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EXPERIMENTAL STUDY OF HIGH PERFORMANCE CONCRETE DESIGNED USING INDUSTRIAL WASTE FOR DURABILITY

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ABSTRACT :

The experimental work is to study the influence of fly ash and silica in achieving high performance concrete (HPC).This study analyses the performance of various combinations of concrete in which partially replacement with 8,16,21%of fly ash ,and 4,5,7% of silica fume.Superplasticizer PC400 of 1.5%for every specimen is added in order to improve workability of the mix.Specimens are casted for M70,80&90 grade as per mix design.Durability tests conducted including carbonation test and water absorption ,Compressive Strength ,Flexure Strength &Spilt tensile strength of concrete.

INTRODUCTION :

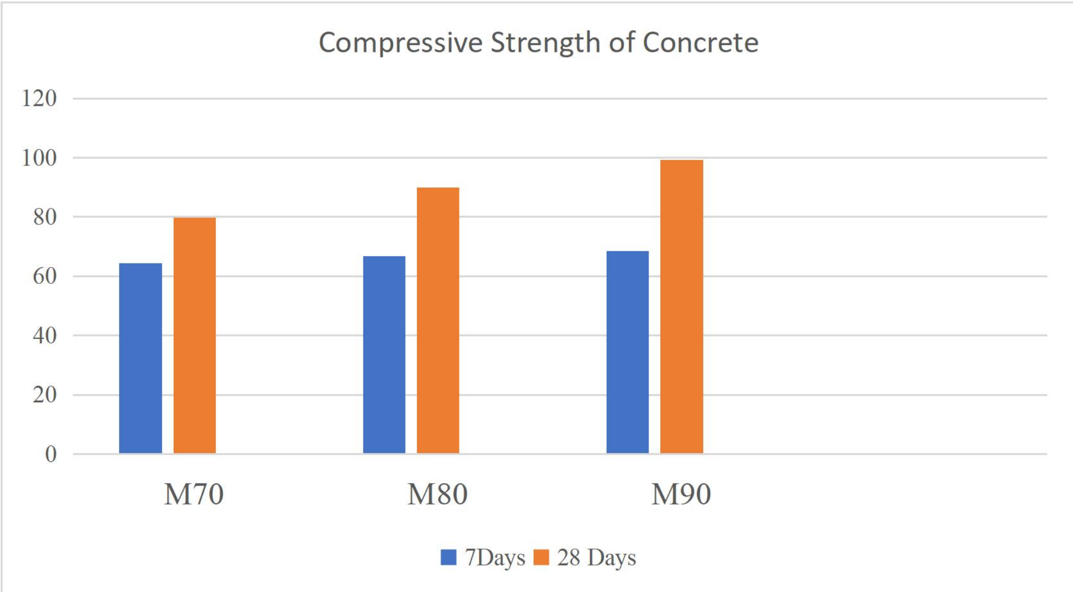
Concrete is indeed a crucial construction material comprised of cement, fine aggregates (such as sand), coarse aggregates (like gravel or crushed stone), and water. Its widespread use globally underscores its importance in construction projects.High Strength Concrete (HSC) goes beyond conventional concrete by offering not just high compressive strength but also uniform high density and very low permeability. Achieving these properties often involves enhancing concrete mixtures with mineral admixtures such as fly ash and silica fume.The cement industry, while vital for construction, is also a significant emitter of carbon dioxide (CO_2). To mitigate this impact, there's a growing trend towards replacing some of the cement in concrete mixtures with mineral admixtures like fly ash and silica fume. These materials not only contribute to reducing CO_2 emissions but also improve the performance of concrete in terms of strength and durability.The development of High Strength Concrete represents a significant advancement in concrete technology, offering engineers and architects the ability to design structures that are stronger, more durable, and more sustainable. Supplementary Cementitious Materials (SCMs) like fly Ash and Silica Fume have become essential components in the mix design of high performance and high strength concrete. They enhance various properties of concrete, including strength, durability, and resistance to environmental factors.
The term high strength concrete is generally used for concrete with compressive strength higher than 60MPa. Here we have designed M70,M80 and M90 design mix using OPC 53 ,Fly Ash ,Silica Fume ,fine aggregate ,coarse aggreagae 10mm and 20mm using chemical admixtures superplastizers.

DESIGN MIX

M70 :-
Cement Content :434 kg/m^3
Fly Ash Content :98 kg/m3
Silica fume :35 kg/m^3
Water :149kg/m^3
Coarse Aggregate(10mm) :356kg/m^3
Coarse Aggregate(20mm) :586kg/m^3
Fine aggregate :693kg/m^3
Water Cement Ratio :0.26
Design Mix : M80
Cement Content :450
Fly Ash :37
Silica :18
Water :131
Coarse Aggregate(10mm) :450kg/m^3
Coarse Aggregate(20mm) :675kg/m^3
Fine aggregate :544kg/m^3
Water Cement Ratio :0.26
Design Mix : M90
Cement Content :450 kg/m^3

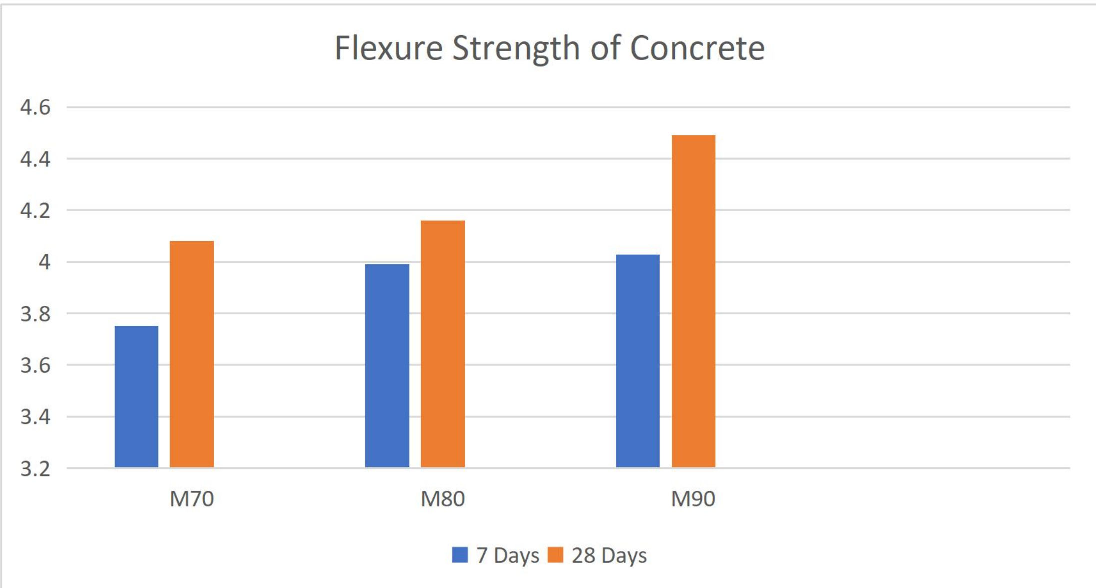
Fly Ash :72 kg/m^3
Silica :22.5 kg/m^3
Water :131 kg/m^3
Coarse Aggregate(10mm) :493kg/m^3
Coarse Aggregate(20mm) :740kg/m^3
Fine aggregate :591.162kg/m^3
Water Cement Ratio :0.24

	Water	Cement	Fine Aggregate	Coarse Aggregate	Coarse Aggregate	FlyAsh	Silica Fume	7 Days	28 Days
M70	149	434	693	586	356	98	35	64.49	79.72
M80	131	450	544	675	450	37	18	66.72	89.88
M90	131	450	596	740	493	72	22.5	68.58	99.26

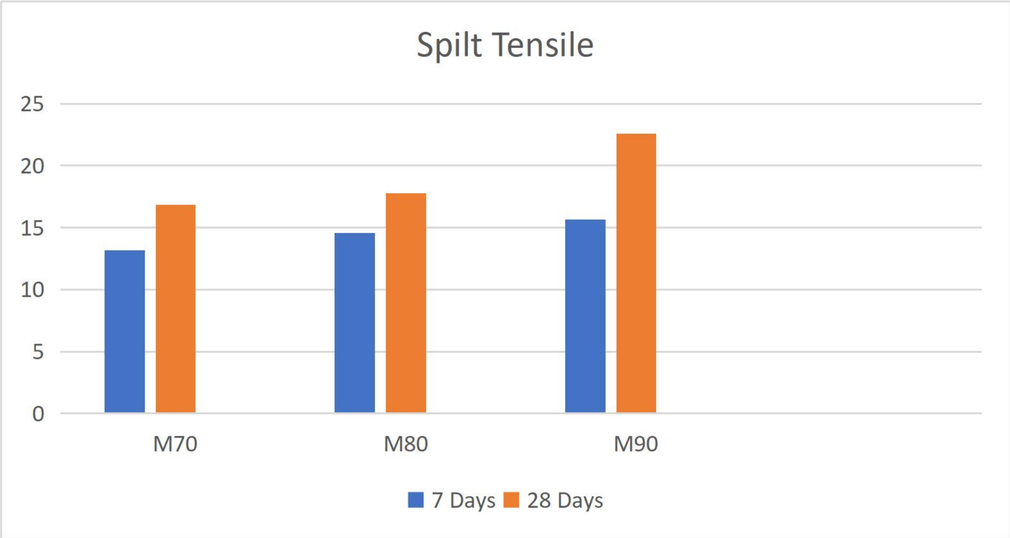


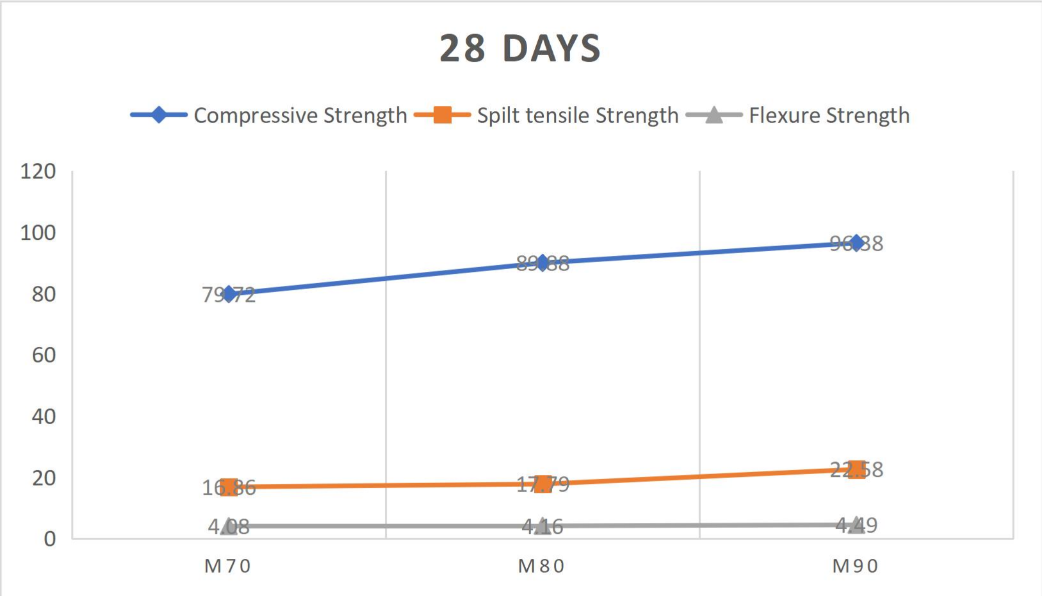
Flexure Strength of Concrete

	Water	Cement	Fine Aggregate	Coarse Aggregate	Coarse Aggregate	FlyAsh	Silica Fume	7 Days	28 Days
M70	149	434	693	586	356	98	35	3.75	4.08
M80	131	450	544	675	450	37	18	3.992	4.16
M90	131	450	596	740	493	72	22.5	4.028	4.49



	Water	Cement	Fine Aggregate	Coarse Aggregate	Coarse Aggregate	FlyAsh	Silica Fume	7 Days	28 Days
M70	**149**	**434**	**693**	**586**	**356**	**98**	**35**	**13.19**	**16.86**
M80	**131**	**450**	**544**	**675**	**450**	**37**	**18**	**14.55**	**17.79**
M90	**131**	**450**	**596**	**740**	**493**	**72**	**22.5**	**15.65**	**22.58**





Carbonation Test Procedure

1. **Sample Preparation**: Collect concrete samples from representative areas of the structure.
2. **Phenolphthalein Indicator**: Apply phenolphthalein solution to the fractured surface. It will turn pink in alkaline conditions (pH > 9) and remain colourless in acidic conditions.
3. **Observation**: Note the depth of colour change. A colourless zone indicates carbonation, where the pH has dropped below 9, signalling potential corrosion risks.
4. **Depth Measurement**: Measure the depth of carbonation to assess the severity and estimate the remaining service life of the structure.
5. **Analysis**: Evaluate results to determine the necessity of repairs, protective measures, or changes in maintenance practices

Regular carbonation testing allows for early detection of vulnerabilities, enabling timely interventions to maintain concrete integrity and extend its lifespan

Water Absorption Test (ASTM C642-81)

Purpose:

Moisture penetration significantly impacts the durability of concrete. As a porous material, concrete can allow water migration, which may lead to the corrosion of steel reinforcement and the ingress of harmful chemicals. Therefore, assessing water absorption is crucial for evaluating concrete quality.

Procedure:

1. **Sample Preparation**: Cast concrete cube specimens with dimensions of 150 mm x 150 mm x 150 mm.
2. **Immersion**: Immerse the specimens in water for 28 days to ensure they are fully saturated.
3. **Oven Drying**: After immersion, dry the specimens in an oven at 110˚C for 24 hours, or until a constant mass is achieved.
4. **Weight Measurement**:
   - $\mathbf{w_1}$: Measure the oven-dried weight of the specimen.
   - $\mathbf{w_2}$: Measure the final weight of the specimen after drying.
5. **Calculation**: Determine the percentage of water absorption using the formula:

Percentage of Water Absorption=$(w_1-w_2)\times100/ w_2$

Where:

- w_1= Oven-dried weight of the specimen
- w_2= Final weight of the specimen

Importance

This test helps assess the porosity and permeability of concrete, providing valuable insights into its durability and suitability for various applications. By understanding water absorption characteristics, appropriate measures can be taken to enhance concrete performance and longevity.

Weight of oven dried cube	Weight of Specimen	% Water
8.75	8.77	0.23
8.89	8.91	0.22
8.61	8.63	0.23
8.52	8.54	0.27
8.78	8.81	0.29
8.90	8.92	0.21
8.88	8.91	0.26

CONCLUSION :

By taking the water cement ratio 0.24 and 0.26 the designed target mean strength is achieved by using various percentage of fly ash and silica fume

- Strength Characteristics: Compressive strength is typically higher than flexural strength for concrete. While compressive tests measure the material's ability to withstand axial loads, flexural tests assess its resistance to bending forces.
- Failure Modes: Compressive strength failure occurs through crushing, while flexural failure involves cracking. This highlights the different stress distributions and loading conditions each strength type
- Split Tensile Strength: Failure occurs through the formation of cracks when a tensile load is applied
- Indicating good durability :Regular carbonation testing helps in maintaining the integrity of concrete structure .It is essential to track carbonation progression over time to ensure long term durability and performance
- The water absorption test provides critical information regrading the quality and long term durability of concrete structure .Regular monitoring are essential for ensuring structural integrity and performance, particularly in environments prone to moisture exposure.

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