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EXPERIMENTAL INVESTIGATION ON STRENGTH PROPERTIES OF METAKOALIN BLENDED CONCRETE

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ABSTRACT: Metakaolin is a supplementary cementitious material with pozzolanic properties. Its activation by triacalcium silicate (C3S), triacalcium aluminate (C3A), and ordinary Portland cement is already reported. Metakaolin is a revolutionary artificial pozzolana admixture obtained from thermally activated ordinary clay and kaolinitic clay which greatly enhances the properties of ordinary concrete and become the central to the research in the making of special concrete. The overall objective of the present study is to study the effect of adding Metakaolin in concrete on its performance and its durability under acid curing. For this Mix proportions of OPC concrete for M20 and M40 by IS method were determined. The mix proportion with partial replacement such as 0%, 10%, 20% and 30% of metakaolin with OPC were calculated. The concrete specimens such as cubes for M20 and M40 grade concrete were prepared and cured the specimens for 28 days and 90 days. The compressive strength of concrete increased when cement is replaced by Metakaolin for both M20 and M40 grade of concrete. The split tensile strength of concrete is increased when cement is replaced with Metakaolin. The flexural strength of concrete is also increased when the cement is replaced by Metakaolin. The compressive strength values of acid effected concrete decreases on comparison with of normal concrete, but the effect of acid on concrete decreases with the increase of percentage of metakaolin.

KEYWORDS: Concrete, Compressive Strength, Split tensile strength, Flexural Strength, Metakaolin, Admixture,

I. INTRODUCTION

The quest for the development of high strength and high performance concretes has increased considerably in recent times because of the compelling demands from the construction industry. In the last three decades, supplementary cementitious materials such as fly ash, silica fume and ground granulated blast furnace slag have been judiciously utilized as cement replacement materials as these can significantly enhance the strength and durability characteristics of concrete in comparison with ordinary Portland cement (OPC) alone, provided there is adequate curing. Addition of Metakaolin is one of the latest developments in this field. Metakaolin is a revolutionary artificial pozzolana admixture obtained from thermally activated ordinary clay and kaolinitic clay which greatly enhances the properties of ordinary concrete and become the central to the research in the making of special concrete. Metakaolin is a manufactured pozzolanic mineral admixture which significantly enhances many performance characteristics of cement based motors, concrete and related products. The use of pozzolanic materials in the manufacture of concrete has a long, successful history. Most pozzolans used in the world today are by products from other industries, such as coal fly ash, blast furnace slag, rice husk and silica fume. As such there has been relatively little work done with regard to manufactured, optimized and engineered pozzolanic materials which are specially intended for use in Portland cement based formulations. The use of Metakaolin and various chemical admixtures have become staple in gradients in the production of concrete with designed strength in excess of 7500psi(>50Mpa)or where service environments, exposure or life cycle cost considerations dictate the use of High performance concrete (HPC). Amongst the various methods used to improve the durability of concrete, and to achieve high performance concrete the use of Metakaolin is a relatively new approach. The partial replacement of ordinary Portland cement with pozzolanic materials can be advantageous in that it can increase the durability of paste, mortar or concrete if the proper curing regime is adopted. This is due to the fact that the Calcium Hydroxide produced by the cement hydration reacts with the pozzolana and produces additional gel which has a pore blocking effect and therefore alters the pore structure and the strength. In addition there is a reduction in Calcium Hydroxide (CH) which leads to improved resistance to sulphate attack and alkali-silica reaction Recently Metakaolin which is an ultra fine pozzolan produced from calcined clay has been added to the list of pozzolanic materials.

II. METHODOLOGY

The overall objective of the present study is to study the effect of adding Metakaolin in concrete on its performance; however the task is divided in to specific objectives to achieve step by step through experimental procedures.

The main objectives of the present project work are listed below:

1. To prepare the concrete specimens such as cubes for compressive strength, cylinders for split tensile test, prisms for flexural strength and also cubes for durability studies in laboratory with 0%, 10%, 20% and 30% replacement of metakaolin with OPC for M20 and M40 grade concrete.
2. To evaluate the mechanical characteristics of concrete such as compressive strength, split tensile test, flexural strength.

3. To evaluate the durability studies of M20 and M40 grade metakaolin replaced concrete subjected to 1% and 5% concentrations of Hydrochloric acid (HCl) and Sulphuric acid (H_2So_4).
4. To evaluate and compare the results.

Properties of Metakaolin

In the present investigation Metakaolin marketed by specialty Minerals, Baroda, Gujarat, is used. The results furnished by the manufacturer are presented in table its specific gravity as found is 2.65 and bulk density is 710 kg/m3. Physical Properties of Metakaolin were given in the Table 2.1 below. The metakaolin appears like a fine powder with light grey colour shown in the Figure 2.1 below.

Table 2.1 Physical Properties of Metakaolin

Characteristic	Value for Metakaolin
Average particle size, µm	1.5
Specific Gravity	2.65
Bulk density (kg/m^3)	710 kg/m^3
Physical form	White Powder

Figure 2.1 Metakaolin

III. RESULTS & DISCUSSION

The tests were carried out to obtain compressive strength of M20 and M40 grade concrete. The compressive strength of concrete is tested for 28 days, 90 days for 0%, 10%, 20% and 30% replacement of metakaolin and the values are presented in Table no 3.1 and graphs were plotted below.

EFFECT OF VARIATION OF METAKAOLIN ON SPLIT TENSILE STRENGTH

From both tables and graphs it is observed that at about 20% replacement of cement with Metakaolin, concrete attains its maximum compressive strength for both M20 and M40 grade concretes, when the replacement exceeds 20%, the compressive is found to be decreasing slightly. And 10% replacement of metakaolin is greater than the 30% replacement of metakaolin.

Table 3.1Compressive Strength of concrete for M20 & M40

S. NO:	%OF METAKAOLIN	COMPRESSIVE STRENGTH OF M20 (N/MM^2)		COMPRESSIVE STRENGTH OF M40 (N/MM^2)	
		28 DAYS	90 DAYS	28 DAYS	90 DAYS
1	0	33.3	46.26	49.99	54.22
2	10	35.57	50.26	51.66	56.99
3	20	37.49	53.33	54.59	58.11
4	30	34.37	48.85	50.36	54.44

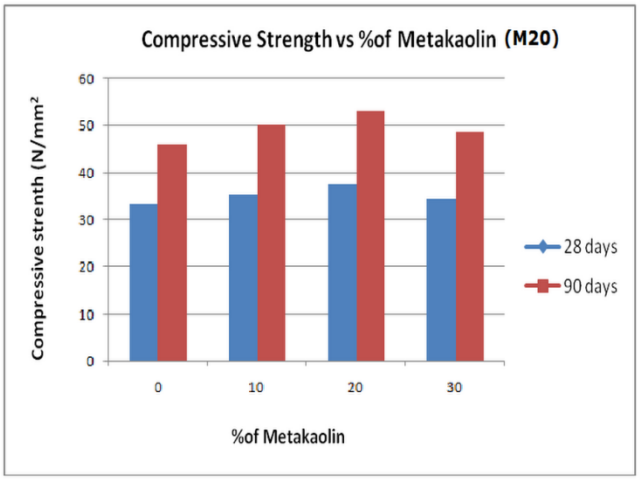

Figure 3.1 Graph between Compressive Strength of concrete for M20 vs % of metakaolin

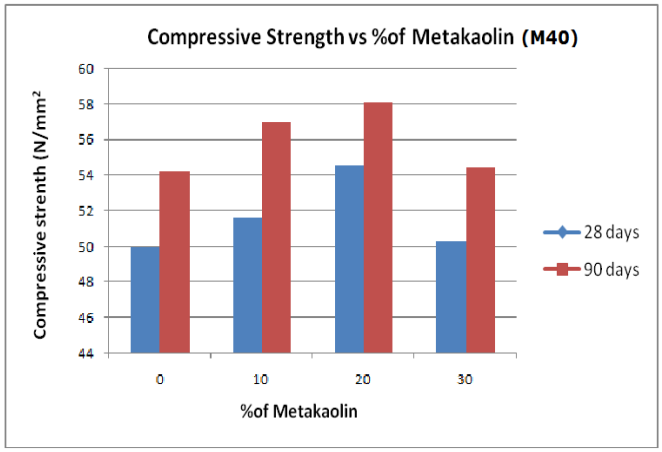

Figure 3.2 Graph between Compressive Strength of concrete for M40 vs % of metakaolin

EFFECT OF VARIATION OF METAKAOLIN ON SPLIT TENSILE STRENGTH

The test was carried out to obtain split tensile strength of M20 and M40 grade concrete. The split tensile strength of concrete is tested for 28 days, 90 days for 0%, 10%, 20% and 30% replacement of metakaolin and the values are presented in Table no 3.2 and also graphs were plotted bellow.

Table 3.2 Split Tensile Strength of Concrete for M20 &M40

S. NO:	%OF METAKAOLIN	SPLIT TENSILE STRENGTH OF M20 (N/MM^2)		SPLIT TENSILE STRENGTH OF M40 (N/MM^2)	
		28 DAYS	90 DAYS	28 DAYS	90 DAYS
1	0	2.69	3.5	3.11	3.67
2	10	2.9	3.69	3.36	3.82
3	20	3.1	3.9	3.62	4.1
4	30	2.82	3.71	3.22	3.7

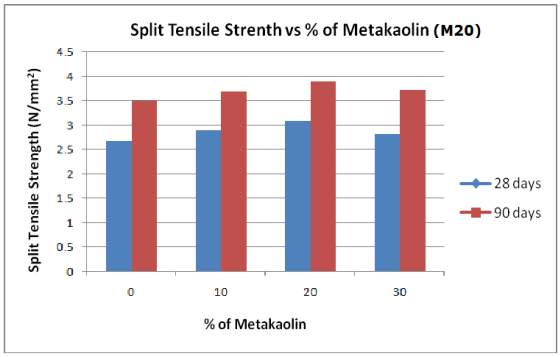

Figure 3.3 Graph between Split Tensile Strength of concrete for M20 vs % of metakaolin

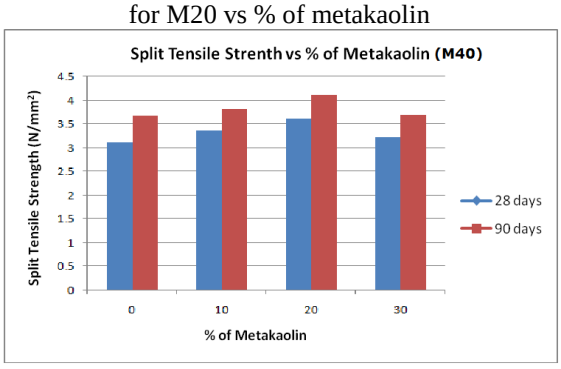

Figure 3.4 Graph between Split Tensile Strength of concrete for M40 vs % of metakaolin

EFFECT OF VARIATION OF METAKAOLIN ON FLEXURAL STRENGTH

The test was carried out to obtain flexural strength of M20 and M40 grade concrete. The flexural strength of concrete is tested for 28 days, 90 days for 0%, 10%, 20% and 30% replacement of metakaolin and the values are presented in table no 3.3 and also graphs were plotted bellow.

Table 3.3 Flexural Strength of Concrete for M20 &M40

S. NO:	%OF METAKAOLIN	FLEXURAL STRENGTH OF M20 (N/MM^2)		FLEXURAL STRENGTH OF M40 (N/MM^2)	
		28 DAYS	90 DAYS	28 DAYS	90 DAYS
1	0	5.21	6.51	6.1	7.02
2	10	5.64	7.12	6.5	7.56
3	20	5.91	7.95	7.12	8.21
4	30	5.32	6.62	6.34	6.9

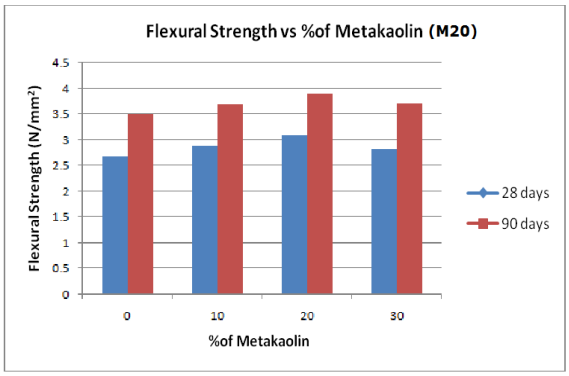

Figure 3.5 Graph between Flexural Strength of concrete for M20 vs % of metakaolin

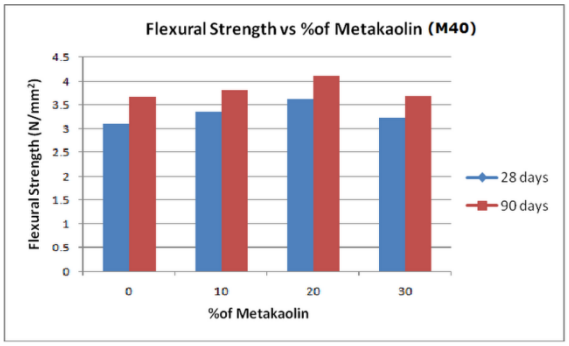

Figure 3.6 Graph between Flexural Strength of concrete for M20 vs % of metakaolin

From both tables and graphs it is observed that at about 20% replacement of cement with Metakaolin, concrete attains its maximum split tensile strength for both M20 and M40 grade concretes, when the replacement exceeds 20%, the compressive is found to be decreasing slightly. And 10% replacement of metakaolin is greater than the 30% replacement of metakaolin.

EFFECT OF H_2So_4 AND HCl ACIDS ON CONCRETE (DURABILITY STUDIES)

Concrete cubes of 0%, 10%, 20% and 30% of metakaolin concrete of M20 and M40 grade concrete exposed to H2So4 and HCl of 1% and 5% concentrations are tested for compressive strength for 90 days and 28 days respectively. And results are presented in table 3.4 and 3.5

Table 3.4 Compressive strength for M20 grade concrete after H_2SO_4 Acid curing

S. NO:	% OF METAK AOLIN	COMPRESSIVE STRENGTH M20 (N/MM^2)		COMPRESSIVE STRENGTH M40 (N/MM^2)	
		28 DAYS(5 % H_2SO_4)	90 DAYS (1% H_2SO_4)	28 DAYS(5 % H_2SO_4)	90 DAYS (1% H_2SO_4)
1	0	27.3	38.54	41.66	45.44
2	10	31.03	43.21	43.44	48.22

3	20	34.21	48.23	47.33	52.7
4	30	30.22	40.62	43.26	48.48

Table 3.5 Compressive strength for M20 grade concrete after HCl Acid curing

S. NO:	% OF METAK AOLIN	COMPRESSIVE STRENGTH M20 (N/MM^2)		COMPRESSIVE STRENGTH M40 (N/MM^2)	
		28 DAYS(5 % HCL)	90 DAYS (1% HCL)	28 DAYS(5 % HCL)	90 DAYS (1% HCL)
1	0	28.1	39.45	42.44	46.99
2	10	31.58	44.2	45.06	49.7
3	20	35	49.11	49.22	54.1
4	30	31.12	42.62	45.64	49.92

Effect of H_2SO_4: From above tables and graphs it is observed that the compressive strength values of 5% (28 days) and 1% (90 days) concentration H_2SO_4 containing M20 and M40 grade concrete decreases, but resistance power of concrete increases with replacement of metakaolin against to H_2SO_4, up to 20% replacement resistance power increases beyond that resistance power decreases, but at 20% replacement of metakaolin the resistance power of concrete is more.

Effect of HCl: The compressive strength values of 5% (28 days) and 1% (90 days) concentration Hcl containing M20 and M40 grade concrete decreases, but resistance power of concrete increases with replacement of metakaolin against to Hcl, up to 20% replacement resistance power increases beyond that resistance power decreases, but at 20% replacement of metakaolin the resistance power of concrete is more. So the compressive strength values of acid effected concrete decreases on comparison with of normal concrete, but the effect of acid on concrete decreases with the increase of percentage of metakaolin. At 20% replacement of metakaolin the resistance power of concrete is more.

Comparision of H_2SO_4 and HCl: The compressive strength values of metakaolin concrete effected to Hcl were greater than the metakaolin concrete effected to H_2SO_4. The effect of Hcl on strength of the concrete is lower than the effect of H_2SO_4 on strength of the concrete.

IV. CONCLUSIONS AND RECOMMENDATIONS

Based on the analysis of experimental results and discussion there upon the following conclusions can be drawn.

The compressive strength of concrete increased when cement is replaced by Metakaolin for both M20 and M40 grade of concrete. At 20% replacement of cement by Metakaolin the concrete attained maximum compressive strength for both M20 and M40 grade of concrete. The split tensile strength of concrete is increased when cement is replaced with Metakaolin .The split tensile strength is maximum at 20% of replacement.

The flexural strength of concrete is also increased when the cement is replaced by Metakaolin. At 20% replacement, the flexural strength is maximum. The compressive strength values of acid effected concrete decreases on comparison with of normal concrete, but the effect of acid on concrete decreases with the increase of percentage of metakaolin. At 20% replacement of metakaolin the resistance power of concrete is more. The compressive strength values of metakaolin concrete effected to HCl were greater than the metakaolin concrete effected to H_2SO_4. The effect of HCl on strength of the concrete is lower than the effect of H_2SO_4 on strength of the concrete. Workability of concrete decreases with the increase in metakaolin replacement level.

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