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METAKAOLIN – A SUPPLEMENTARY ADDITIVE MINERAL ADMIXTURE FOR CONVENTIONAL CONCRETE.

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Abstract: In these generation of concrete world, there is a over extensive use of conventional concrete as a advantageous physical properties of it. As these concrete provides the structural rigidity at a glance with lower cost along with locally available material. As the consumption of material is more for conventional concrete day by day the hike in rates of material for conventional concrete is increasing. Hence its necessary to find out the alternative which is sustainable & compares the properties of material as same as conventional material. Conventional concrete is extensively used material world wide approximately up to three billions tones placed per year worldwide. The concern for emission of CO2 for manufacturing process. Hence there has been pressure by various environment protection agencies to reduce consumption of cement with intention to increase the inventions for usage of alternative mineral admixtures. Metakaolin looks to be promising supplementary material to the cement in conventional concrete by its properties along with availability of metakaolin in abundance in country is itself a advantage for these Green concrete. Here the substitution of metakaolin for cement is varied in proportions of 0%, 10%, 30%, 50%, 70 % by weight of cement. A cube casting for various proportions where done to determine the compressive strength of concrete. Hence the test result were evaluated and compare with various proportions to decide the percentage for addition of metakaolin as a additive material with cement for moving society toward Green concrete.

Index Terms - Green concrete; Metakaolin; Compressive strength; Conventional concrete; Mineral admixtures.

I. INTRODUCTION

The increasing risks of climate change and maximum use of conventional material required for conventional concrete is huge due to larger use of concrete worldwide. Hence there is a depletion of natural resources maximally, to avoid such depletion an research for search of perfect additive material for OPC was must. Here we are testing the mineral admixture Metakaolin to fit at perfect amount for cement in terms of compressive strength in concrete. A various proportions of metakaolin for addition to OPC was 0%, 10%, 30%, 50% & 70% in concrete. The specimens were casted for M30 grade of concrete with different replacement levels of metakaolin.

II. OBJECTIVE:

Knowing that conventional cement production is one of the leading causes of global warming, So there are extensive efforts worldwide to achieve a sustainable environment, This study aims to contribute the growing research area of Green concrete by conducting a comprehensive study on the sustainability, strength properties of Green concrete to check for its feasibility as an eco-friendly and structural material instead of conventional cement. Objective for the study is to study a partial replacement of MK for sustainable,

economic & environmental wellness of society. The other objective of studies the effect of MK after addition to various proportions with conventional concrete on basis of Compressive Strength Test & Workability Test. Also the hidden industrial mineral of society to be use as best suited binding material which posse the same properties of conventional cement in construction industry and finally to move towards the revolution of green concrete as use of conventional cement will reduce due to replacement of MK in conventional concrete, which do not leave carbon foot print harmful to mother earth.

III. LITRATURE REVIEW:

C. Manikandan (2015): They concluded that the addition of Metakaolin along with cement has increased the compressive strength of the concrete when compared to the control mix. The more effective percentage of replacement seems to be between 10 –15%. By replacing the cement with metakaolin, they reduced the consumption of cement. By reducing the consumption of cement, the ecology of the earth can be improved and the air pollution due to the production of cement can be reduced.

Abhishek Jandiyal (2016): They concluded that on the basis of this study they have seen that metakaolin replacement has a good influence on strength parameters. It canbe replaced up to 25% & optimum is at 10 %. The increase of compressive strength varied between 5-38% for M20 grade, 2-37% for M30 grade, 3-13% for M40 grade and 3-18% for M50 grade of concrete. The increase of split tensile strength varied between 5-36% for M20 grade, 2-13% for M30 grade, 2-34% for M40 grade and 2-26% for M50 grade of concrete. The increase in cost for 10% replacement varied between 11-13% for all grades of concrete.

M. Narmatha (2016): They stated that the strength of all Metakaolin concrete mixes over shoot the strength of OPC. Their 15% cement replacement by Metakaolin was superior to all other mixes. The increase in Metakaolin content has improved the compressive strength and split tensile strength up to 15% cement replacement. The results encouraged the use of Metakaolin, as a pozzolanic material for partial replacement in producing high performance concrete.

Nova John (2013): He investigated the cement replacement levels were 5%,10%,15%,20% by weight for metakaolin. The strength of all metakaolin admixed concrete mixes over shoot the strength development of concrete. Mix with 15% metakaolin is superior to all other mixes. The increase in metakaolin content improves the compressive strength, split tensile strength and flexural strength upto15% replacement. The result encourages the use of metakaolin, as pozzolanic material for partial cement replacement in producing high strength concrete. The inclusion of metakaolin results in faster early age strength development of concrete. The utilization of supplementary cementitious material like metakaolin concrete can compensate for environmental, technical and economic issues caused by cement production.

Erhan Guneyisi (2007): They reported that the inclusion of metakaolin as a supplementary cementinous material in concrete helps in a wonderful way to reduce drying shrinkage strain. The pore structure of concrete was greatly enhanced due to the utilization of ultrafine metakaolin which was also accompanied by the decrease in the harmful large pores thereby improving the overall permeability of concrete. The imperviousness was greatly seen at 20% replacement level. The studies also revealed that the strength was dependent on the levels of replacement, water cement ratio and age of testing and also the strength enhancement was in varying magnitudes.

IV. MATERIAL AND METHODOLOGY:

A. **Cement**: OPC of 53 grade confirming to IS: 12269-1978 was used in the above study. The specific gravity of
conventional cement was 3.10

B. **Coarse aggregate**: Crushed stone of maximum size 20mm confirming IS: 383-1970 was used from local sources

C. **Fine aggregates**: A river sand passing through 4.75mm IS sieve confirming to grading zone-II of IS: 383-1970 was used from local sources

D. **Water**: A water with PH value 7 $\pm$ 2 free from concentration of acid and organic substance is used for mixing into concrete and curing purpose.

E. **Metakaolin**: This material is classified as a mineral admixture by IS : 456-2000. These material is not a by-product. It is obtained by the clacination of pure refined kaolinite clay at temperature 650-850^{0}C followed by grinding process to achive finess of 700-900 m^2/Kg. These is a high quality pazzolanic material. These is a new material to a concrete industry which effective in increasing strength of concrete by increasing the air void network in concrete. The formation properties of metakaolin are compared by the conventional cement in presented chart in table 1.

Chemical composition	Cement %	Metakaolin %
Silica (SiO_2)	34	54.3
Alumina (Al_2O_3)	5.5	38.3
Calcium Oxide (CaO)	63	0.39
Ferric Oxide Calcium Oxide (Fe_2O_3)	4.4	4.28
Magnesium Oxide (MgO)	1.26	0.08
Potassium Oxide(K_2O)	0.48	0.50
Sulphuric anhydride (SO_4)	1.92	0.22
Specific Gravity	3.15	2.5
Physical Form	Fine powder	Fine powder
Colour	Gray	Off white

Table no- 01 (Chemical Properties of Cement & Metakaolin)

F. **Mix Proportions** Trial mixtures were prepared to obtain the maximum strength for the control mixture at 28 days containing the w/c ratio as 0.42. The details of mixtures (MK0, MK10, MK30, MK50, MK70) were employed to examine the influence of strength properties of mixes. The slump was found to be varying between 100 – 120 mm. The mix proportions for conventional and volume based partial replacement of cement by metakaolin presented in above table .02.

Ingredients	0% MK	10% MK	30% MK	50% MK	70% MK
Cement	510	455	355	255	150
Metakaolin	0	55	155	255	360
Fine Agg.	806	806	806	806	806
Coarse Agg.	972	972	972	972	972
Water	162	162	162	162	162

Table no- 02 (Mix proportions of volume based partial replacement of MK)

V. RESEARCH METHODOLOGY

A. Casting of specimens

The test program considered the casting and testing of concrete specimen of cube (150 X 150 mm). The specimen was casted in M30 grade concrete using conventional cement, Natural river sand, crushed stone along with metakaolin. Each three specimens were made to take the average value. The specimens were demoulded after 24-hrs. The specimens were allowed to curing periods as follows.

B. Testing of specimens

Testing of specimens was carried out manually. The compressive strength values were presented in table no 3 above.

C. Compressive Strength Test

For all the proportions of partial replacement of cement by metakaolin totally thirty cubes of size 150 X 150 mm were casted and tested using Universal Testing Machine (UTM). The specimens were placed on the platform of UTM. The load was applied gradually until the failure stage. The failure stage load was noted down and hence calculated the compressive strength of corresponding specimen.

VI . RESULTS AND DISCUSSION

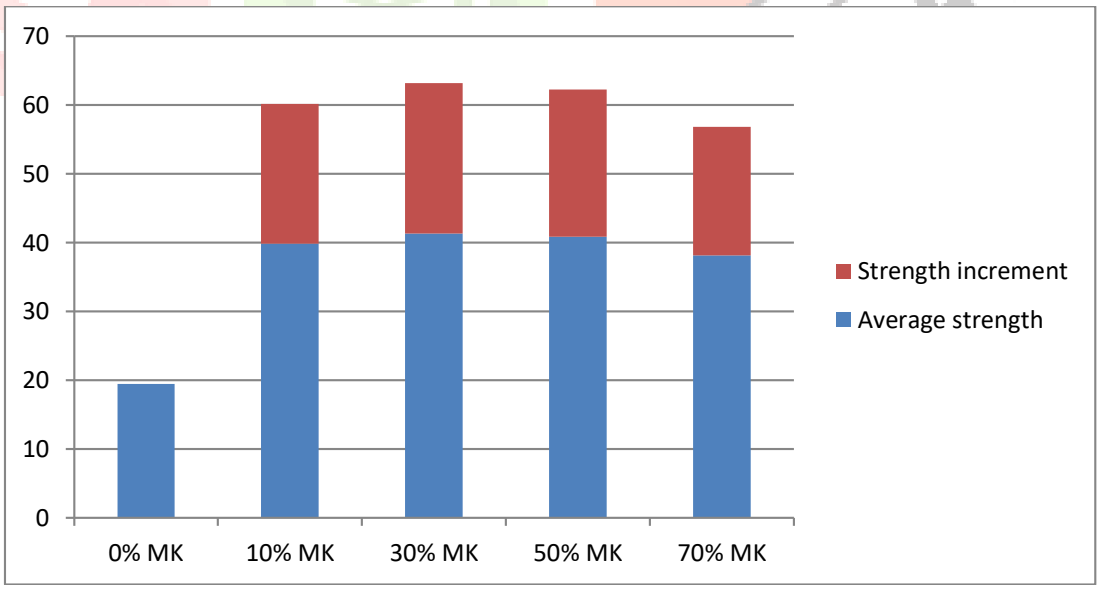
The test results of concrete specimen discussed as below:

Compressive Strength Test: The compressive strength of various proportions of metakaolin was compared for 7 & 28 days strength and further the results are described above in table and graphs simultaneously.

A. **7 days test results:**

Age of Test	0 % MK	10 % MK	30 % MK	50 % MK	70 % MK
7 days Test Average (MPa)	19.41	39.78	41.29	40.83	38.11
Strength increment after adding MK (MPa)	_	20.37	21.88	21.42	18.70

Table no: 03 (Compressive Strength test results for 7 days testing)

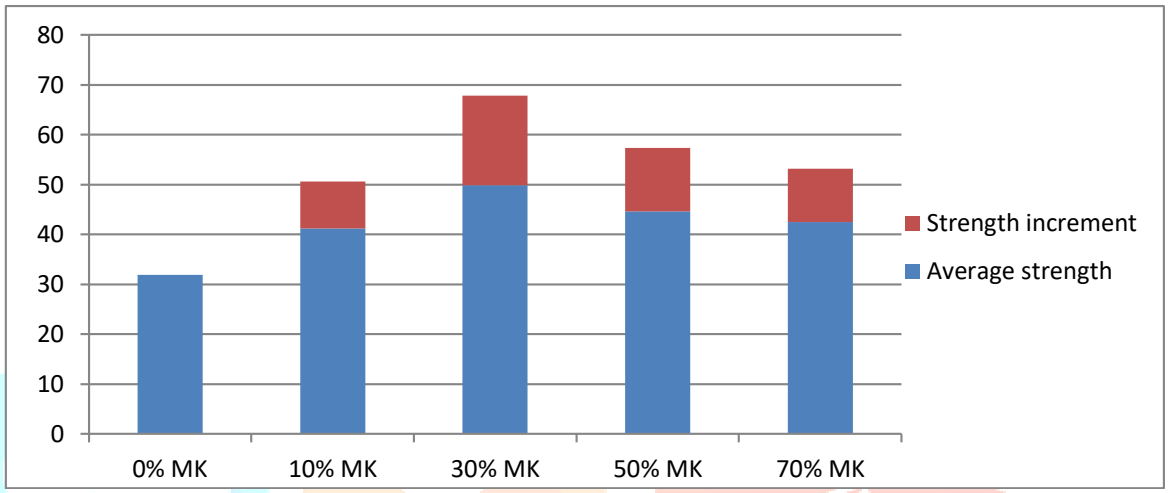


Graph no: 01 (Compressive Strength test results for 7 days testing)

B. 28 days test result:

Age of Test	0 % MK	10 % MK	30 % MK	50 % MK	70 % MK
28 days Test Average (MPa)	31.89	41.24	49.86	44.64	42.52
Strength increment after adding MK (MPa)	_	9.35	17.97	12.75	10.63

Table no: 04 (Compressive strength test results for 28 days testing)

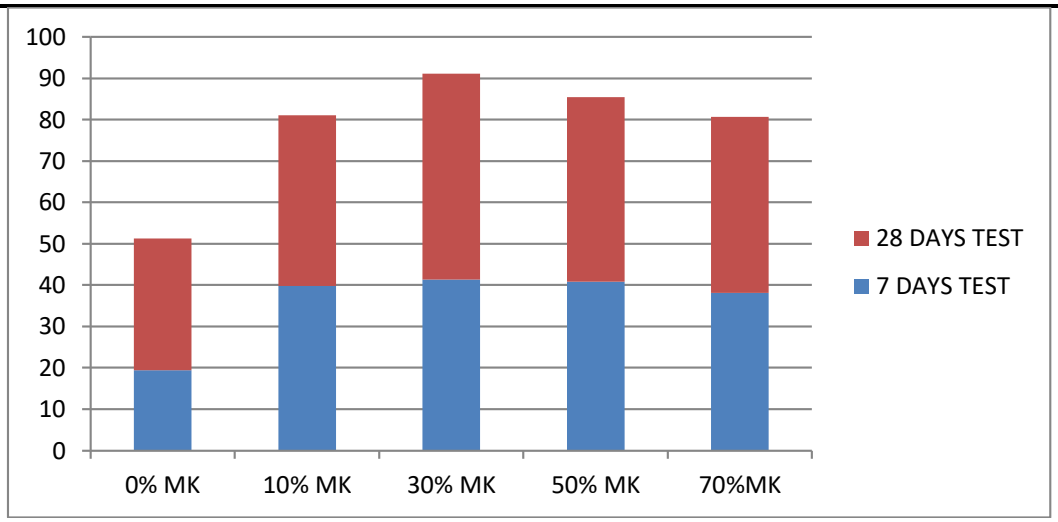


Graph no: 02 (Compressive strength test results for 28 days testing)

C.Comparison for 7 days & 28 days compressive strength test:

Age of Test	0 % MK	10 % MK	30 % MK	50 % MK	70 % MK
7 days Test Average (MPa)	19.41	39.78	41.29	40.83	38.11
28 days Test Average (MPa)	31.89	41.24	49.86	44.64	42.52

Table no: 05 (Compressive Strength test for 7 & 28 days)



Graph no: 03 (Comparison between compression strength of 7 & 28 days test)

VII.SUMMARY AND CONCLUSIONS:

From the present investigation on effect of partial replacement of cement with MK in concrete, the following Conclusions were drawn as listed below:

[1] The result encourages the use of MK as a pazzolanic material for partial replacement in producing a Green concrete, as MK do not leaves carbon foot prints in nature.

[2] The supplementary use of MK with OPC improves the compressive strength up to 30% conventional cement replacement.

[3] MK was very effective in gaining higher early strength than the conventional concrete with 100 % OPC use.

[4] Metakaolin help in production of abrasion resistant concrete as it lies second to diamond on hardness scale.

[5] It is environment acceptable or eco-friendly or does not cause pollution.

VIII.SCOPE FOR FURTHER WORK

[1] In addition, to these thesis a further study could also be conducted to determine the MK-concrete in larger scale specimens such as beams & slabs under shear, flexure to develop an understanding of how the combination of MK-Concrete ,bar, stirrups can create a system that is functional and safe.

[2] Use of metakaolin as a supplementary cementitious materials can move concrete world to move toward the “GREEN CONCRETE” which is utmost essential for today’s generation.

[3] Finally thesis will serve as a base for analyzing the other type of substitutes in MK-Concrete, such as Agricultural & Municipal Waste.

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