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COMPARISON ON THE STATIC MODULUS OF ELASTICITY OF M50 GRADE CONCRETE USING METAKAOLIN AND POLYPROPYLENE FIBERS

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ABSTRACT:

The substance that is used the most worldwide is concrete after water and has a good compressive strength and durability. Cement is the main ingredient of concrete. Depending upon the nature of work, the water, coarse, fine aggregates and cement are mixed in specific proportions to produce plain concrete. In an effort to lower the price per unit of concrete and the energy needed to produce it, the use of SCM, waste materials, industrial by-products, and inventive materials is becoming necessary.

The use of additional cementations elements is now essential to improving the characteristics of concrete.. These may be occurring naturally, industrial wastes, or by products or the ones requiring less energy to manufacture. Metakaolin is obtained by calcination of Kaolinite. It is being used very commonly as Pozzolanic material in mortar and concrete, and has exhibited considerable influence in enhancing the mechanical properties and durability properties of mortar and concrete. Metakaolin has shown the following benefits: increase in compressive strength, tensile strength, flexural strength, and decrease porosity and permeability and is abundantly available. Polypropylene fiber is a kind of polymer material with light weight, high strength, and corrosion resistance. Polypropylene is often added to the cement matrix to improve the resistance of concrete. The crack resistance of concrete can be improved by adding PPFs.

In this investigation, Metakaolin is used in replaced by cement with 0%, 5%, 10%, 15% and 20% and the optimum percentage is obtained for 28 days compressive strength. After finding the optimum percentage ,the mix is later varied by adding Polypropylene fibers in different proportions such as 0%, 0.5%, 1% and 1.5% to find the mechanical properties of concrete such as Flexural strength, Compressive strength and Modulus of elasticity for the curing period of 28 & 56 days. Also the study focuses on Analysis and comparison of the results obtained by the experimental tests using bar charts and graphs and studies the variation in strength when compared to conventional concrete.

1) INTRODUCTION:

Concrete has a strong compressive strength and durability, making it the second most consumed substance in the world after water. The primary component of concrete is cement. To make plain concrete, different amounts of cement, fine aggregate, coarse aggregate, and water are combined depending on the type of job being done. It is becoming more and more important to employ SCM, waste materials, industrial by-products, and new materials to lower the unit cost of concrete and the energy needed to produce it.

METAKAOLIN:

The commercial availability of Metakaolin (MK) dates back to the mid-1990s, and it is considered one of the more recent supplemental cementing materials (SCM).

A pozzolanic substance is Metakaolin. It is an aluminous, siliceous substance that may react with calcium hydroxide (Ca(OH)2) to create cementations compounds when finely divided. One of the most common natural clay minerals, kaolin clay, is heated to a high temperature typically between 600 and 900 degrees Celsius in order to make Metakaolin.

Rich in kaolinite, these minerals are called china clay or kaolin, and have long been utilized in the production of paints, porcelain, and ceramics. Met kaolin's particles are not as tiny as silica fume, but they are still smaller than those of cement.

Unlike other supplemental cementations materials (SCMs) such as fly ash, silica fume, and slag, Metakaolin is produced under carefully regulated circumstances for a specific purpose and is not a by-product of an industrial process.

The crystalline kaolin is changed during the calcination process into an amorphous substance known as Metakaolin. Because of its unique qualities, Metakaolin may be used as an additional cementation ingredient for making concrete. The qualities of concrete mixes, such as workability, durability, and strength, can be enhanced by the addition of Metakaolin.

POLYPROPYLENE FIBERS (PPF):

Polypropylene fiber is a type of synthetic fiber produced from polypropylene, a polymer derived from the polymerization of propylene gas. As a thermoplastic polymer, it softens when heated and hardens upon cooling, making it moldable into various forms.

Polypropylene is often added to the cement matrix to enhance the resistance of concrete. Fiber reinforced concrete is more durable and less likely to crack when compared to plain concrete.

The fibers used were fine polypropylene monofilaments .The fibers were supplied by Reliance

Industry by name RECRON 3s .It is available in 3 different sizes i.e. 6mm, 12mm and 24 mm In the present investigation 6mm fiber length is used.

STATIC MODULUS OF ELASTICITY:

The Modulus of Elasticity (E) is also known as Young's Modulus, and is defined as "the ratio of the axial stress to axial strain for a material subjected to uni-axial load.

Modulus of Elasticity (E) is one of the most important material properties of concrete, as it is always used throughout the structural design process.

Modulus of Elasticity is always required to analyze the deflection of a structure. Concrete structural members must be designed appropriately to prevent lateral and longitudinal deformations, and to ensure that the applied loads do not exceed the capacity of the members.

The static modulus of elasticity, often referred to simply as the modulus of elasticity or Young's modulus, is a material property that describes how a material deforms under an applied load. It is denoted by the symbol (E) and directly measured from the Deformational Experiment.

2) LITERATURE REVIEW:

A Several investigators have examined the use of Metakaolin as the partial replacement of cement and also studied the Static and Dynamic Behavior of Modulus of Elasticity with different grades of concrete. They performed the various tests by changing various parameters of concrete and admixtures. Some of reviews of researchers in this field can be discussed below.

In a study on the use of Metakaolin as a pozzolanic material for mortar and concrete, **Sabir.B.B et al. (2001)** discussed the broad variety of applications of Metakaolin in the construction sector. According to what they said, using Metakaolin as a pozzolana will contribute to the growth of initial strength and some enhancement of long-term strength.
They said that the pore structure of concrete and cement paste mortar is changed by Metakaolin, which also significantly increases the durability of the material.

Priyanka P. Chavhan et al have studied the Correlation of Static and Dynamic modulus of Elasticity (E) for Different SCC mixes by using silica fume and fly ash and found that Dynamic modulus of Elasticity is 5% greater than Static modulus of Elasticity for high strength SCC. They have also performed different test like workability test and compression test, tensile test for static modulus and UPV for dynamic modulus of concrete on cylindrical specimens and concluded that UPV test can be effectively used to determine dynamic modulus of elasticity of high Strength SCC .

A partial replacement of cement in concrete with Metakaolin was studied experimentally by **Murali.G. And Sruthee P (2012)**.The strength qualities of concrete were significantly improved by the addition of Metakaolin. It was stated that a replacement rate of 7.5% was ideal. The findings demonstrated that adding 7.5% of Metakaolin to concrete enhanced its flexural strength by 9.3%, split tensile strength by 7.9%, and compressive strength by 14.2%.

Justice.J.M et al (2005) made a comparative study by replacing 8% by weight of cement with Metakaolin and Silica fume. Metakaolin addition proved to be beneficial, resulting in concrete with considerably higher strengths and greater durability than the normal mixes. The use of finer Metakaolin was more effective in improving concrete properties than the coarser Metakaolin. Addition of Metakaolin increased the use of super plasticizers. Addition of Metakaolin exhibited improvements in shrinkage, durability and other strength aspects like compressive strength and tensile strength.

Jian-Tong Ding and Zongjin Li used a variety of mixtures to examine and analyze the impacts of silica fume and Metakaolin on concrete. At a weight-to-cement ratio of 0.35, several concrete mixtures were cast, with 0, 5, 10, and 15% of the cement substituted with either Metakaolin or silica fume of concrete and found that the two admixtures significantly decreased the chloride diffusivity of the concrete while also increasing the strength of the Metakaolin-modified concrete at all ages in a manner comparable to that of the silica fume-modified concrete.

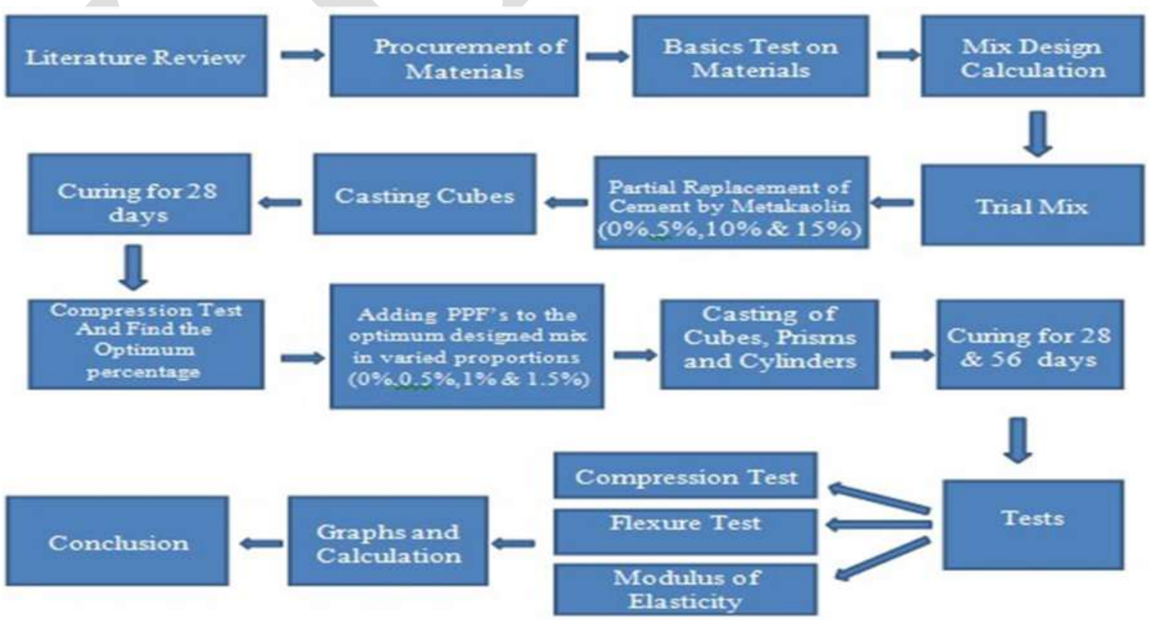
Nova John experimentally investigated, Metakaolin as a potential partial substitute for cement in concrete. Concrete's strength characteristics were significantly increased by the addition of Metakaolin. It was stated that 15% replenishment was the ideal level. Compressive strength, split tensile strength, and flexural strength have all increased, according to the results. The findings also support the partial substitution of cement in high-strength concrete with Metakaolin, a pozzolanic substance.

The use of Metakaolin replacements in different percentages of 5%, 10%, 15%, and 20% by weight of cement and with a combination of crimped steel fibers by 0%, 0.5%, 1%, and 2% by volume of concrete was examined by **Dr. K. Srinivasu, M.L.N. Krishna Sai, and Venkata Sairam Kumar**. Comparing the results to regular concrete of M50 grade, it was found that replacing 10% of the cement with Metakaolin and adding 1% of steel fibers was the ideal amount to boost compression strength.

Ibrahim, Yasin A., Hasan, Arsalan H., and Maroof, Nyazi R. (2019) investigated how the amount of polypropylene fibre in concrete affected its strength and workability. The static and dynamic characteristics of concrete can be enhanced by adding the appropriate number of fibres, which function as a crack arrester. The 28-day strength characteristics of nine distinct concrete mixes, each with a different fibre volume fraction (FVF) ranging from 0.06% to 2.16%, were found to increase with the inclusion of polypropylene fibre.

Aswathy Lal and Divya S. Dharan looked into the impacts of polypropylene fiber in concrete. The implications of adding different amounts of polypropylene fibers for grade M30 are discussed in this study. Their investigation's primary goal was to determine the ideal percentage of polypropylene fiber content by analyzing the effects of a polypropylene fiber mix at different contents, such as 0%, 0.5%, 1%, 1.5%, and 2%. There was a rise in the flexural, tensile, and compressive strengths. Comparing the compressive strength of polypropylene fiber reinforced concrete to conventional concrete, a 17% increase in strength was reported.

3) METHODOLOGY:



4) OBJECTIVES:

1)To find out the Optimum percentage of Metakaolin that can be used for enhancing the properties of concrete by replacing it with cement in varied proportions such as 0%, 5% 10%, 15% and 20%.

2)To compare the mechanical properties of concrete by performing tests such as Compression test, Flexural strength test and Static modulus of elasticity (E) using optimum percentage of Metakaolin and adding varied percentages of polypropylene fibers to the mix such as 0%, 0.5%, 1% and 1.5%.

5)MATERIAL PROPERTIES:

Cement: The cement utilized was accessible locally of Grade OPC 53 of SAGAR CEMENTS. The cement has a specific gravity of 3 with initial and final setting time as 35 and 355 minutes respectively. The physical properties are confirming to IS: 12269-1987.

Aggregates: Coarse Aggregates were Crushed angular granite from a local source was used. The Specific gravity was 2.75, Bulk density of 1450 kg/m3.

Sand from the river was utilized as fine aggregate and conforming to Zone: III with a specific gravity of 2.62. The physical properties are confirming to IS: 2368-1968.

Water: To mix the materials of concrete, tap water has been used.

Polypropylene fibers (PP): The fibers used are fine polypropylene monofilaments .The fibers were supplied by Reliance Industry by name RECRON 3s .It is available in 3 different sizes i.e. 6mm,12mm and 24 mm .In the present investigation 6 mm fiber length is used .

Metakaolin: Metakaolin is a type of pozzolanic material that can be used as a binder in concrete. It is made by calcining Metakaolin, a type of kaolin clay. It is in the form of powder and the color of Metakaolin is off-white with a specific gravity of 2.5.

Super plasticizer: Roofplast SP45 is sulphonated naphthalene based super plasticizing admixture that is devoid of chloride. It is offered as a murky solution that readily dissolves in water. The performance of the concrete's water content is enhanced by Roofplast SP45. Significant strength increases are possible at extremely high levels of water reduction. To identify the optimal SP dose, trial mixtures should be employed.

6) MIX PROPORTIONS OF M50:

The mix proportion is designed to determine correct proportions of materials cement, coarse and fine aggregates and water to satisfy the workability of concrete. The design mix was based on requirements of IS: 10262: 2019, water to cement ratio of 0.38, cement -aggregate ratio of 1:2.1:2.79.

Cement: 390 kg/m^3

Fine-Aggregate: 820 kg/m^3

Coarse-Aggregate: 1090 kg/m^3

Super Plasticizer: 3.9 kg/m^3

Water: 149 kg/m3

7) EXPERIMENTAL INVESTIGATION:

7.1) Optimum percentage of Metakaolin

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To find out the Optimum percentage of Metakaolin that can be used for enhancing the properties of concrete we are replacing the Metakaolin with cement in varied proportions such as 0%, 5%, 10%, 15% and 20%.

For a 28-day curing period, a total of 15 cube specimens measuring 150x150x150 mm were cast in order to test the compressive strength.

TEST RESULT:

Mix / Specimen No.	M0 (MPa)	M1 (MPa)	M2 (MPa)	M3 (MPa)	M4 (MPa)
1	61.2	56.5	**63.95**	58.6	56.2
2	56.9	64.64	**64.42**	62.01	-
3	57.96	59.3	**63.28**	61.36	62.16
Average	58.6867	60.1467	**63.8833**	60.6567	59.18

Table 1

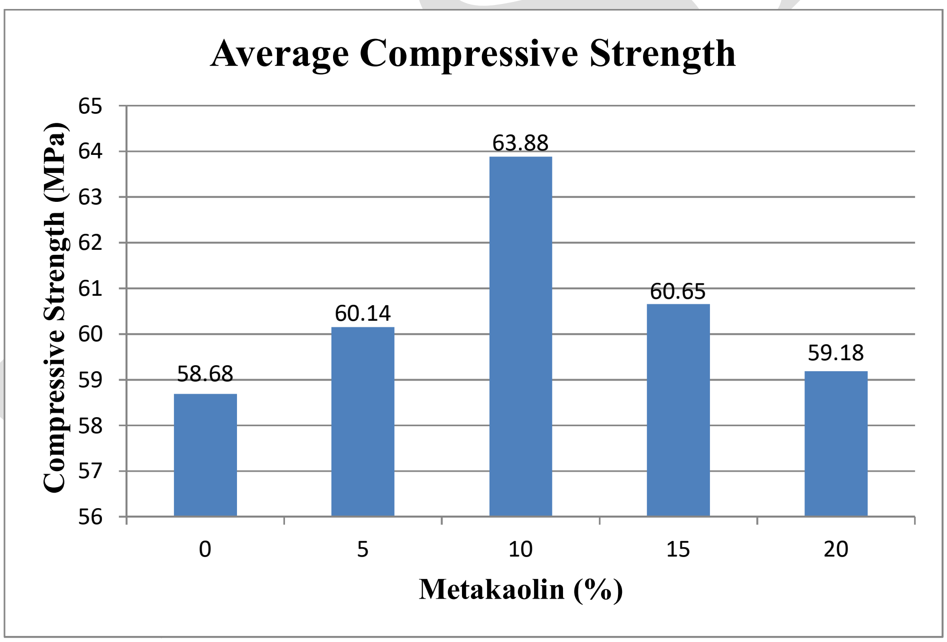

Fig 1

From the above table, the optimum amount of Metakaolin to be replaced was opted as 10% based on the obtained average compression strength results. To the obtained Optimum percentage of Metakaolin that can be used for enhancing the properties of concrete, Polypropylene fibers are added to the mix in varied proportions such as 0%, 0.5%, 1% and 1.5% and mix proportions was designed. The tests which were conducted are Compression test, Flexure test and Modulus of elasticity (E) test.

7.2) To find out the Mechanical properties of concrete such as Compression Test, Flexure Test & Static Modulus of Elasticity (E) we have casted a total of 72 specimens with optimum percentage of Metakaolin (10%) & varied proportions of Polypropylene Fibers such as 0%, 0.5%, 1% and 1.5% for 28 and 56 days.

Mix	28 days Curing	56 Days Curing
P0	3+3+3	3+3+3
P1	3+3+3	3+3+3
P2	3+3+3	3+3+3
P3	3+3+3	3+3+3

*Cubes+Prisms+Cylinders

Table 2

The cubes were cast in steel moulds of inner dimensions of 150x150x150mm and the cylinders with 150x300 mm height and prisms with 100x100x500 mm length.

Compression test and modulus of elasticity tests were performed on cube and cylinder respectively at uniform rate using the 3000KNAutomatic Compression Testing machine.

Flexure test was performed on Concrete Prisms on Flexure Testing machine.

TEST RESULT:

7.2.1) Compression Test

Average Compressive strength of cubes at 28 and 56 Days.

Mix	Average Compressive Strength MPa for 28 Days	Average Compressive Strength MPa for 56 Days
P0	59.76	62.60
P1	61.48	65.04
P2	63.53	67.84
P3	55.74	57.68

Table 3

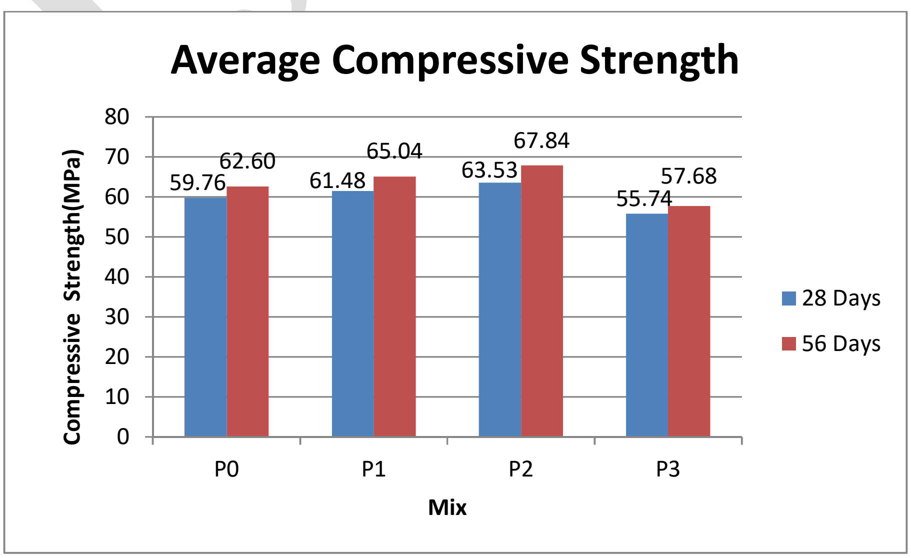

Fig 2

7.2.2) Flexure Test

Average Flexural Strength of Prisms at 28 and 56 Days.

Mix	Average Flexural Strength MPa for 28 Days	Average Flexural Strength MPa for 56 Days
P0	4.69	5.73
P1	5.54	6.36
P2	6.68	7.34
P3	7.23	7.99

Table 4

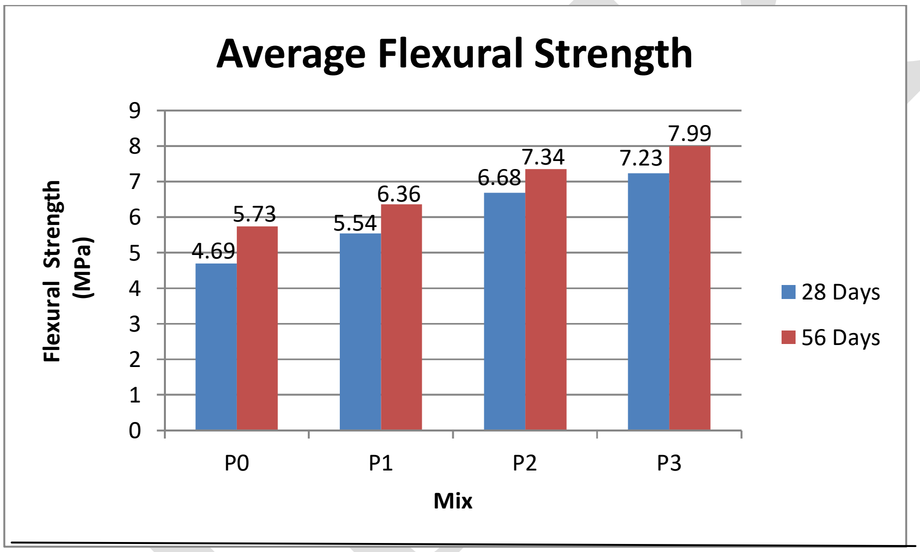

Fig 3

7.2.3) Modulus of Elasticity (E)

Modulus of Elasticity (E) of Cylinders at 28 and 56 Days.

Mix	Modulus of Elasticity GPa for 28 Days	Modulus of Elasticity GPa for 56 Days
P0	35.32	36.96
P1	36.79	36.60
P2	36.05	37.98
P3	41.34	42.88

Table 5

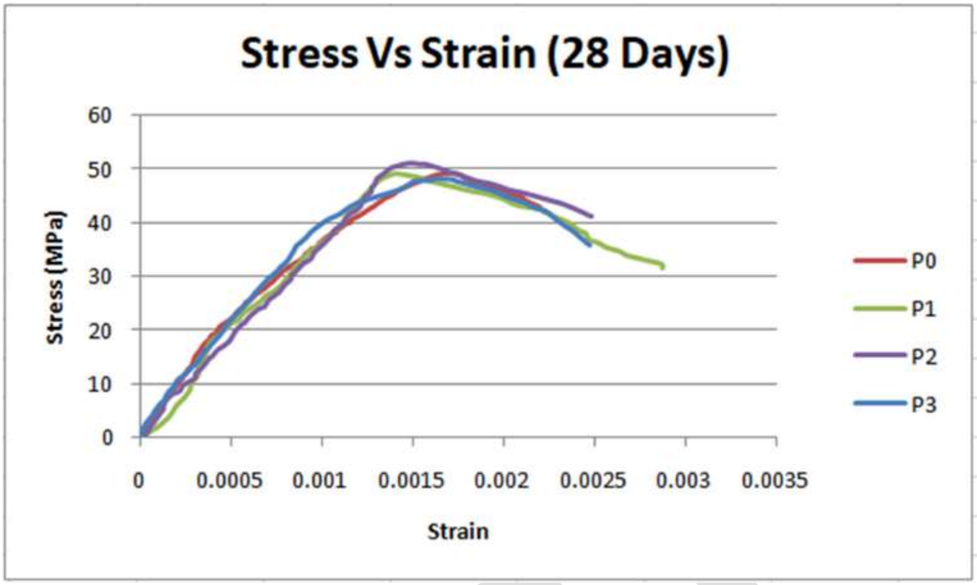
Stress Vs Strain (28 Days)
Stress (MPa)
60
50
40
30
20
10
0
0
0.0005
0.001
0.0015
0.002
0.0025
0.003
0.0035
Strain
P0
P1
P2
P3

Fig 4

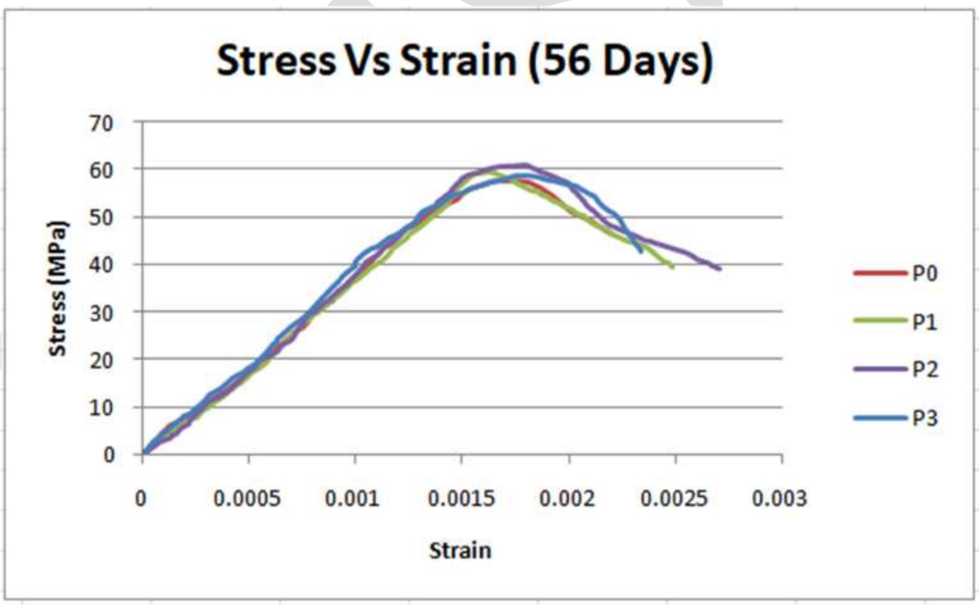
Stress Vs Strain (56 Days)
Stress (MPa)
70
60
50
40
30
20
10
0
0
0.0005
0.001
0.0015
0.002
0.0025
0.003
Strain
P0
P1
P2
P3

Fig 5

Conclusions:

In the experimental results it is observed that,

- The Optimum percentage of replacement of Metakaolin in Concrete is **10%**.
- Percentage of increase in Compressive strength at 28 days of concrete with the replacement of Cement by 10% of Metakaolin is **12.26%.**
- The optimum percentage of Polypropylene fibers was obtained in compressive as **1%** of cement content. But after 1% there is a decrease in Compressive Strength gradually.
- From the experiment it is concluded that adding of Polypropylene fibers increased the compressive strength by **8.26%** and **11.94%** after 28 days and 56 days respectively as compared to controlled samples.
- The Optimum percentage of Polypropylene fibers was obtained both in Flexural strength and Modulus of elasticity as **1.5%** of cement contents.
- From the experiment it is concluded that adding of Polypropylene fibers increased the Flexure strength by **54.15%** and **39.44%** after 28 days and 56 days respectively, whereas **17.04%** and **16.01%** increase was observed in Modulus of Elasticity after 28 days and 56 days respectively.

References:

1. A.M. Neville, "Properties of Concrete," Pearson Education.
2. Indian Standard IS 456:2000, "Plain and Reinforced Concrete – Code of Practice," Bureau of Indian Standards.
3. Indian Standard IS 10262:2019, "Concrete Mix Proportioning – Guidelines," Bureau of Indian Standards.
4. ASTM C469/C469M-14, "Standard Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression," ASTM International.
5. Chaitanya Kumar, S.V. (2016). "Effect of Metakaolin on the Properties of High-Strength Concrete." International Journal of Engineering Research & Technology (IJERT), 5(6), 147-151.
6. Poon, C.S., Kou, S.C., & Lam, L. (2002). "Use of Metakaolin in Concrete: A Review." Construction and Building Materials, 16(6), 441-455.
7. Siddique, R., Klaus, J. (2009). "Influence of Metakaolin on the Properties of Mortar and Concrete: A Review." Applied Clay Science, 43(3-4), 392-400.
8. Afroughsabet, V., Biolzi, L., & Ozbakkaloglu, T. (2016). "High-Performance Fiber-Reinforced Concrete: A Review." Journal of Materials Science, 51, 6517-6551.
9. Ahmad, S., & Umar, R. (2018). "Effect of Polypropylene Fibers on the Mechanical Properties and Durability of High-Performance Concrete." Journal of Materials in Civil Engineering, 30(2).
10. Patel, S. (2018). "Experimental Study on M50 Grade Concrete with Partial Replacement of Cement by Metakaolin and Addition of Polypropylene Fibers." Master's Thesis, Civil Engineering Department, [University Name].
11. Rajkumar, M. (2017). "Study on Mechanical Properties of Concrete Incorporating Metakaolin and

Polypropylene Fibers." Ph.D. Dissertation, [University Name].

12. Rashad, A.M. (2014). "A Brief Review on High Performance Concrete Incorporating Metakaolin and Polypropylene Fibers." Proceedings of the 3rd International Conference on Sustainable Construction Materials and Technologies, 45-55.
13. Kumar, R., & Rathi, V. (2015). "Effect of Polypropylene Fibers and Metakaolin on High-Strength Concrete." Proceedings of the 10th International Conference on Concrete Engineering and Technology, 89-97.
14. "Impact of Metakaolin and Polypropylene Fibers on High-Strength Concrete," Concrete International, April 2020.
15. "Enhancing Concrete Performance with Metakaolin and Polypropylene Fibers," Journal of Advanced Concrete Technology, January 2019.