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Experimental Study of High Strength Concrete Using Admixture Metakaolin (MKA)

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ABSTRACT: High-strength concrete (HSC) is now widely used in the construction industry all over the world. Mix design is a process of choosing the mixture of ingredients necessary to meet expected properties of fresh and hardened concrete. The fine aggregate should filled all the voids in the coarse aggregate, and the cement paste should fulfill all the voids in the fine aggregate, according to the principle. Concrete is stronger because the aggregate has less voids. Trial and error can be used to determine the percentage of fine to coarse aggregate that provides the maximum weight of combined aggregate. Choosing the right proportions of traditional concrete ingredients (OPC cement, sand, and aggregate) as well as the required inclusions of Chemical and Mineral admixture (one or more) can be difficult when designing high strength concrete (grades M 65 and above). Mineral admixtures in concrete improve not only the strength but also the longevity of the concrete. The aim of this study is to develop a design mix for high strength concrete with a distinctive compressive strength of 65 N/mm² in accordance with IS 456:2000 and IS 10262:2019. High strength concrete can be made with a low water to cementitious ratio. The compressive strength are investigating finding the optimum use of mineral admixture Metakaolin(MKA) of levels 10,12.5,15,17.5 and 20 % at 7 days and 28 days of curing.

KEYWORDS: Metakaolin(MKA), HSC(high strength concrete), superplasticizer, Mix design concrete.

I. INTRODUCTION

The main goal of a concrete Mix design approach is to determine the proportions of concrete ingredients that can be used in a first trial batch to make a concrete with a specific strength, long-term properties, and performance. A mix design specifies the initial mix proportions, which must be tweaked to achieve the desired concrete properties. Because the water-cementitious ratios is very low in high strength concrete, and it may contain mineral admixtures that alter the properties of green or fresh and harden concrete, the Mix design differs from that of regular concrete. With the newest generation of High range water lowering Admixture and highly reactiv mineral Admixtures like-Metakaoli(MKA),Silica fume, and others , high strengthen concrete (HSC) has been made possible. The right concrete mix construction becomes high-strength steel. High-rise buildings (typically over 30 stories) are examples of high-strength concrete applications. Because of its increased load-bearing capacity, high-strength concrete allowed for the Decrease of columns and beams size.

Metakaolin is a clay that is widely used in the manufacture of ceramic , but it's also used as a cement substitutes in concrete. Metakaolin(MKA) undergoes a pozzolani reactions in concrete, which refine the microstructures of the hydrated cement paste. When used to substitute cement at a percentage of 5 to 15% by weight, the resulting concrete is more strength and less likely to bleed. At this level of substitution, the compressive strength of hardened cube concretes is also improved. Metakaolin(MKA) is an ingredients which is used in HSC as a substitute material for cement (high strength concrete). If the compressive strength of a concrete is greater than 60 mpa, it is considered high strength concrete.

Plasticizers are organic compounds that allow for the concrete production with a moisture content of about 15% less. Poly-carboxylate ether based (PCE) combination-copolymers are commonly used as water-lowering additive in the concrete industries , with the polymer adsorptions to the cement particle allowing for high fluidity. In High strength concrete(HSC) ,highly perform steel, high volume slag / fly ash concretes , Dry mortars , and cement grouting as a high range water lowering admixture To prevent particle segregation, these polymer are use as dispersant, particularly in early High compressive strength concrete. Superplasticizers turn rigid, low-slump concrete into pourable, easy-to-place concrete that flows. This product is intended to provide medium to high water reduction while maintaining good flow and slump retention during placement without altering the initial setting,time.

1.1 Objectives of Study :-

The primary goal of this project was to look into the mechanical properties of Metakaolin (MKA) substitution cement concrete with Super Plasticizer added to it (polycarboxylate ether). The following goals are primarily taken into account. To investigate the differences between the properties of fresh or green and hardened concrete.

- 1 To obtain the raw material's physical and chemical properties.
- 2 To find out how much Metakaolin (MKA) and Super Plasticizer (PCE) strengthen concrete's mechanical properties.
- 3 To investigate the use of Metakaolin(MKA) to enhance the compressive strength of concrete .
- 4 To obtain the expense of Metakaolin (MKA) and Super Plasticizer(PCE).

1.2 Planning for Experiment :-

Two kinds of materials are used in this project. The mixtures are separated into five batches, i.e. (Mix -01, Mix -02, Mix -03, Mix -04, Mix -05). For all work in this project, the pattern and batch composition will be the same.

Table 1 : Batches of concrete mixes

S.No.	Batches	Description (cement + Metakaolin + super plasticizer %)
1.	Mix - 1	90 + 10 + 1.2
2.	Mix - 2	87.5 + 12.5 + 1.2
3.	Mix - 3	85 + 15 + 1.2
4.	Mix - 4	82.5 + 17.5 + 1.2
5.	Mix - 5	80+ 20 + 1.2

II. MATERIALS**1.1 pc 53 Cement :**

For this project, ordinary Portland cement from the “ RAMCO ” brand was used in 53 grades. In the local market, “ RAMCO ” cement brand 53 grade OPC is available. Cement is a building binder that binds materials together by setting, hardening, and adhering them together.

1.2 Fine Aggregate:

Fine aggregate is define as aggregate that passes through a 4.75 mm IS sieve's As fine aggregate, natural river sand was gathered from the Indrawati River in Jagdalpur, Chhattisgarh, and conformed to IS 383:1970.

1.3 Coarse Aggregate:

The angular crushed coarse aggregate of sized 20mm passed sieve and 4.75 mm retain sieve size of limestone hard rock group derived from a quarry near Jagdalpur, Chhattisgarh and conforming to IS 2386 part-3:1963 is used.

1.4 Metakaolin(MKA) Admixture:

Metakaolin is a clay that is widely used in the manufacture of ceramics, but it is also used as a cement substitute in concrete. When used to substitute cement at a percentage of 5 to 15% by weight, the resulting concrete is more coherent and less likely to bleed. At this level of substitution, the compressive strength of hardened concrete is also improved.Higher levels of substitution (up to 20%) result in a cement matrix with low porosity and permeability.

1.5 Superplasticizer(PCE):

Superplasticizers (SPs), also referred to as high-range water reducers, are additives used in the productions of (HSC)high-strength concrete. in high performance steel, high strength concrete, large volume fly ash/slag concrete, cement grouting, and dry mortar as a high range water lowering admixture To prevent particle segregation, these polymers are used as dispersants, particularly in early strength concrete.SP's are used to increase the flow

characteristics (rheology) of suspensions where a well-dispersed particle suspension is needed, such as in concrete applications.

III. MIX DESIGN

The M-65 grade concrete is used for special purposes, and the raw materials for concrete mix design are gathered from resources that meet particular requirements and quality standards. Previously, concrete mix design calculations were done in accordance with (IS 456:2000), but now, with the newest provisions, concrete mix design calculations are done in accordance with IS (10262-2019).

Step-1. Test data required for materials

Table 2: Data required for mix proportioning

S. No.	Characteristic properties	Values
1	Grade of concrete	M -65
2	Maximum nominal size of aggregates	20mm
3	Grade of cement (IS 269)	OPC 53 grade
4	Exposure conditions IS-456:2000 Table no. 3	Severe (RCC)
5	Maximum water-cement ratio	0.31
6	Workability (for slump test)	100 mm
7	Grading Zone of fine aggregate	Zone-II (Table-9) IS-383
8	Degree of supervision	Good
9	Specific gravity of cement	3.10
10	Specific gravity of coarse aggregate	2.75
11	Aggregate shape	Crushed Angular
12	Entrapped air	0.5 %
13	Specific gravity of Metakaolin	2.6
14	Specific gravity of superplasticizer	1.11
15	Maximum temperature of concrete at the time of pouring.	$27 \pm 2^{\circ}\text{C}$
16	Maximum cement content	450 kg/m ³
17	Specific gravity of fine aggregate	2.5
18	Water absorption – A. In fine aggregates B. In coarse aggregates	2.4 % 0.94 %
19	Method of transporting & placing	Manual
20	Chemical admixture type (superplasticizer)	Poly carboxylate ether

Step 2. Calculations of target mean strength = 74.9 N/mm²

Step 3. Calculation or selection of water /cementious material ratio = 0.28

Step 4. Calculation of water content = 138 kg/m³

Step 5. Calculation of cementious content = 490 kg/m³

Step 6. Calculation a proportions of volume of Fine aggregate(FA) and coarse aggregate(CA) :-

1. Mass of coarse aggregate = 1129 kg/m³

2. Mass of fine aggregate = 701.5 kg/m³

Step 7. Final mix proportion by weight for trial mixes:-

Table 3: Trial Mix Design Ratio

Water	Op cement	(FA) fine aggregate	Total (CA) coarse aggregate	
138 Kg/m ³	490 Kg/m ³	701.5 Kg/m ³	20 mm C.A.	10 mm C.A.
			677.4 kg/m ³	451.6 kg/m ³
0.28	1	1.43	2.30	

IV. TEST ON CONCRETE

Concrete specimens were test for compressive cube strength in a Compressions Testing Machine (CTM) with a maximum loading capacity of 2000KN. The compressive cube strength of 15 concrete specimens was inspected for 7 days and the compressive cube strength of 15 concrete specimens was tested for 28 days. The following process was followed for this test by (IS 516:2014, 2004) .

- Start the machine. Place one concrete specimen in the loading area's centre.
- Push the lever to lower the piston against the top of the concrete specimen. Simply put the piston on top of the concrete specimen and make sure it is in contact with it.
- Gradually increase the load without causing shock.
- Examine the concrete sample. Stop applying load when it starts to crack.
- Take note of the maximum load displayed on the machine's display screen.
- Clean the machine of the creaked concrete once the piston is back in place.
- Do the same thing with all of the concrete cube specimens. Then switch the machine off.



Figure 1: Compression testing machine



V. RESULT AND DISCUSSION

From 7 days Cube compressive strength test following results obtained:-

Table 4: 7 Days compressive strength test

sample No.	Percentage of Metakaolin (MKA)	Percentage of Super-plasticizer (PCE)	Compressive Strength (N/mm ²) of			Average Compressive Strength (N/mm ²)
			Specimen 01	Specimen 02	Specimen 03	
1.	10	1.2	43.10	42.95	43.61	43.22
2.	12.5	1.2	44.45	43.79	44.11	44.12
3.	15	1.2	46.67	47.20	48.29	47.38
4.	17.5	1.2	45.39	45.67	44.28	45.13
5.	20	1.2	41.97	42.90	43.30	42.72

From above results a graph is plotted below for comparative analysis:-

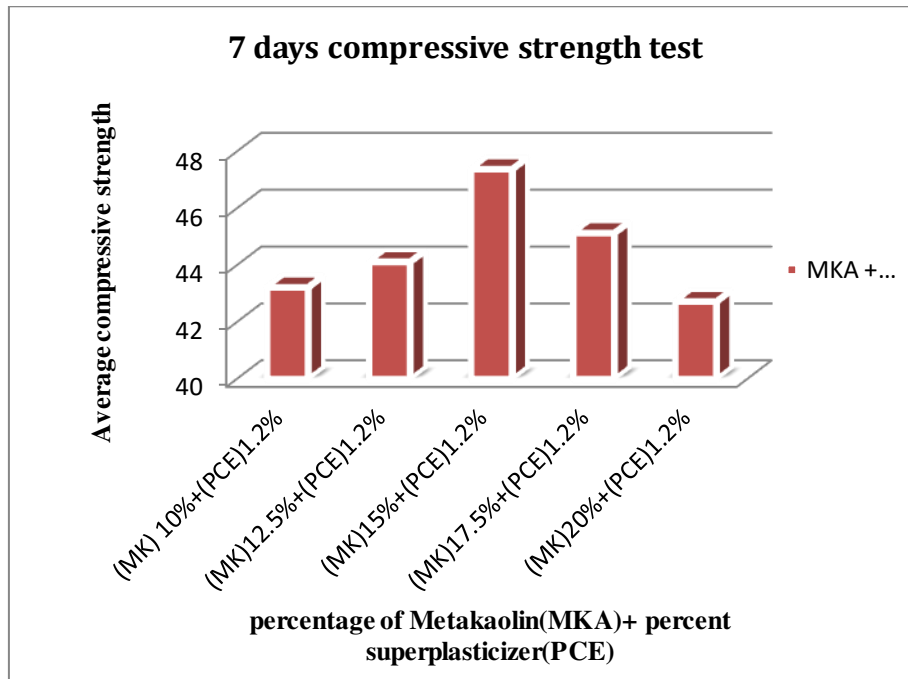


Figure 2: 7 days compressive strength result

1.1 7 Days Cube Compressive Strength Test :

The peak compressive cube strength of concretes containing 15% Metakaolin + 1.2 percent Superplasticizer was 47.38 N/mm² after 7 days of testing. Metakaolin(MKA) was used as a partial substitution of cement in this study up to a limit of 15% percent. The strength of Metakaolin(MKA) is improved when it is used as an admixture in various percentages. For example, when Metakaolin(MKA) replaces 10% of the cement, the average compressive strength after 7 days is 43.22 N/mm², indicating an increase in compression strength. The compressive strength is 44.12 N/mm² with 12.5 percent substitutes. The average compressive strength is 47.38 N/mm² with 15.0 percent substitutes. It is obvious from this strength that using Metakaolin(MKA) in



concentrations greater than 15% has no benefit. As a result, the optimal dosage is 15% Metakaolin(MKA), which can be mixed as a partial substitute for cement to provide the highest possible compressive strength at any stage.

From 28 days Cube compressive strength test following results obtained:-

Table 5 : 28 Days compressive strength test

sample No.	Percentage of Metakaolin	Percentage of Super-plasticizer	Compressive Strength(N/mm ²) of			Average Compressive Strength (N/mm ²)
			Specimen 1	Specimen 2	Specimen 3	
1.	10	1.2	67.31	66.57	68.51	67.46
2.	12.5	1.2	67.78	68.23	69.79	68.6
3.	15	1.2	74.79	73.29	74.41	74.16
4.	17.5	1.2	71.31	71	72.79	71.70
5.	20	1.2	63.79	64.70	65.13	64.50

From above results a graph is plotted below for comparative analysis:-

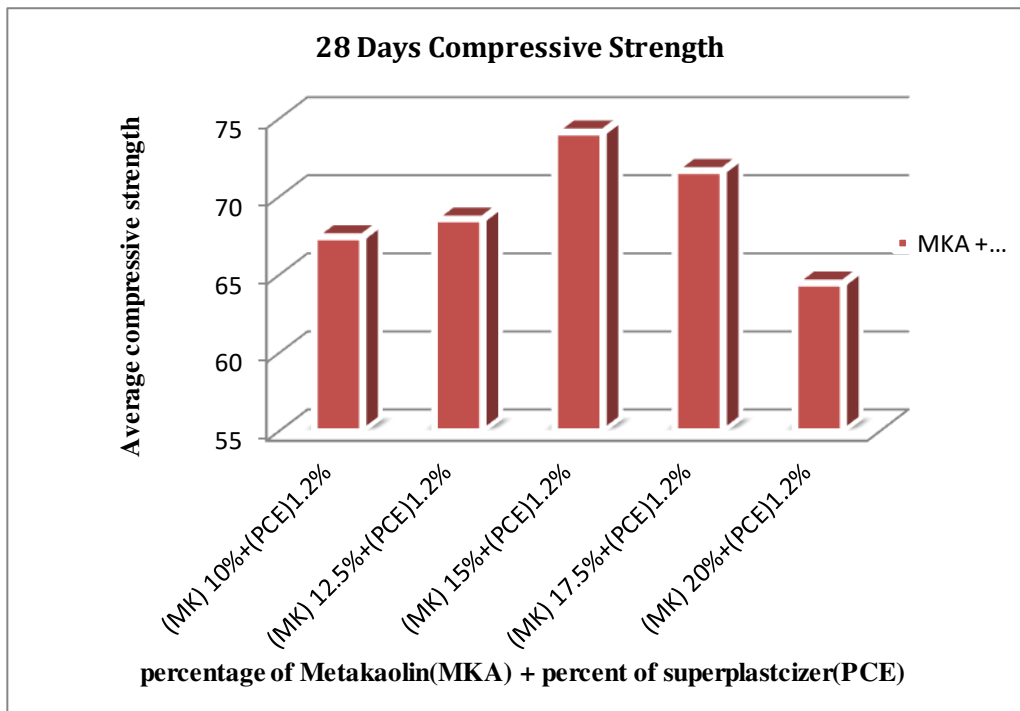


Figure 3: 28 days compressive strength result

1.2 28 Days Cube Compressive Strength test :

The peak compressive strength of concrete containing 15% Metakaolin + 1.2 percent Superplasticizer was found to be 64.65 N/mm² after 28 days. Metakaolin was used as a partial substitution for cement in this study up to a limit of 15.0 percent. The strength of Metakaolin is improved when it is used as an admixture in various percentages. For example, when Metakaolin replaces 10% of the cement, the average compressive strength at 28 days is 60.93 N/mm², indicating an increase in compression strength. The compressive strength is 61.07 N/mm² with 12.5 percent substitution. The average compressive strength is 64.65 N/mm² with 15.0 percent substitution. It is obvious from this strength that using Metakaolin in concentrations greater than 15% has no benefit. As a result,

the optimal dosage is 15% Metakaolin, which can be mixed as a partial substitute for cement to provide the highest possible compressive strength at any stage.

VI. CONCLUSION

The following conclusions can be drawn from all of the findings and discussions:-

1. Adding Metakaolin(MKA) and Superplasticizer to concrete increases the material's compressive strength and durability.
2. When compared to other Metakaolin replacements, concrete with a 15 percent replacement of cement with Metakaolin(MKA) has a higher strength (MKA).
3. A 1.2 percent Polycarboxylatether(PCE) based high range water reducer (WR - 517) was used by weight of cement.
4. The best dosage of Metakaolin(MKA) is 15% by weight of cement, and the best dosage of Superplasticizer(PCE) is 1.2 percent by weight of cementitious material.
5. Metakaolin(MKA) accelerates cement hydrations and forms the C-S-H gel, which is the sole reason for concrete's strength.

The mix proportion is 1:1.43:2.3, resulting in average compressive strengths of 47.38 N/mm² for On 7 days and 74.16 N/mm² for On 28 days. It is apparent from the preceding points that concrete containing 15% Metakaolin(MKA) and 1.2 percent Superplasticizer has a significantly higher compressive strength. According to this experimental study, the recommended dosages of Metakaolin(MKA) and Superplasticizer(PCE) are 15% and 1.2 percent percent, respectively.

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REFERENCES

- [1] A. Busari, J. Akinmusuru, and B. Dahunsi, "Strength and durability properties of concrete using metakaolin as a sustainable material: Review of literatures," *Int. J. Civ. Eng. Technol.*, vol. 10, no. 1, pp. 1893–1902, 2019.
- [2] S. Barbhuiya, P. L. Chow, and S. Memon, "Microstructure, hydration and nanomechanical properties of concrete containing metakaolin," *Constr. Build. Mater.*, vol. 95, pp. 696–702, 2015, doi: 10.1016/j.conbuildmat.2015.07.101.
- [3] D. Ramesh, S. Murali, S. Balaji, and V. Ganesan, "Design of High Strength Concrete Mixes M60 and Investigation of its Strength Parameter," pp. 10157–10161, 2015, doi: 10.15680/IJIRSET.2015.0410064.
- [4] S. Srivastava, S. S. Jain, and M. P. S. Chauhan, "High Strength Concrete of M60 Grade for Highway Pavements for Heavy Vehicles," vol. 4, no. 11, pp. 1–5, 2014.
- [5] N. John, "Strength Properties of Metakaolin Admixed Concrete," *Int. J. Sci. Res. Publ.*, vol. 3, no. 6, pp. 1–7, 2013, [Online]. Available: www.ijsrp.org.
- [6] R. Madandoust and S. Y. Mousavi, "Fresh and hardened properties of self-compacting concrete containing metakaolin," *Constr. Build. Mater.*, vol. 35, pp. 752–760, 2012, doi: 10.1016/j.conbuildmat.2012.04.109.
- [7] H. Paiva, A. Velosa, P. Cachim, and V. M. Ferreira, "Effect of metakaolin dispersion on the fresh and hardened state properties of concrete," *Cem. Concr. Res.*, vol. 42, no. 4, pp. 607–612, 2012, doi: 10.1016/j.cemconres.2012.01.005.
- [8] A. I. Laskar, "Mix Design of High-performance Concrete," vol. 14, no. 4, pp. 429–433, 2011, doi: 10.1590/S1516-14392011005000088.
- [9] F. Lagier and K. E. Kurtis, "Influence of Portland cement composition on early age reactions with metakaolin," *Cem. Concr. Res.*, vol. 37, no. 10, pp. 1411–1417, 2007, doi: 10.1016/j.cemconres.2007.07.002.



- [10] J. Bai, S. Wild, J. A. Ware, and B. B. Sabir, "Using neural networks to predict workability of concrete incorporating metakaolin and fly ash," *Adv. Eng. Softw.*, vol. 34, no. 11–12, pp. 663–669, 2003, doi: 10.1016/S0965-9978(03)00102-9.
- [11] C. S. Poon, S. Azhar, M. Anson, and Y. L. Wong, "Performance of metakaolin concrete at elevated temperatures," *Cem. Concr. Compos.*, vol. 25, no. 1, pp. 83–89, 2003, doi: 10.1016/S0958-9465(01)00061-0.
- [12] X. Qian and Z. Li, "The relationships between stress and strain for high-performance concrete with metakaolin," *Cem. Concr. Res.*, vol. 31, no. 11, pp. 1607–1611, 2001, doi: 10.1016/S0008-8846(01)00612-3.
- [13] C. S. Poon, L. Lam, S. C. Kou, Y. L. Wong, and R. Wong, "Rate of pozzolanic reaction of metakaolin in high-performance cement pastes," *Cem. Concr. Res.*, vol. 31, no. 9, pp. 1301–1306, 2001, doi: 10.1016/S0008-8846(01)00581-6.
- [14] M. Frías, M. I. S. De Rojas, and J. Cabrera, "Effect that the pozzolanic reaction of metakaolin has on the heat evolution in metakaolin-cement mortars," *Cem. Concr. Res.*, vol. 30, no. 2, pp. 209–216, 2000, doi: 10.1016/S0008-8846(99)00231-8.
- [15] B. of I. S. (BIS), "IS 383: 1970 Specification for Coarse and Fine Aggregates From Natural Sources for Concrete," *Indian Stand.*, pp. 1–24, 1970.
- [16] Bureau of Indian Standard (BIS), "IS : 2386 (Part I)-1963- Indian Method of test for aggregate for concrete. Part I - Particle size and shape.," *Indian Stand.*, p. (Reaffirmed 2002), 1963.
- [17] IS 10262-2019, "CONCRETE MIX PROPORTIONING GUIDELINES," *Indian Stand.*, 2019.
- [18] IS 456, "Concrete, Plain and Reinforced," *Bur. Indian Stand. Dehli*, pp. 1–114, 2000.
- [19] IS 516:2014, "Method of Tests for Strength of Concrete," *IS 516 - 1959 (Reaffirmed 2004)*, p. New Delhi, India, 2004.
- [20] IS 12269:1987, " Specification For 53 Grade Ordinary Portland Cement" *Is 12269-1987(Reaffirmed 2004)*, p. New Delhi, India, 2004
- [21] M. S. SHETTY " Concrete Technology: Theory And Practice" p. S. Chand , New Delhi, India, 2005 , *Isbn: 81-219-0003-4*



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