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Study of Strength Parameters of Concrete Partially Replaced with Metakaolin

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Abstract - *Now a day's concrete enterprise turns into a well known cause for leaving great ecological footprint. First of all a big quantum of material needed every year for the production of concrete around the sector. Collectively with the energy requirement and water consumption, concrete industry is also liable for emission of greenhouse gasses. To allow global growth of infrastructure with least harmful impact on environment, it becomes critical to use green substances. Metakaolin is a most viable alternative for the partial substitute of OPC because it along with-reduction in CO_2 emissions also enhances the useful life span of the buildings by improving strength properties and durability of concrete. Among many mineral admixtures available, Metakaolin (MK) is a mineral admixture, whose potential is not yet fully tested and only limited studies have been carried out in India on the use of MK for the development of high strength concrete.*

The study attempts to evaluate the impact of six different additives, including natural additives in M 40 grade concrete. The test design is adopted on for the mixes and the optimum amount of admixtures are determined for concrete mixes and their performance is analyzed. The experimental work has been carried out as partial replacement of cement with MK in M40 grade of concrete at 0%, 5%, 10%, 15%, of replacements brings to change in properties of the concrete.

Key Words: **Mineral admixtures, Metakaolin (MK), High strength concrete, Greenhouse gasses**

1. INTRODUCTION

Concrete is one of the most commonly used building materials. It is a composite material made from several readily available constituents (aggregates, sand, cement, water). Concrete is a versatile material that can easily be mixed to meet a variety of special needs and formed to virtually any shape Similarly the ingredients that make up concrete have changed over a period of time. At present, age of High Performance Concrete (HPC). The addition of admixtures to the HPC mixes is what gives it the superior strength and durability.

1.1 Concrete with mineral admixture

Also called „Supplementary Cementing Materials Used when special performance is needed: Increase in strength, reduction in water demand, impermeability, low heat of hydration, improved durability, correcting deficiencies in aggregate gradation (as fillers), etc. Result in cost and energy savings: Replacement of cement leads to cost savings; energy required to process these materials is also much lower than cement Environmental damage and pollution is minimized by the use of these by-products – about 6 – 7% of total CO2 emission occurs from the production of cement Usage depends on supply and demand forces, as well as the market potential and attitude.

1.2 Portland Cement with Metakaolin

Metakaolin is a pozzolan, probably the most effective pozzolanic material for use in concrete. It is a product that is manufactured for use rather than a by-product and is formed when china clay, the mineral kaolin, is heated to a temperature between 600 and 800�. It shows the influence of MK dosage on heat evolution per gram of cement. An increase in MK dosage from 0% (Mix 22) to 10% (Mix 31) and 20% (Mix 21) resulted in acceleration of C3S hydration, as evidenced by the monotonic increase in the magnitude of the main hydration peak. The timing of the peak was also accelerated from approximately 6.3 hours with no MK to 5.3 hours with 15% MK, and 4 hours with 30% MK. This behavior is different from that observed in the binary OPC+MK systems. Addition of 21% MK to the control paste accelerated the time of occurrence of the main hydration peak and increased its magnitude; however, further increase of MK content to 30% did not affect the main hydration peak any further. Other font types may be used if needed for special purposes.

Fig -1: Sample metakaolin

2. LITERATURE REVIEW

Poon et al. (2001), investigated about the rate of pozzolanic reaction of metakaolin in High-Performance-Concrete. Hydration progress in metakaolin blended high performance concrete with age was studied from the compressive strength, porosity and pore size distribution properties. The results were compared with concretes containing silicafume, flyash and Portland cement. They reported the rates of pozzolanic reaction and calcium hydroxide consumption in the metakaolin blended cement concretes. The higher pozzolanic activity results in a higher rate of strength development and pore structure reinforcement for the cement concrete at earlier ages.

Mohamed Said-Mansou et al. (2010), observed that kaolin has been thermally activated and used as a pozzolan in blended cement. This study leads to the Thermal treatment at 850 C for 3 h is efficient for the conversion of kaolin to metakaolin. At these conditions the produced metakaolin exhibits the highest pozzolanic reactivity. Algerian MK is an active mineral admixture that could be used in cement concrete products. It has a good effect on the mechanical properties of cement mortars. Resistance to acid attack is higher for metakaolin.

A.A.Ramezanianpour et al. (2012), investigated that the effect of local metakaolin as supplementary cementing materials and filling materials on the strength and durability of concretes was investigated. From the results obtained in this study, the following conclusion can be drawn: Concrete incorporating local metakaolin had higher compressive strength at various ages and up to 180 days when compared with the OPC concrete. The level of compressive strength developed with the period of curing and with decreasing the w/b ratio. For the materials in this study at w/b ratio 0.4 and 0.35, the optimum replacement of metakaolin is 12.5% and 10%, respectively. The metakaolin concretes provided lower water penetration depth. It was found that in sorptivity test, the addition of 10% of MK gives the best result when compared to other replacement levels irrespective of w/b ratio and testing age.

L. Dvorkin et al. (2012), studied the influence of metakaolin as a complex admixture to self compacting high-strength concrete. A method using traditional deterministic and stochastic dependencies was developed for concrete composition design. Regression equations, describing the influence of water-binder ratio, binder content and metakaolin portion in binder on super plasticizer content, compressive strength and efficiency factor of metakaolin, were obtained. It was demonstrated that metakaolin performance in concrete is affected by its dosage, binder content, water-binder ratio and by the super plasticizer type. The method for mathematical experiments planning allows obtaining regression equations for determining the influence of water-binder ratio, binder content and metakaolin portion in it on super plasticizer content in concrete, compressive strength and efficiency factor of metakaolin.

2.1 Aim & Objectives

- To investigate the performance of concrete using mineral additive.
- To compare metakaolin additive with conventional concrete mixture for the better use ability and to bring low cost in construction.
- To maintain a good indoor environmental quality & performance of the building all through.
- To conduct the compressive test.
- The split tensile test.
- And flexural strength test for the M40 concrete.

3. MATERIALS AND METHODOLOGY

3.1 Materials used

Cement: Ordinary Portland cement of grade 43 is adopted for this work. The brand of cement used was Ultra Tech OPC with grade 43. The cement was gray and free from lumps.

Aggregates: In this research work fine aggregates used was river sand zone II and coarse aggregates used were crushed stones. These materials were easily available from local market.

Metakaolin: Metakaolin from Kaolin techniques Pvt. Ltd, Gujarat, having diameter 1μ to 13μ and obtained at the heating temperature of 750oC and flash calcination was done. As from suppliers it was also assured that the Metakaolin has 2.57g/cm2 specific gravity, pH 6.3, with average particle size 3μ, off white colour with reddish tint and also environment friendly.

Water: Clean tap water was used for washing aggregates, and mixing and curing of concretes.

3.2 Method Adopted

1. Properties of various constituents of concrete viz,

Cement, fine aggregates, coarse aggregates and Metakaolin were determined, by carrying out various tests.

2. Grade M40 concrete was designed as per IS: 10262-2009, which was used as reference mix.

3. Metakaolin was partially replaced at 0%, 5%, 10% and 15%.

4. Cube and cylinders was casted and curing was done.

5. Compressive strength test, split tensile strength test and flexural test was done.

4. EXPERIMENTAL PROGRAMME

Mix Proportions for M40 grade of Concrete

Mix Proportions

Cement = 10.84 kg

Metakaoline=1.204kg (by 10% replacement of cement)

Water = 5.201 litre

Fine aggregate(M sand) = 19.24 kg

Coarse aggregate 20mm =32.34 kg

The specimens of standard sizes and required shapes of different mix proportions were casted for 7, 14, 28, days and curing process is carried out after 24hrs from casting time.

5. RESULTS AND DISCUSSIONS

All the tests have been performed in standard procedures and the results and load values obtained were tabulated and calculated in following sections.

5.1 Slump flow

Slump cone values for Metakaolin concrete mixes are given in table 5.1 below

Sl.no	Type of Samples		Slump(mm)
1	Nominal mix		95
2	Metakaolin	5%	90
		10%	87
		15%	75

Table -5.1: Slump Flow values

5.2 Compressive Strength

Compressive strength tests were conducted on cured cube specimen at 7 days, 14 days and 28 days age using a compression testing machine of 200 kN capacity. The cubes were fitted at center in compression testing machine and fixed to keep the cube in position. The load was then slowly applied to the tested cube until failure.

Sl.no	Mix (days)		Cube
			Compressive strength (N/mm²)
1	7	OPC	31.3
		5%	33.0
		10%	34.2
		15%	32.1
2	14	OPC	40.7
		5%	42.1
		10%	43.6
		15%	42.0
3	28	OPC	48.6
		5%	50.3
		10%	52.4
		15%	48.4

Table -5.2: Compressive Strength values

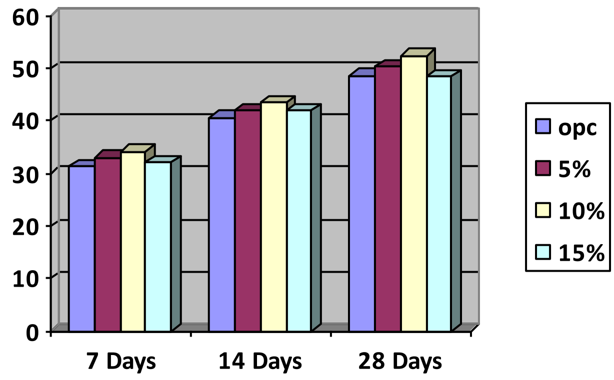

Chart -5.2: Compressive Strength

5.3 Split Tensile Strength

The split tensile test were conducted as per IS 5816:1999. The size of cylinder is 300mm length with 150mm diameter. The specimen were kept in water for curing for 7 days, 14 days and 28 days and on removal were tested in wet condition by wiping water and grit present on the surface. The test is carried out by placing a cylindrical specimen horizontally between the loading surfaces of a compression testing machine and the load is applied until failure of the cylinder along the vertical diameter.

Sl.no	Mix (days)		Cube
			Compressive strength (N/mm²)
1	7	OPC	3.21
		5%	3.63
		10%	1.63
		15%	3.34
2	14	OPC	3.82
		5%	4.42
		10%	4.71
		15%	4.01
3	28	OPC	4.52
		5%	4.93
		10%	5.19
		15%	4.71

Table -5.3: Split Tensile Strength values

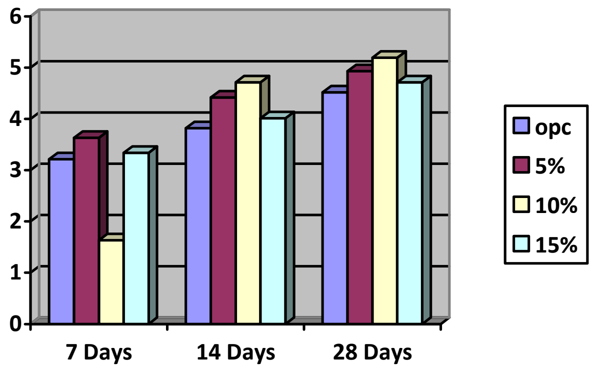

Chart -5.3: Split Tensile Strength

6. SUMMARY AND CONCLUSIONS

The main objective of this study is to analyse the performance of addition of commercially available Metakaolin as mineral additives in cementitious materials to avoid void resistance for concrete structures and to incresase the mechanical properties. Metakaolin is economically cheap in readily available state and is environment friendly.

The following conclusions were obtained as a result and performance for the tests conducted.

The conventional mix & M40 achieves a compressive strength of 48.6 N/mm2 and Split tensile strength values of 4.52 N/mm2 for 28 days of curing.

A concrete with Metakaolin admixture achieves a compressive strength of 52.4 N/mm2 and Split tensile strength values of 5.22 N/mm2 for 28 days of curing by partial replacement of metakaolin by 10% .

The strength of concrete increase by adding 5% metakaolin Therefore the amount increase when percentage of metakaolin is increased by 10% for optimum.on further increasing the amount of metakaolin by 5% .i.e 15% the strength is reduced.

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