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Study of Effect of Silica Fume and Metakaolin Combinations on Elasticity of Concrete

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Abstract- The use of supplementary cementitious materials is fundamental in developing low cost construction materials for use in developing countries. By virtue of adding pozzolanic materials to cement concrete the properties such as workability, durability, strength, etc. can get improved to a large extent. With addition of pozzolanic materials such as Metakaolin, silica fume GGBS etc. in certain proportions it is noticed that modulus of elasticity properties of concrete is improved. This project presents experimental investigation carried out to find the suitability of silica fume and Metakaolin combination in production of concrete. It deals with M30 grade concrete by replacing cement with Silica Fume (0%,5%,10%,15%) and Metakaolin (0%,5%,10%,15%). Later combinations of Metakaolin and Silica Fume at highest strength of SF were carried. The current work focuses on studying durability properties of concrete in which silica fumes or Metakaolin are replaced. The combinations will be compared with conventional concrete and results were be tabulated.

Index Terms- Metakaolin; Silica Fume: modulus of elasticity; conventional concrete.

1. INTRODUCTION

Concrete is made from cement, fine aggregate, coarse aggregate and water. This hard and alkaline material along with steel is an excellent composite material used in the construction. The cement and water form glue or cream, which coats the sand and aggregate. When the cement is chemically reacted with the water, it is hardened and binds the whole mix. The setting of concrete takes place usually within a few hours. It takes some more weeks for concrete to get a full hardening and gain strength. So the time elapse the compression strength of concrete keep on increasing. With addition of pozzolanic materials such as Metakaolin, GGBS etc. in certain proportions it is noticed that the compressive strength of concrete is improved.

Much research carried out for the betterment of concrete and its properties. In recent times concrete researchers are concentrating on secondary cementatious materials for the improvement of concrete and its strength etc. Hydraulic cement, a primary binder is produced on an average of two billion tons per year amounting to 2.5 tons of per capita consumption. Concrete structures got a perennial problem of contribution to CO_2 emission and as a result greenhouse effect. A method to reduce the cement content in concrete mixes is the use of some pozzolanic concrete materials. In this investigation some pozzolanic concrete materials were used that are metakaolin and silica fume are the partial cement replacement of concrete.

2. LITERATURE REVIEW

Badogiannis.EJustice.J.M et al (2005) made a comparative study by replacing 8% by weight of cement with Metakaolin and Silica fume. Addition of Metakaolin to concrete improved various properties of concrete such as strength, shrinkage, durability etc. The addition of Metakaolin in the form of fine powder gave good results when it is added as coarse particles. It was also noticed that Metakaolin when used in concrete led to increased use of super plasticizers.

Abdullah et al., (2004) In a study to evaluate the effect of silica fume on the compressive strength, split tensile strength and modulus of elasticity of low quality coarse aggregate concrete was conducted whose results indicated that the type of coarse aggregate influenced the compressive strength, split tensile strength and modulus of elasticity of both plain and silica fume cement concretes. Incorporation of silica fume enhanced the compressive strength and split tensile strength of all concretes especially that of the low quality limestone aggregates

In an experiment it was showed that the compressive and tensile strengths increased with silica fume incorporation, and the results indicated that theoptimum replacement percentage is not constant but depends on the water-cementitious material ratio of the mix. They also found that compared with split tensile strengths, flexural strengths have exhibited greater improvements (Bhanja and Sengupta, 2005) while in another, it was showed experimentally that the compressive strengths of mortars with nano-SiO2 particles were all higher than those of mortars containing silica fume at 7 and 28 days (Jo Gupta, S.etal.,2007). It was demonstrated that the nano-particles are more valuable in enhancing strength than silica fume.

O. H. Wallevik et al (2000)

High-performance concrete and high-quality ordinary concrete, with or without silica fume, were tested for mechanical and fracture mechanical properties. These tests were carried for 2 years meaning at 28th day. Ten percent silica fume resulted in a 20 to 25% increase in the direct tensile strength and a 10 to 20% increase in flexural and compressive strength, but had little effect on the dynamic modulus of elasticity. The dynamic modulus of elasticity increased with increasing age and with decreasing w/b-ratio. The mixes containing silica fume revealed practically the same dynamic modulus of elasticity as their companion mixes without silica fume.

3. MATERIALS AND METHODS

Cement: Ordinary Portland cement of 53 grade confirming IS 12269: 1987 was used in the study. Its Physical Properties are presented in Table 1.

Table 1 Physical properties of cement

Parameters	Result
Specific Gravity	3.15
Standard Consistency	33%
Initial setting Time	90 min's
Final Setting Time	340 min's

FINE AGGREGATE:
The natural sand taken for this investigation is the close by available usual waterway sand. It was composed and washed for impurities, so that it is free from clayey matter, saline and organic impurities. Particles passing through IS sieve of 4.75 mm conforming to grading zone-II of IS: 383-1970 was used in this work. Properties such as gradation, specific gravity, fineness modulus, bulking, and bulk density had been assessed.

COARSE AGGREGATE:
Coarse aggregate is an important constituent of concrete as it occupies three quarters of the volume of the concrete. It contributes significantly to the structural performance of concrete, especially strength, durability and volume stability. The reinforcement spacing is the main factor in determining the maximum aggregate size.

Locally available machine Crushed angular granite, retained on 4.75mm I.S. sieve of maximum size of 20mm confirming to I.S: 383-1970 was used in the existing trial investigation. It is allowed from impurities such as dirt, clay units and organic matter etc. The coarse aggregate is tested for its various properties such as specific gravity, fineness modulus, elongation test, flakiness test, sieve analysis, bulk density in accordance with in IS 2386 – 1963.
The properties of coarse aggregate and fine aggregate are presented in the Table 2.

Table 2 Properties of Aggregates

Properties	Coarse aggregate	Fine aggregate
Specific Gravity	2.78	2.67
Water Absorption	0.5%	1%
Fineness Modulus	7.52	3.05

Water: The least expensive but most important component of concrete. It is an important part in the production of concrete as it actively participates in chemical reaction with cement to form the strength giving Gel. The quality and quantity of water should be carefully selected in the investigation. Generally, the water which is suited for drinking will suits for production of Concrete. Close by available fresh bore well water confirming to the requirements of IS: 456 - 2000 was used for mixing concrete and curing the specimens as well.

Mineral admixtures: Metakaolin used in this existing investigational study is obtained from ASTRRA chemicals, Chennai. Silica fume is also from ASTRRA Chemicals, Moores Road, Moores Garden, Thousand Lights, Chennai, Tamil Nadu, India were used as admixtures.

The properties of mineral admixtures are presented in the Table 3 and 4

Table 3 Physical Properties of Admixtures

Physical Properties	Test Results	
	SF	MK
Specific Gravity	2.6	2.5
Bulk density	0.76Gm/Cc	1.26

Table 4 Chemical Properties of Admixtures

Parameters	% By weight	
	SF	MK
Silicon Dioxide(SiO_2)	99.50	53.0
Alumina(Al_2O_3)	0.043	43.0
Iron oxide(Fe_2O_3)	0.040	0.5
Calcium oxide (CaO)	0.001	0.1
Magnesium oxide (MgO)	0.020	1.76
Sodium oxide(Na_2O)	0.003	0.05
Loss on ignition	0.015	0.30

MODULUS OF ELASTICITY TEST

*Com*pressometer with dial gauge is used to determine the modulus of elasticity of concrete, using cylinders of diameter 0.15M and height of 0.3M. Compressometer comprises two steel rings for clamping to the specimen, two gauge length bars, dial gauge and spherically seated lever unit. When the unit is attached to the specimen the gauge length bars are removed and the dial gauge set to zero for the test. Experimental setup is shown in figure 5.5. Load should be increased gradually, and parallelly dial gauge readings were noted. Strain (change in length/original length) is calculated using dial gauge reading and gauge length of the specimen. Modulus of Elasticity is calculated from the graph drawn for stress and strain.

4. RESULTS AND DISCUSSIONS

Modulus of Elasticity Results:

The Modulus of Elasticity of M30 grade of control concrete is 26.22 GPa. The Modulus of Elasticity of concrete increases with all the proportions of Metakaolin (5%, 10% & 15%) and Silica Fume (5%, 10% & 15%), The Concrete with 10% of Silica Fume and 10% of Metakaolin possesses higher Modulus of Elasticity when compared to all other proportions and with further increase in the content of Metakaolin, The Modulus of Elasticity decreases as shown in Table No. 6.3. The Percentage increase in the Modulus of Elasticity of M30 grade of concrete with 10% of Silica Fume and 10% of Metakaolin is 12.77 %. The Variation of Modulus of Elasticity of M30 Grade of Concrete for Control Concrete and Metakaolin (5%, 10% & 15%), Silica Fume (5%, 10% & 15%) and Metakaolin (20%) & Silica Fume (5%, 10% & 15%) as shown in figure.1,2 and 3.

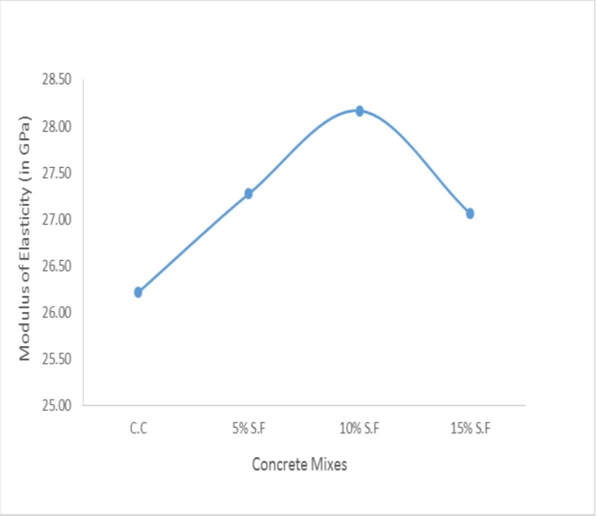

Fig . 1 Difference of Modulus of Elasticity of M30 Grade of Control Concrete and Silica Fume (5%, 10% & 15%)

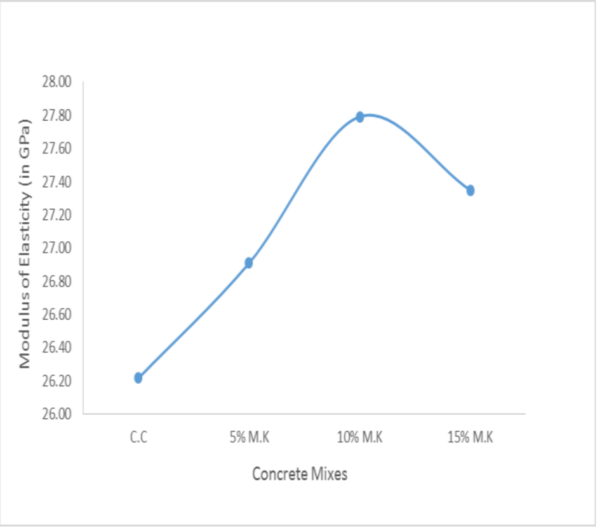

Fig. 2 Difference of Modulus of Elasticity of M30 Grade of Control Concrete and Metakaolin (5%, 10% & 15%)

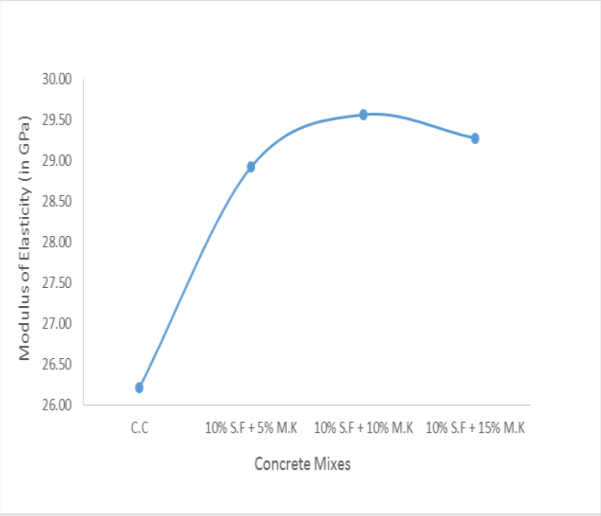

Fig No. 3 Disparity of Modulus of Elasticity of M30 Grade of Control Concrete and Silica Fume (10%) &Metakaolin (5%, 10% & 15%)

5. CONCLUSIONS

- Observed in the case of Modulus of Elasticity, There is 12.77 % increase in Modulus of Elasticity in Concrete (MK10% &SF10%) when compared to Control Concrete.
- Based on the experiments carried out in this work, it can be safely concluded that silica fume and Metakaolin can be a good replacement for Cement with higher strength at 10% replacement, saving in cost of concrete and reducing the environmental pollution.

REFERENCES

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