



# EXPERIMENTAL INVESTIGATIONS OF M30 GRADE PERVIOUS CONCRETE WITH SILICA POWDER FOR PAVEMENT APPLICATION

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## Abstract

Pervious concrete is increasingly used in pavement systems due to its ability to reduce surface runoff, enhance groundwater recharge, and mitigate flooding. However, its lower compressive strength limits its widespread structural application. This study investigates the effect of incorporating silica powder as a partial cement replacement on the mechanical and hydraulic properties of M30 grade pervious concrete. Cement was replaced by silica powder at levels of 0%, 5%, 10%, and 15% by weight. Laboratory experiments were conducted to evaluate compressive strength, flexural strength, unit weight, porosity, and permeability. Results show that silica powder significantly enhances compressive and flexural strengths up to 10% replacement without compromising permeability. The 10% replacement mix demonstrated optimal performance, indicating its suitability for medium-load pavement applications.

**Keywords—** Pervious concrete, silica powder, partial replacement, compressive strength, permeability, pavement.

## I. INTRODUCTION

Pervious concrete is a zero-slump concrete consisting of interconnected voids that allow rapid percolation of water, making it an eco-friendly solution for pavement and stormwater management applications. Unlike traditional concrete, pervious concrete is highly porous, but this porosity reduces its strength and

durability. Therefore, improving its mechanical performance without sacrificing permeability is an ongoing research objective.

Silica powder (micro-silica) is a highly reactive pozzolanic material known to enhance the microstructure of cement matrixes. Its extremely fine particles fill voids within the paste and promote the formation of calcium silicate hydrate gel, which can potentially increase strength and durability. However, excessive silica powder may densify the matrix and adversely affect the drainage capacity. This study focuses on identifying an appropriate silica powder replacement percentage for pavement applications where both strength and permeability are essential.

## II. MATERIALS

Ordinary Portland Cement (OPC 53 grade), locally available angular coarse aggregates (8 mm nominal size), potable water, and commercial-grade silica powder were used. Aggregates were used without fine sand to maintain high porosity. A polycarboxylate-based superplasticizer was incorporated at 0.8% of binder content to improve paste workability.

## III. MIX DESIGN AND SPECIMEN PREPARATION

Four concrete mixes were prepared by replacing cement with silica powder at 0%, 5%, 10%, and 15% by weight while keeping water-binder ratio constant at 0.40. Table I presents the mix proportions.

**Table I. Mix Proportions (kg/m<sup>3</sup>)**

Mix ID	Cement	Silica Powder	Coarse Aggregate	Water	SP (%)
M0	350	0	1100	140	0.8
M5	332.5	17.5	1100	140	0.8
M10	315	35	1100	140	0.8
M15	297.5	52.5	1100	140	0.8

Concrete cubes (100 mm), prisms (100×100×500 mm), and cylindrical specimens for permeability were cast. All specimens were water-cured until the day of testing.

#### IV. TEST METHODS

The following tests were conducted:

- **Bulk density (unit weight):** Based on volume–mass relationship.
- **Porosity:** Based on void–solid volume comparison.
- **Permeability:** Falling-head permeability method.
- **Compressive strength:** IS 516, tested at **7 and 28 days**.
- **Flexural strength:** Modulus of rupture per IS 516 (28 days).

#### V. RESULTS AND DISCUSSION

##### A. Fresh and hardened properties

Table II summarizes the average test results.

**Table II. Test Results**

Mix ID	Unit (kg/m <sup>3</sup> )	Weight Porosity (%)	Permeability (mm/s)	7-Day Comp. (MPa)	28-Day Comp. (MPa)	Flexural (MPa)
M0	1920	23.4	4.82	18.4	24.8	2.81
M5	1955	22.7	4.59	21.2	28.3	3.09
M10	1984	21.9	4.43	23.9	31.6	3.37
M15	1962	21.4	4.10	21.8	29.4	3.10

##### B. Strength performance

Compressive and flexural strengths progressively increased up to 10% replacement due to micro-filling and pozzolanic reactions attributed to silica powder. At 15%, the strength dropped slightly, likely due to reduced cementitious paste and increased demand for water at higher silica content.

##### C. Permeability and porosity

Porosity and permeability decreased gradually with silica addition. Up to 10% replacement, the reduction was minimal and within acceptable limits for pavement drainage. A more noticeable drop at 15% indicates partial clogging of voids and greater matrix densification.

##### D. Performance evaluation for pavements

The **M10 mix** demonstrated the best balance of mechanical and hydraulic performance:

- Highest compressive (31.6 MPa) and flexural strength (3.37 MPa)
- Acceptable permeability for pavement drainage (4.43 mm/s)

Thus, a **10% silica replacement** is recommended for medium-load pavements such as parking lots, walkways, low-volume roads, and stormwater management pavements.

#### VI. CONCLUSION

Based on the present experimental investigation, the following conclusions are drawn:

1. Silica powder significantly enhances the mechanical properties of pervious concrete due to its micro-filling and pozzolanic activity.
2. Compressive and flexural strengths improved up to 10% replacement of cement, beyond which marginal reduction was observed.
3. Porosity and permeability decreased slightly with increasing silica powder but remained satisfactory for pavement drainage.

4. The mix with **10% silica powder** exhibited the optimum balance of strength and infiltration characteristics.
  5. Silica-modified pervious concrete is suitable for sustainable pavement systems requiring both structural stability and effective stormwater management.
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