International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017), e-ISSN: 2455-2585
Volume 4, Issue 08, August-2018

AN EXPERIMENTAL STUDY ON PARTIAL REPLACEMENT OF CEMENT WITH METAKAOLIN

Navdeep Mor[1], Tanveer Hussain [2], Sameer Malhotra[3]

[1]*Research Scholar,Civil Deptt. NITTTR,Chandigarh,*

[2]*M.Tech Student, Civil Engineering Department,*
Gurukul Vidyapeeth Institute of Engineering and Technology, Banur, India

[3]*Assistant Professor, Civil Engineering Department,*
Gurukul Vidyapeeth Institute of Engineering and Technology, Banur, India

Abstract— Environmental pollution caused by the extraction of raw materials and CO_2 emissions in the production of cement leads to the pressures to reduce the consumption of this constituent of concrete. At the same time requirement of cement should be fulfilled and also need to increase its durability. The cement highly energy intensive and costly component of concrete thus the unit cost of concrete can be reduced by percentage replacement of cement with other waste pozzolanic materials. Some materials are also used to enhance strength and durability properties of concrete materials such as metakaolin and another byproduct like flyash. Metakaolin is the anhydrous calcined form of the clay mineral kaolinite. Past investigation shows that partial replacement of cement with metakaolin increases the strength of the concrete, durability and gives a fine finish. In this present study, mechanical properties of metakaolin and compressive of the concrete with partial replacement of cement 5%, 10% and 15% with metakaolin are investigated. Various tests on metakaolin are performed and mix design works out. Results show that the specific gravity of metakaolin is 2.73. The compressive strength of MK5 for 28 days was higher by 24% respectively than the control mix M20. The compressive strength of MK10 and MK15 for 28 days was higher by 24%, 44%, and 29% respectively than the control mix M20 and the optimum percentage replacement of MK is found to be 10%. . As Metakaolin has pozzolanic properties, so it shows positive effect in resulting properties of concrete.

Keywords— Metakaolin, Compressive strength, Specific gravity, Concrete, Cement.

I. INTRODUCTION

Environmental concerns caused by the extraction of raw materials and CO2 emissions in the production of Portland cement led to pressure for reducing the consumption of this constituent of concrete, and also fulfil the need of construction industry. The cement is the most important ingredient of concrete, which increases the unit cost of concrete. The cost can be reduced by using waste pozzolanic materials in replacement of cement. Metakaolin is the anhydrous calcined form of the clay mineral kaolinite. The particle size of metakaolin is smaller than cement particles but not as fine as silica fume. Metakaolin can be used as high strength and lightweight concrete.

The cement industry is one of the two primary product producers of carbon dioxide(CO2),creating up to 5% of worldwide man –made emissions of this gas, of which 50% is from the chemical process and 40% from burning fuel. The CO2 emission from the concrete is directly proportional to the cement content used in the concrete mix; 900 kg of CO2 are emitted for the production of every ton of cement. Metakaolin is in widespread use all over the world in the concrete industry. The advantages of metakaolin are not only the many concrete performance benefits, both in mechanical and durability properties, but also the environmental benefits. While the production of Portland cement is associated with high CO2 emissions.

Metakaolin is a dehydroxylated form of the clay mineral kaolinite. Metakaolin can be produced by primary and secondary sources containing kaolinite are high purity kaolin deposits, kaolinite deposits or tropical soils of lower purity, paper sludge waste which contains kaolinite, oil sand tailings contains kaolinite. From the previous observations it is proved that use of waste product namely Metakaolin increased compressive and flexural strengths, increases durability. Metakaolin usage helps in developing high performance and high strength in concrete.

The cement industry is one of the two primary product producers of carbon dioxide(CO2),creating up to 5% of worldwide man –made emissions of this gas, of which 50% is from the chemical process and 40% from burning fuel. The

CO_2 emission from the concrete is directly proportional to the cement content used in the concrete mix; 900 kg of CO_2 are emitted for the production of every ton of cement. Metakaolin is in widespread use all over the world in the concrete industry. The advantages of metakaolin are not only the many concrete performance benefits, both in mechanical and durability properties, but also the environmental benefits. While the production of portland cement is associated with high CO_2 emissions. Metakaolin is a dehydroxylated form of the clay mineral kaolinite. Metakaolin can be produced by primary and secondary sources containing kaolinite are high purity kaolin deposits, kaolinite deposits or tropical soils of lower purity, paper sludge waste which contains kaolinite, oil sand tailings contains kaolinite. From the previous observations it is proved that use of waste product namely Metakaolin increased compressive and flexural strengths, increases durability. Metakaolin usage helps in developing high performance and high strength in concrete.

II. LITERATURE REVIEW

Past results showed that (Beulah M et.al) the influence of replacement of cement by metakaolin on the properties of high-performance concrete subjected to magnesium sulphate attack and found that addition of metakaolin not only increases its compressive strength but it also improves its resistance to magnesium sulphate attack. Rathan raj reports the physical and mechanical properties of ordinary Portland cement concrete containing up to 14% metakaolin as a cement replacement material. Specimens with water binder ratio 0.38, 0.36 and 0.33 were subjected to slump, compaction factor and Vee– Bee consistometer tests. Katib and Wild (1998) investigated the partial substitution of cement with metakaolin in terms of resistance of MK mortar to sodium sulphate (Na_2SO_4) solution. Results on strength, porosity, pore size distribution, and calcium hydroxide contents are also reported. It was found out that partial replacement of cement with. metakaolin increases the strength of the concrete, durability and gives a fine finish.

METHODOLOGY

The methodology is a system of methods used in the experiment to get the desired result. In Present study, mechanical properties of metakaolin and compressive strength of the concrete with partial replacement of cement 5%, 10% and 15% with metakaolin were investigated. Various tests on metakaolin are performed and mix design is worked out. Locally available sand of size less than 4.75mm was used and its specific gravity was found to be 2.6. OPC of grade 43 was used and its specific gravity was found to be 3.15. The coarse aggregate of size 20mm, 12mm and 6mm was used and its specific gravity was determined as 2.74. water used for mixing and curing is a potable water. Metakaolin of specific gravity 2.73 was used for this study. The details regarding the physical properties of Metakaolin is shown in Table No: 1.

Table 1 Physical Properties of Metakaolin

SR. NO.	TEST	Value
1	Specific Gravity	2.73
2	Normal Consistency	34%
3	Setting Time – Initial	230 minutes
4	Setting Time – Final	375 minutes
5	90 – Micron Sieve	94%

The mix design for control mix, MK5, MK10, and MK15 is done from IS 10262-2009. Same mix design procedure (IS10262-2009) was followed for the casting of cubes for MK5, MK10, and MK15. Here with the increase % of metakaolin, the quantity of cement decreased. The water-cement ratio taken was the same (0.5). Cubes were prepared and tested. Compressive strength test of concrete specimens was carried out. The test was done using a universal tensile machine having a load capacity of 1000kN. The compressive strength of cubes of different grades i.e. control mix M20, MK5, MK10 and MK15 for 7, 14 and 28 days were tested.

Compressive Strength of Control Mix

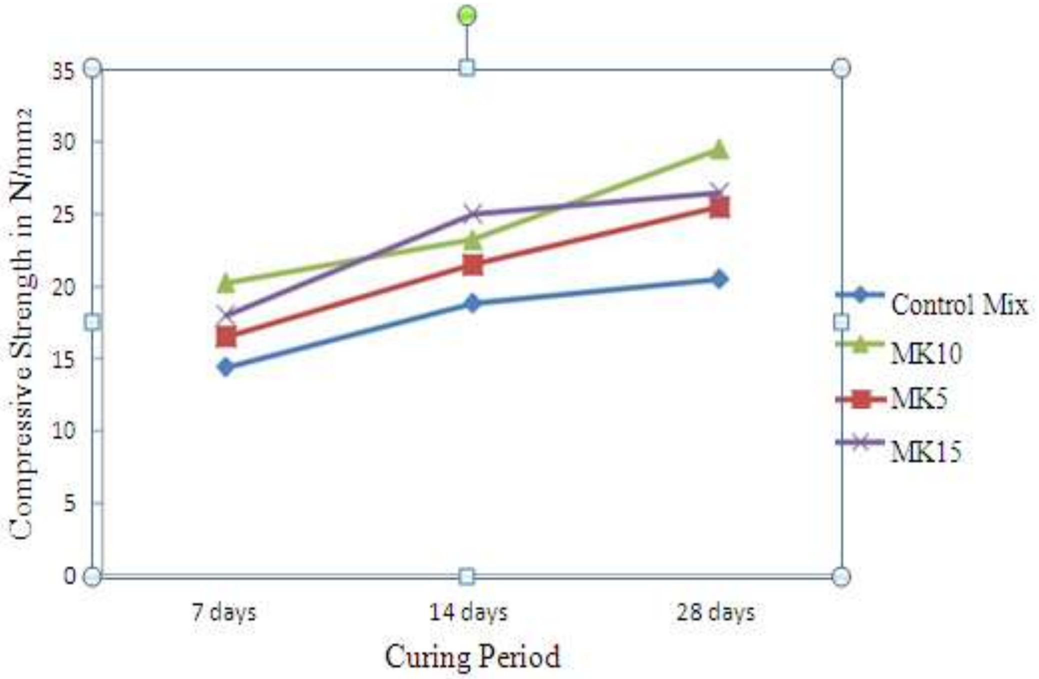
After completion of curing the compressive strength of the cubes, specimen were tested after 7, 14 and 28 days of curing. The compressive strength test was carried out and calculated. The results are given below in Table No. 2 and same is represented as in figure No 1.

Table No: 2 Comparison of Compressive Strength

Curing period	Control mix (M20) in N/mm2	MK5 in N/mm2	MK10 in N/mm2	MK15 in N/mm2
7 days	14.4	16.75	20.25	18
14 days	18.8	21.5	23.25	25
28 days	20.5	25.5	29.5	26.5

The compressive strength of cubes for 7days, 14 days and 28 days were determined and their values were compared.

Figure No:1 Comparison of Compressive Strength after 7,14 & 28 days of curing.



Comparison of Compressive Strength

The compressive strength of MK5, MK10, and MK15 for 28 days increased by 24%, 44%, and 29% respectively than that of control mix M20. The compressive strength of MK15 for 28 days is 26.5N/mm^2 which is less than that of MK10. Hence the optimum replacement of MK is 10%. The compressive strength of all cubes of different grades is given above in Table No:3 and same is represented as in Figure No:1

CONCLUSION

The compressive strength of MK5 for 28 days was higher by 24% respectively than the control mix M20. The compressive strength of MK10 and MK15 for 28 days was higher by 24%, 44%, and 29% respectively than the control mix M20 and the optimum percentage replacement of MK is found to be 10%.

FUTURE SCOPE

As Metakaolin is natural white clay obtained by heating kaolin to particle structure, thus, making it a highly reactive, amorphous pozzolans. Above research showed that if this material is accepted for construction, it will give a commendable increase in compressive strength. As Metakaolin has pozzolanic properties bringing positive effect in resulting properties of concrete. Thus, Pozzolanic properties cause a chemical reaction which will not only increases the strength but can affect the durability and other properties also. So at last, it can be said that using this material cost and material both can be saved and use of this material in construction should be promoted.

I. References

1. Beulah M and Prahallada M.C(2013) investigated the effect of replacement of cement by metakaolin on the properties of high-performance concrete subjected to magnesium sulphate attack International Journal of IT, Engineering and Applied Sciences Research (IJIEASR), volume 2, No.2, February 2013. ISSN: 2319-4413.
2. Dhinakaran.G, Thilgavathi.S, and Venkataramana.J(2012) investigated the compressive strength and chloride resistance of metakaolin concrete. The study was conducted for different w/c ratios of 0.32, 0.35, 0.4 and 0.5. KSCE Journal of Civil Engineering (2012) 16(7):1209-1217
3. Jian-Tong Ding and Zongjin Li (2002) investigated the effects of metakaolin and silica fume on various properties of concrete, ACI Materials Journals, Vol.99, No: 4, pp. 393-398.
4. Khatib and Wild (1998) investigated the partial substitution of cement with metakaolin in terms of resistance of MK mortar to sodium sulphate (Na2SO4) solution, Cement and Concrete Research, Volume 28, Issue 1, January 1998, Pages 83-89.
5. Patil B.B and Kumar P.D(2012) studied the strength and durability properties of high-performance concrete incorporating high reactivity metakaolin. International Journal of Modern Engineering Research, Vol.2, Issue.3, May-June (2012), pp-1099-1104.
6. Rathan raj (2013) reports the physical and mechanical properties of ordinary Portland cement concrete containing up to 14% metakaolin as a cement replacement material. Indian Concrete Journal.
7. Supriya K. Nalawade, Hemlata K. Muno and Balkrishna Dawari(2011), Properties of concrete wit metakaolin and flyash as partial replacement of cement, International Journal of Earth Sciences and Engineering ISSN 0974-5904, Volume 04, N 06 SPL, October 2011, pp. 1059-1059.
8. Vikas (2012) concluded from his project that the gain in compressive strength is improved depending upon the replacement level of OPC by metakaolin, J.Acad. Indus. Res. Vol. 1(5) October 2.12, pp. 251-253.
9. Yang C. C, Chor S.W, Huang R. (2002). “The relationship between charge passed and the chloride-ion concentration in concrete using steady-state chloride migration test.” Journal of Cement and Concrete Research, Vol. 32, No. 2, pp. 217-222.
10. A text book of Concrete Technology, theory and practice (New Delhi, Tata McGraw Hill Education Pvt. Ltd. Fourth Edition 2009) by Gambhir M.L.