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STRENGTH STUDIES ON CONCRETE WITH STEEL PELLETS AND METAKAOLIN

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ABSTRACT

This study investigates the effects of incorporating steel pellets and metakaolin on the strength properties of concrete. Concrete is a composite material consisting of a mixture of cement, water, fine aggregate, and coarse aggregate. The study focuses on understanding how the addition of steel pellets and metakaolin can enhance the strength and durability of concrete structures. Steel pellets are small, spherical particles made of steel, often produced from recycled materials, making them an eco-friendly additive. When incorporated into concrete, steel pellets act as a filler, improving compressive strength and enhancing resistance to various stresses. They also help reduce cracking and increase durability, providing better resistance to abrasion, impact, and freeze-thaw cycles. Additionally, steel pellets can improve fire resistance and increase the ductility of concrete, making them a valuable component for constructing strong and long-lasting structures. Metakaolin is a pozzolanic material derived from the calcination of kaolin clay. It is a fine, white powder commonly used as a supplementary cementitious material in concrete. Metakaolin reacts with calcium hydroxide in the cement paste to form additional calcium silicate hydrate (C-S-H), which enhances the overall strength, durability, and impermeability of the concrete. Overall, the combined use of steel pellets and metakaolin in concrete mixtures contributes to improved mechanical performance, durability, and sustainability of concrete structures.

KEYWORDS: *Metakaolin, Steel pellets, calcium silicate, durability, Compressive strength and Split tensile strength*

1. INTRODUCTION

Concrete is one of the most widely used construction materials due to its versatility, high compressive strength, and durability. It is a composite material composed of cement, water, fine aggregate, and coarse aggregate, which together form a solid, load-bearing structure when properly mixed and cured. To enhance the mechanical properties and sustainability of concrete, supplementary materials and additives are often incorporated. **Metakaolin**, a pozzolanic material obtained by calcining kaolin clay, is widely used as a partial replacement for cement. It reacts

with calcium hydroxide in the cement paste to form additional calcium silicate hydrate (C-S-H), improving the strength, durability, and impermeability of concrete. **Steel pellets**, small spherical particles typically made from recycled steel, can be added to concrete as a filler material. Their inclusion improves compressive strength, reduces cracking, enhances resistance to abrasion and impact, and increases ductility and fire resistance. The combined use of metakaolin and steel pellets in concrete provides a sustainable approach to producing high-strength, durable, and long-lasting concrete suitable for structural applications.

2. OBJECTIVES

1. To investigate the effect of **steel pellets** and **metakaolin** on the **compressive and split tensile strength** of concrete at 7 and 28 days of curing.
2. To determine the **optimal percentage of steel pellets and metakaolin** that enhances the **mechanical properties and durability** of concrete compared to conventional concrete.

3. MATERIALS

3.1 Cement:- A fine powder made from limestone and clay that acts as a binder in concrete. It hardens upon hydration, providing strength and stability to the mixture.

3.2 Fine Aggregate:- Small granular materials, like sand, used in concrete to fill voids between coarse aggregates. They improve workability and cohesion of the concrete mix.

3.3 Coarse Aggregate:- Larger particles, such as gravel or crushed stone, used in concrete to provide bulk, strength, and structural stability.

3.4 Water:-Water is an essential component of concrete, required for the hydration of cement. It ensures proper workability and setting of concrete mix. The quality and quantity of water directly affect concrete strength.

3.5 Metakaolin:- A pozzolanic material obtained by calcining kaolin clay. It reacts with cement hydration products to enhance concrete strength and durability.

3.6 Steel pellets:- Small, spherical particles made from steel, added to concrete to improve compressive strength, Split tensile, crack resistance, and durability.

4. EXPERIMENTAL RESULTS

4.1 Compressive strength:-In this test, concrete cubes of standard size (usually 150 mm × 150 mm × 150 mm) are cast and cured. After 7 or 28 days, the cubes are placed in a compression testing machine. Load is applied gradually until failure, and the maximum load is used to calculate compressive strength.

Table 1: Compressive strength results of concrete Metakaolin as partial replacement of cement.

Sl.no	% of Metakaolin	Compressive Strength Results, N/mm ²	
		7 days	28 days
1	0%	22.38	32.54
2	5%	23.96	34.28
3	10%	25.22	35.99
4	15%	33.27	48.72
5	20%	24.57	35.56

Table 2: Compressive strength results of concrete steel pellets as partial replacement of coarse aggregate.

Sl.no	% of Steel pellets	Compressive Strength Results, N/mm ²	
		7 days	28 days
1	0%	22.38	32.54
2	5%	30.45	44.19
3	10%	32.18	45.65
4	15%	29.57	42.31

Table 3: Compressive strength results of combined replacement of 15 % MK+10%SP in concrete.

Sl.no	15 % MK+10%SP	Compressive Strength Results, N/mm ²	
		7 days	28 days
1	0%	22.38	32.54
2	15 % MK+10%SP	33.36	48.08

4.2 Split tensile strength: - **Split tensile strength** is an indirect method to evaluate the tensile resistance of concrete, since concrete is inherently weak in direct tension. In this test, a cylindrical specimen is placed horizontally and a compressive load is applied along its diameter. This loading induces tensile stresses inside the cylinder, causing it to split along the loaded diameter. The test is carried out at 7 and 28 days of curing to study the cracking behavior and tensile strength development of concrete.

Table 4: Split tensile strength results of concrete Metkaolin as partial replacement of cement.

Sl.no	% of Metakaolin	Split tensile Strength Results, N/mm ²	
		7 days	28 days
1	0%	2.24	3.21
2	5%	2.37	3.36
3	10%	2.54	3.63
4	15%	3.32	4.86
5	20%	2.4	3.49

Table 5: Split tensile strength results of concrete steel pellets as partial replacement of coarse aggregate.

Sl.no	% of Steel pellets	Split tensile Strength Results, N/mm ²	
		7 days	28 days
1	0%	2.24	3.21
2	5%	2.81	4.04
3	10%	3.34	4.56
4	15%	2.92	4.19

Table 6: Split tensile strength results of combined replacement of 15 % MK+10%SP in concrete.

Sl.no	15 % MK+10%SP	Split twnsile Strength Results, N/mm ²	
		7 days	28 days
1	0%	2.24	3.21
2	15 % MK+10%SP	3.47	5.04

5. CONCLUSION

1. The **Normal concrete** without any replacement achieved a compressive strength of **22.38 N/mm² at 7 days** and **32.54 N/mm² at 28 days**.
2. The use of **Metakaolin (MK)** as a partial replacement of cement showed optimum compressive strength at **15% replacement**, reaching **33.27 N/mm² at 7 days** and **48.72 N/mm² at 28 days**.
3. The use of **steel pellets (SP)** as a partial replacement of coarse aggregate yielded the highest compressive strength at **10% replacement**, achieving **32.18 N/mm² at 7 days** and **45.65 N/mm² at 28 days**.
4. The **combined replacement of 15% MK + 10% SP** resulted in the maximum compressive strength, reaching **33.36 N/mm² at 7 days** and **48.08 N/mm² at 28 days**, significantly higher than normal concrete.

5. The Normal concrete without any replacement achieved a **split tensile strength of 2.24 N/mm² at 7 days** and **3.21 N/mm² at 28 days**.
6. The **Metakaolin (MK)** as partial replacement of cement showed optimum split tensile strength at **15% replacement**, reaching **3.32 N/mm² at 7 days** and **4.86 N/mm² at 28 days**.
7. The **Steel pellets (SP)** as partial replacement of coarse aggregate showed the highest split tensile strength at **10% replacement**, achieving **3.34 N/mm² at 7 days** and **4.56 N/mm² at 28 days**.
8. The **combined replacement of 15% MK + 10% SP** gave the highest split tensile strength, reaching **3.47 N/mm² at 7 days** and **5.04 N/mm² at 28 days**, which is significantly higher than normal concrete.

REFERENCES

1. Avancha Sri Sowmya, K. Sundara Kumar. STUDIES ON STRENGTH CHARACTERISTICS OF CONCRETE WITH METAKOALIN AS AN ADMIXTURE. International Research Journal of Engineering and Technology (IRJET) 2(9)2015. 166-173.
2. Naveen Nishchal Varinder, S Kanwar Abhishek Kanoungo. STUDY OF COMBINED EFFECT OF METAKAOLIN AND STEEL FIBER IN CONCRETE - A CRITICAL REVIEW. Pertanika Journal of Science and Technology 5(1)2021. 61-65.
3. S. Ramyakala, Shaik Sufiyan Shezan, Jasmeen, Mohd Nawaz Ahmed⁴, Mohd Arshad Iqbal⁵. STUDY OF STRENGTH PARAMETERS OF CONCRETE PARTIALLY REPLACED WITH METAKAOLIN. International journal of scientific engineering and technology research 7 (2)2020. 1022-1025.
4. Sunny A. Jagtap, Mohan N. Shirsath, Sambhaji L. Karpe. EFFECT OF METAKAOLIN ON THE PROPERTIES OF CONCRETE. International Research Journal of Engineering and Technology (IRJET) 4(7)2017. 643-645.
5. Ch. Kirthini, T. Sujatha. International Journal of Concrete Structures and Materials EFFECT OF INCORPORATING METAKAOLIN ON THE PROPERTIES OF HIGHPERFORMANCE CONCRETE. International Journal of Concrete Structures and Materials 3(10)2014. 1011-1014.
6. Rutuja A. Meshram, Dr. Swapneel Satone, Er. Dipartha Kundu. A COMPARATIVE STUDY ON HARDENED PROPERTIES OF CONCRETE BY PARTIAL REPLACEMENT OF CEMENT WITH METAKAOLIN BY EXPERIMENTAL AND ANSYS APPROACH. 10(IV)2022. 2031- 2033.
7. Brijesh Soni, Ritesh Lahoti. STUDY OF METAKAOLIN FIBRE AND POND ASH AS A REPLACEMENT TO CEMENT IN CONVENTIONAL CONCRETE. International Journal of Concrete Structures and Materials 05 (10)2016. 47-49.
8. J. Sree Naga Chaitanya, Dr. K. Chandramouli, Dr. D. Vijaya Kumar, P. Dileep. STRENGTH STUDY ON COMPARATIVE OF BANANA FIBRE REINFORCED CONCRETE WITH NORMAL CCONCRETE. International Journal of Civil Engineering and Technology (IJCIET) 10 (VIII)2022. 1537-1539.
9. Dr. K. Chandra Mouli, Dr. N. Pannirselvam, V. Anitha, Dr. D. Vijaya Kumar, S. Valeswara Rao. STRENGTH STUDIES ON BANANA FIBRE CONCRETE WITH METAKAOLIN. International Journal of Civil Engineering and Technology (IJCIET) 10(2)2019. 684-689.
10. M. Narmatha, Dr.T.Felixkala. METAKAOLIN –THE BEST MATERIAL FOR REPLACEMENT OF CEMENT IN CONCRETE. IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)13(4)2016. 66-71.