fig 4.1.1 displayed Specific gravity test carried out on cement, Fine aggregate, coarse aggregate, flyash and Phosphogypsum. Specific gravity test conducted for cement is similar to be tested for flyash and Phosphogypsum with specific gravity bottle according to IS2720- Part3. The Specific gravity values of flyash and Phosphogypsum exhibits lower compared to cement value. Speciic gravity of fine and coarse aggregates is conducted according to IS 2386 Part3 -1963.

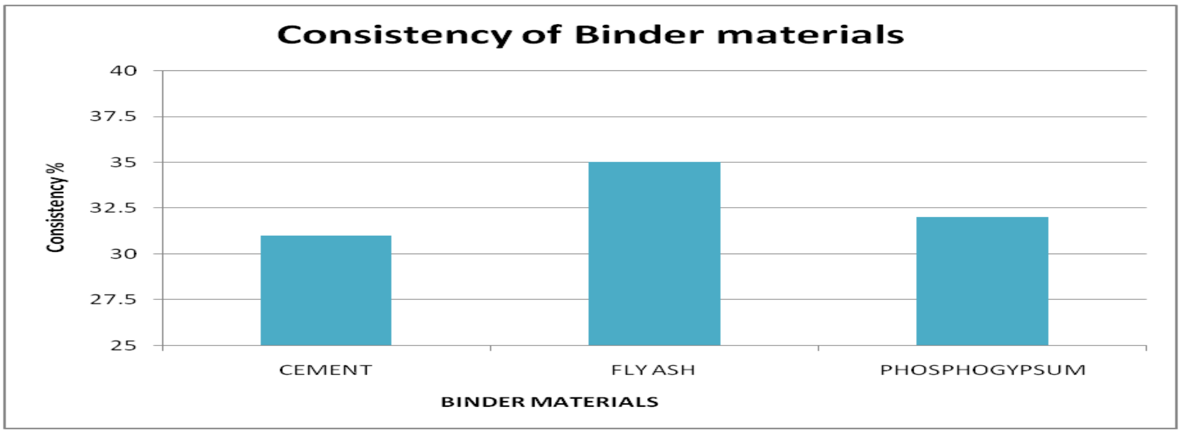

Figure 4.1.2 Soundness test for binder materials

Fig 4.1.2 exhibits Normal consistency test conducted for cement, flyash and Phosphogypsum according to IS 4031-1988. Fly ash and Phosphogypsum obtains low soundness value 0.6 & 0.8 mm than cement 1.9 mm. it observes from soundness values of binder material in permissible limits.

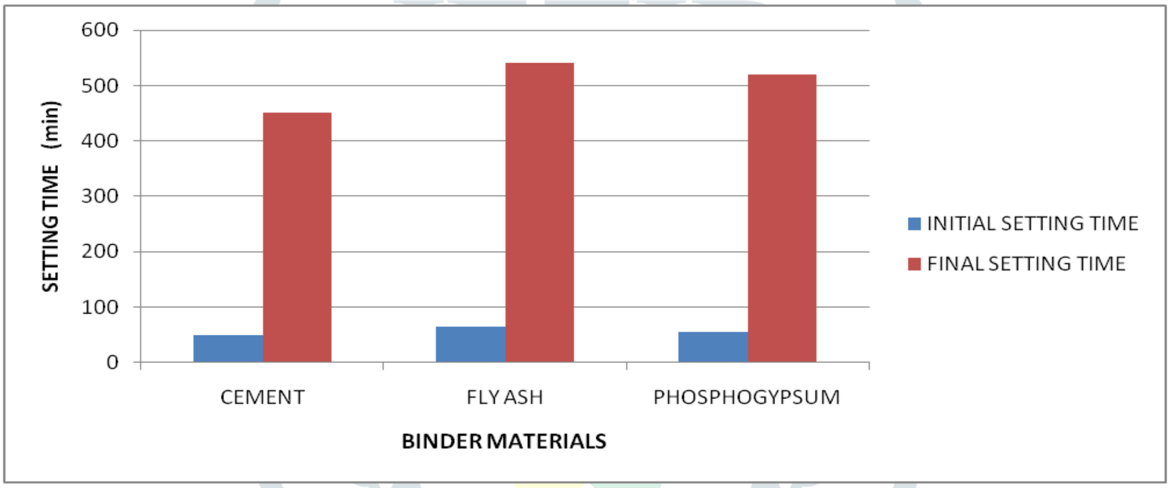

Figure 4.1.2 Soundness test for binder materials

Fig 4.1.3 display Initial setting and final setting time of cement, flyash and Phosphogypsum according to IS 4031-1988. Fly ash and Phosphogypsum obtains low soundness value 0.6 & 0.8 mm than cement 1.9 mm. it observes from soundness values of binder material in permissible limits.

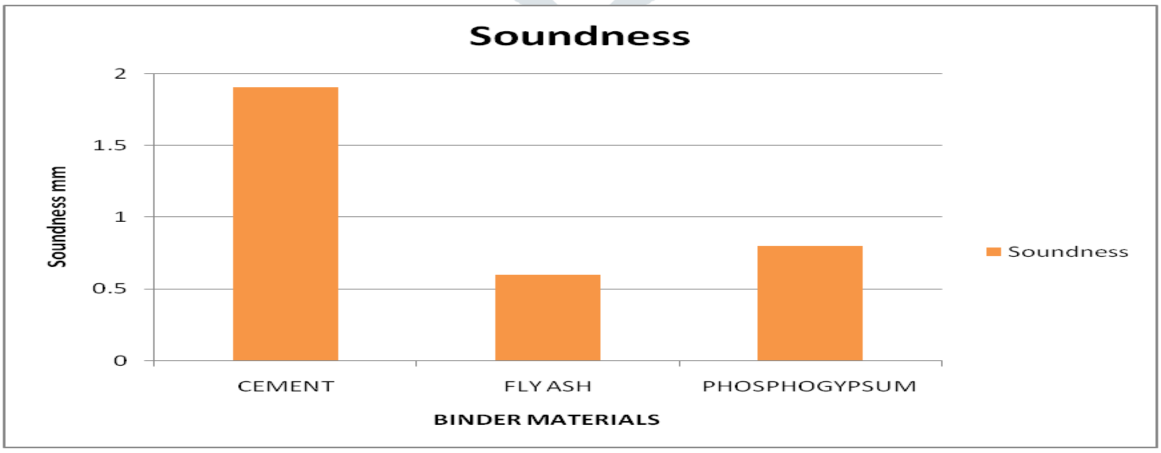

Figure 4.1.4 Soundness test for binder materials

Fig 4.1.4 exhibits soundness test conducted for cement, flyash and Phosphogypsum according to IS 5514-1969. Fly ash and Phosphogypsum obtains low soundness value 0.6 & 0.8 mm than cement 1.9 mm. it observes from soundness values of binder material in permissible limits.

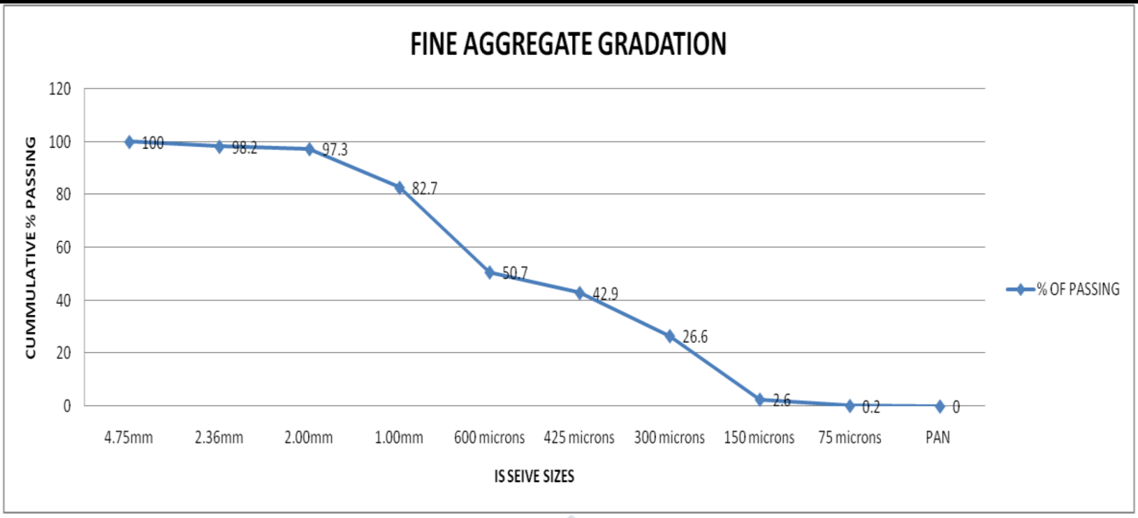

Figure 4.1.5 Gradation of fine aggregate

Fig 4.1.5exhibits gradation of fine aggregate which passes standard sieves to designates the zone of fine aggregate which is employed in concrete mix design. From above graph gradation of fine aggregate used in this study comes under zone-II.

4.2 Results of Fresh concrete properties

Table 4.2: Fresh concrete properties

Binder	W/C ratio	Slump (mm)	Compaction factor	Vee-bee (sec)
PPC53Cement		90	0.86	8
(97.5% PPC53)+ (5% FA)		95	0.90	6
(95% PPC53)+ (10% FA)		98	0.92	6
(92.5% PPC53)+ (15% FA)		100	0.94	5
(90% PPC53)+ (20% FA)		98	0.95	6
(87.5% PPC53)+ (25% FA)		92	0.95	6
(85% PPC53)+ (30% FA)	0.35	90	0.97	7
(97.5% PPC53)+ (5% PG)		97	0.90	7
(95% PPC53)+ (10% PG)		99	0.92	7
(92.5% PPC53)+ (15% PG)		101	0.94	6
(90% PPC53)+ (20% PG)		96	0.95	6
(87.5% PPC53)+ (25% PG)		93	0.95	7
(85% PPC53)+ (30% PG)		91	0.97	6

In our study Workability of concrete is tested for conventional concrete with partial replacing of fly ash and Phosphogypsum in 5%, 10%, 15%, 20%, 25% and 30% . From Table 4.2 we can conclude that high slump value is obtained by replacing 15% of flyash and Phosphogypsum. From Fig 4.2 it show case variance in workability by vee-bee test, at 15% and 20% of replacing flyash and Phosphogypsum flow is less in contrast to regular concrete.

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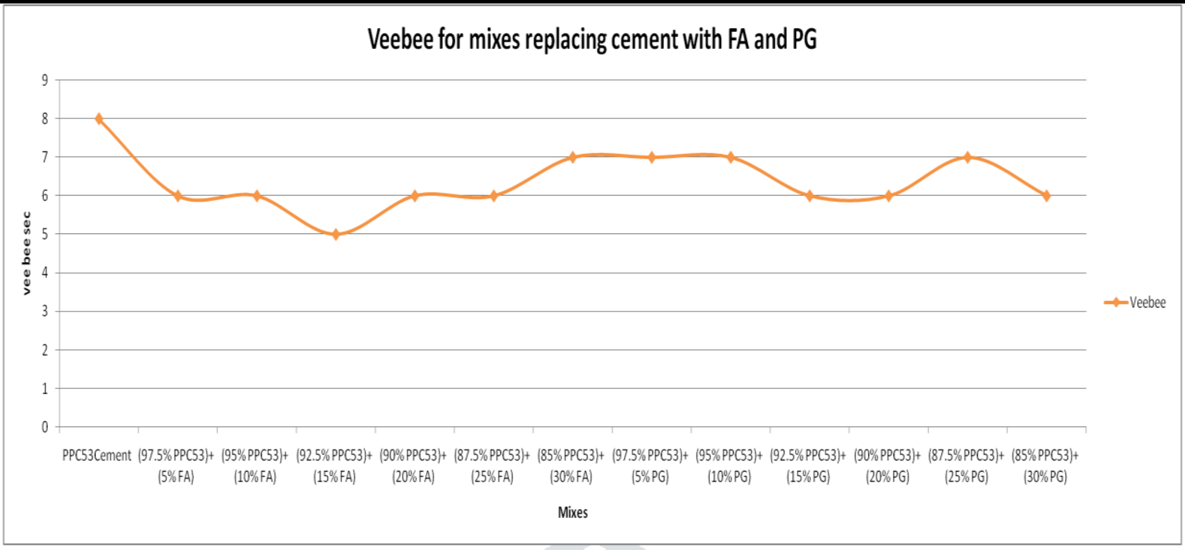

Figure 4.2 Vee-bee graph

4.3 Results of Hardened concrete properties

Hardened concrete property test were conducted by destructive testing of compressive strength and split tensile strength tests with age of days 7,14 and 28 of concrete mixes in replacing of Flyash and Phosphogypsum5%, 10%, 15%, 20%, 25% and 30% . From Fig 4.3.1 it is observed that 7, 14 & 28 days strength of M50 grade concrete is achieves maximum strength in compression at 15% and 20% of Flyash replacement where as Phosphogypsum replacing 15% and 20% is stable as same to conventional concrete.

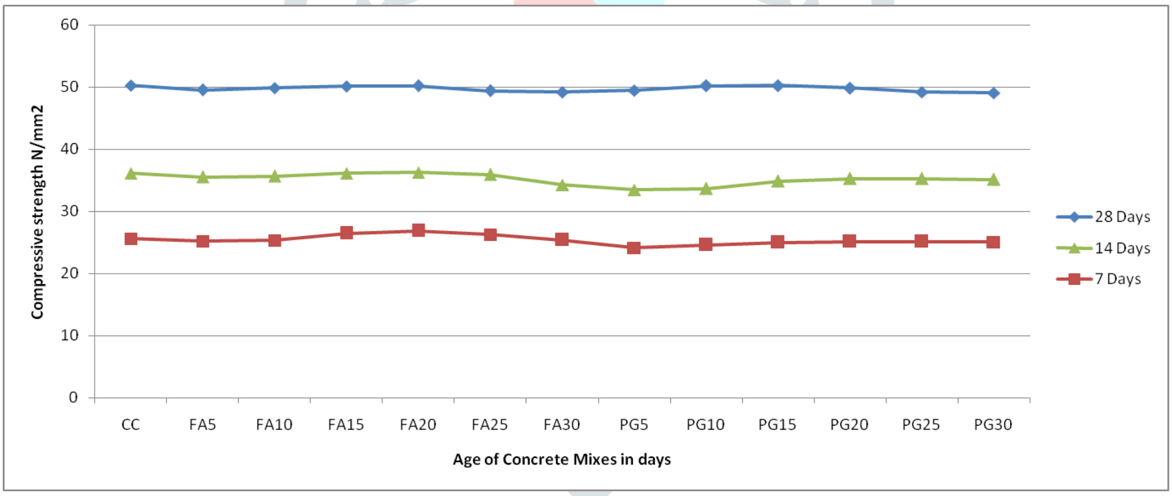

Figure 4.3.1 concrete mixes compressive strength of days 7,14 and 28

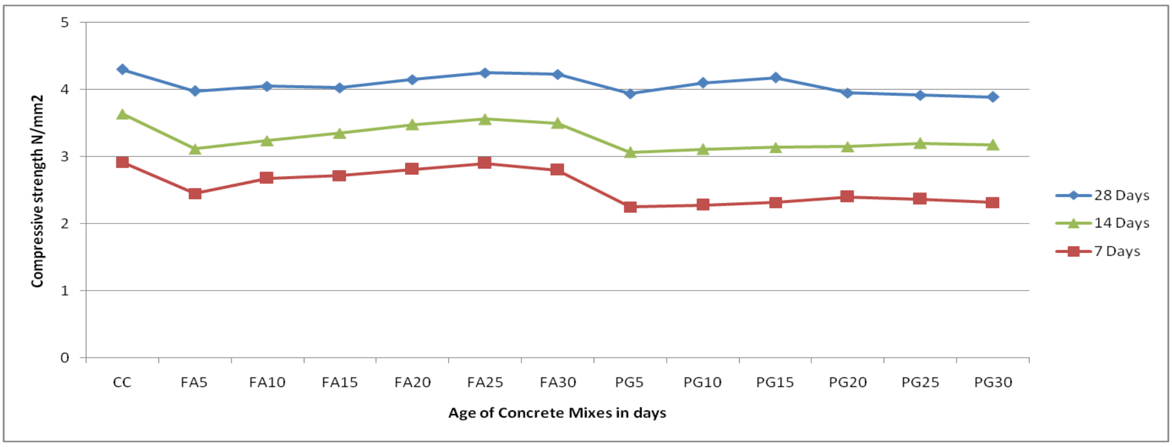

Figure 4.3.2 concrete mixes split tensile strength of days 7,14 and 28

From Fig 4.3.2 it is observed that 7, 14 & 28 days strength of M50 grade concrete is achieves maximum strength at 15% and 20% of Flyash replacement where as Phosphogypsum replacing 20% and 25% is stable as same to conventional concrete.

V. CONCLUSIONS

Concrete with 20% of flyash gives better strength at all ages.

Phosphogypsum also performs well and the strength improvement is almost close to the strength development in conventional M50 concrete.

At all ages of days 7, 14 and 28, the standard concrete compressive strength with induced flyash and Phosphogypsum is more than that of conventional concrete.

It may be noted that addition of flyash and Phosphogypsum causes an increase in strength at all ages. But it decreases strength at 25%.

From the results, discovered that the ideal substitute of flyash and Phosphogypsum are 15% and 20%, respectively.

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