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# Experimental Investigation of Pervious Concrete with Partial Replacement of Cementitious Materials and Addition with Fibers

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*pervious concrete; fly ash; GGBS; silica fume; glass fiber; compressive strength; split tensile strength; sustainable pavement*

**ABSTRACT**

*Pervious concrete is a porous cementitious material developed to provide structural capacity while allowing water to pass through an interconnected pore network. Its environmental value is associated with stormwater management and reduction of surface runoff, but its relatively low mechanical strength limits broader pavement applications. The present study experimentally investigates PC30 mixes incorporating partial replacement of cement by fly ash, ground granulated blast-furnace slag (GGBS), and silica fume, together with controlled additions of fine aggregate and glass fibers. The experimental programme compared a conventional dense M30 reference mixture with pervious concrete mixtures designated MP, M1, M2, and M3. Fine aggregate contents of 0%, 5%, 10%, and 15% were used in the pervious mixes, while the binder was modified using combinations of fly ash, GGBS, and silica fume. Glass-fiber levels were designated F0, F0.5, F1.0, and F1.5 in the source experimental programme. Compressive strength and split tensile strength were evaluated at 7 and 28 days. The selected PC30 control mix MP F0 achieved 20.24 MPa at 7 days and 28.31 MPa at 28 days. Increasing fine aggregate content and the supplementary cementitious-material combination generally increased strength. The highest reported 28-day compressive strength among the pervious mixes was 32.85 MPa for M3 F1.5, while the highest reported 28-day split tensile strength was 3.47 MPa for M3 F1.0 and M3 F1.5. Relative to MP F0, M3 F1.5 increased 28-day compressive strength by approximately 16.0% and split tensile strength by approximately 35.0%. The results demonstrate that combining limited fine aggregate, supplementary cementitious materials, and glass fibers can improve the mechanical performance of pervious concrete, although the reported values remain below the dense M30 reference strength of 38.27 MPa. Because permeability and porosity were not reported as measured outcomes in the present experimental dataset, the* *optimum mixture should be considered a mechanical-strength optimum rather than a fully optimized hydraulic pavement mixture.*

## 1. Introduction

Conventional concrete pavement systems create largely impervious surfaces and can increase stormwater runoff, localized flooding, and the hydraulic burden on drainage infrastructure. Pervious concrete provides an alternative pavement material because its interconnected void structure allows water to infiltrate through the pavement layer. Previous research has shown that the same pore structure responsible for hydraulic functionality also reduces density and mechanical strength, creating a fundamental strength–permeability trade-off [1–6].

The performance of pervious concrete is controlled by aggregate size and grading, paste content, water-to-cement ratio, compaction, porosity, and the characteristics of the binder phase. Studies on mix proportioning and pore structure have demonstrated that changes in aggregate arrangement and paste content can substantially alter compressive response and permeability [3–6]. The use of supplementary cementitious materials (SCMs) provides another route for modifying the paste microstructure while reducing the amount of Portland cement. Recent studies have examined fly ash, silica fume, GGBS, and other industrial by-products as cement replacements in pervious concrete [7–10].

Fiber reinforcement is also relevant because the discontinuous and porous skeleton of pervious concrete can be susceptible to cracking and brittle fracture. Research on fiber-reinforced pervious concrete indicates that fibers can improve post-cracking behavior and fracture resistance, although their effect depends on pore structure, fiber type, dosage, and fiber–matrix interaction [11,12]. The uploaded experimental programme therefore combines three supplementary cementitious materials with fine aggregate modification and glass-fiber addition to evaluate whether the mechanical performance of PC30 can be improved without reverting to a conventional dense concrete matrix.

## 2. Literature Review

Chandrappa and Biligiri reviewed pervious concrete as a sustainable pavement material and emphasized the need to balance mechanical, hydraulic, durability, and life-cycle requirements [1]. Ibrahim et al. experimentally demonstrated that aggregate size, cement content, and water-to-cement ratio influence the coupled relationships among density, porosity, compressive strength, tensile strength, and permeability [2]. Lian and Zhuge investigated enhanced permeable-concrete mix design and showed that mixture proportioning can be used to improve structural performance while retaining permeability [3].

The relationship between porosity and strength has been examined by Lian et al., who demonstrated that porosity is a major determinant of compressive strength in porous concrete [4]. Deo and Neithalath similarly linked compressive response to pore-structure parameters [5], while Sumanasooriya and Neithalath showed that pore size, pore connectivity, and specific surface characteristics influence hydraulic behavior and performance prediction [6]. These findings explain why increasing fine aggregate and binder content can increase strength while potentially reducing the open-pore fraction.

Fu et al. studied aggregate size and binder materials and confirmed that aggregate configuration strongly affects the mechanical and hydraulic properties of pervious concrete [7]. Chen et al. reported that supplementary-cementitious-material modification, including silica fume, can produce high-strength pervious concrete when porosity and binder chemistry are appropriately controlled [8]. Ćosić et al. further showed that aggregate type and aggregate-size distribution affect density, porosity, and mechanical properties [9].

Fiber-related research provides a complementary perspective. Rehder et al. found that porosity is a primary factor governing fracture toughness and that fibers become more influential in post-peak response at higher porosity levels [11]. Kevern et al. reported that macrosynthetic fibers can alter the permeability, abrasion resistance, and freeze–thaw performance of pervious concrete [12]. More recent work on chemically treated fibers indicates that improved fiber–matrix bonding can enhance the mechanical performance of fiber-reinforced pervious concrete [13]. Recent reviews also confirm growing interest in industrial supplementary cementitious materials, including fly ash, silica fume and GGBS, as pathways toward more sustainable pervious concrete [14,15].

Table 1. Summary of literature findings guiding the experimental programme.

| Research aspect | Observation from literature | Relevance to present study |
|---|---|---|
| Pore structure | Higher porosity generally lowers strength but enables water transmission. | Fine aggregate and binder modification are used to change the paste/aggregate skeleton. |
| Aggregate size | Aggregate size and grading affect density, porosity and strength. | The study uses 20 mm and 10 mm aggregate fractions and varies fine aggregate content. |
| SCMs | Fly ash, silica fume and GGBS can modify strength and paste structure. | M1–M3 use combinations of these materials. |
| Fibers | Fibers can improve cracking resistance and post-peak response. | Glass-fiber labels F0–F1.5 are evaluated. |
| Workability | Pervious concrete generally has lower workability than dense concrete. | Trial water-cement ratios and slump are evaluated before final testing. |

## 3. Materials and Methods

### 3.1 Materials

The experimental programme used 53-grade Ordinary Portland Cement conforming to IS 12269, with the source document reporting a measured specific gravity of 3.136 and cement fineness of 7.2% residue on the specified sieve. Natural fine aggregate and coarse aggregate were used, with coarse aggregate divided into 20 mm and 10 mm fractions. Fly ash, GGBS, and silica fume were used as supplementary cementitious materials. Glass fiber was incorporated at four study levels identified as F0, F0.5, F1.0, and F1.5. A superplasticizer was included at 9.9 kg/m³ in the final mix schedule.

Figure 1. Glass fibers used in the source experimental programme

### 3.2 Mix Design and Experimental Variables

The dense M30 reference mixture was proportioned as 330 kg/m³ cement, 725 kg/m³ fine aggregate, 1242 kg/m³ coarse aggregate, and 148.5 kg/m³ water, corresponding to a water-cement ratio of 0.45. Trial batches were prepared at water-cement ratios of 0.38, 0.40, 0.45 and 0.50. The reported 28-day compressive strengths were 34.50, 37.42, 38.27 and 35.00 MPa, respectively; therefore, 0.45 was selected for the final programme.

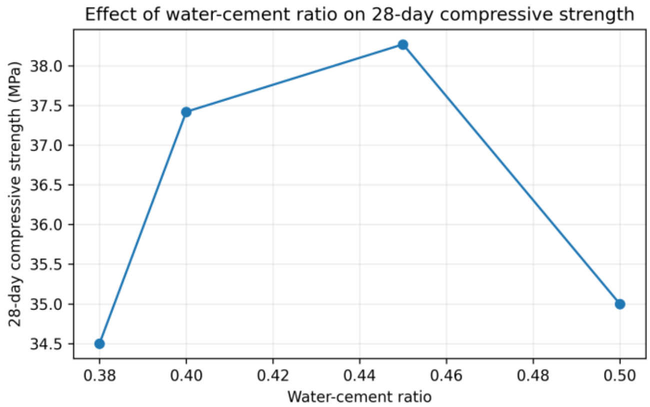


Figure 2. Effect of water-cement ratio on 28-day compressive strength of the trial M30 mix.

Table 2. Final mixture quantities reported in the uploaded experimental study.

| Mix | Cement kg/m³ | Fly ash kg/m³ | GGBS kg/m³ | Silica fume kg/m³ | Fine aggregate kg/m³ | Coarse aggregate 20+10 mm kg/m³ | Water kg/m³ | w/c |
|---|---|---|---|---|---|---|---|---|
| MS (dense M30) | 330 | 0 | 0 | 0 | 725 | 869.40 + 372.60 | 148.50 | 0.45 |
| MP | 330 | 0 | 0 | 0 | 0 | 869.40 + 372.60 | 148.50 | 0.45 |
| M1 | 280.50 | 16.50 | 16.50 | 16.50 | 43.47 | 825.93 + 372.60 | 148.50 | 0.45 |
| M2 | 264.00 | 33.00 | 16.50 | 16.50 | 86.94 | 784.46 + 372.60 | 148.50 | 0.45 |
| M3 | 247.50 | 49.50 | 33.00 | 16.50 | 130.41 | 738.99 + 372.60 | 148.50 | 0.45 |

In percentage terms, the source mix schedule identifies M1, M2 and M3 with increasing fine-aggregate contents of 5%, 10% and 15%, respectively. The 20 mm coarse-aggregate fraction decreases from 70% in MP to 65%, 60% and 55% in M1, M2 and M3, while the 10 mm fraction remains at 30%. The binder system changes from 100% cement in MP to 85/5/5/5, 80/10/5/5 and 75/10/10/5 cement/fly ash/GGBS/silica-fume combinations in M1, M2 and M3, respectively. The glass-fiber levels are retained using the labels reported in the source document; the source does not explicitly specify the dosage basis or unit for F0.5, F1.0 and F1.5, so these labels should be clarified before journal submission.

3.3 Specimen Preparation

The source programme reports that three 150 × 150 × 150 mm cube specimens were cast for each mix condition for compressive-strength testing. The required quantities of cementitious materials, fine aggregate, coarse aggregate and water were weighed separately. Dry mixing was continued until a uniform distribution was obtained, followed by addition of approximately 50–70% of the water and mechanical mixing for 3–4 min. Fresh concrete was placed in moulds using a vibrating table. Specimens were kept at room temperature for approximately 24 h before demoulding and curing. The experimental matrix comprised 51 cubes and 51 cylinders at each curing age, giving 204 specimen-age observations across the cube and cylinder programmes as reported in the source schedule.

Figure 3. Cast pervious-concrete cube specimens (source document photograph).

3.4 Fresh Concrete and Hardened Concrete Tests

Fresh-concrete workability was evaluated using the slump-cone procedure according to IS 1199 as stated in the source document. The reported trial M30 slump values were 61, 57, 49 and 52 mm at water-cement ratios of 0.45, 0.40, 0.38 and 0.50, respectively. The source study notes a significant reduction in workability as the pervious-concrete modification and material additions are introduced.

Figure 4. Slump-test photograph from the source experimental study.

Compressive strength was determined using the compression-testing procedure reported with IS 516. Specimens were tested after 7 and 28 days of curing, and the compressive strength was obtained from the failure load divided by the loaded cross-sectional area. Split tensile strength was determined according to IS 5816 using cylindrical specimens. The source document gives the standard relationship $T = 2P/(\pi LD)$, where P is the maximum applied load and L and D represent specimen dimensions.

## 4. Results and Discussion

4.1 Trial Water-Cement Ratio

The preliminary trial programme indicates that the selected water-cement ratio strongly influenced the dense M30 reference mixture. The maximum reported 28-day compressive strength was 38.27 MPa at w/c = 0.45. Lowering the ratio to 0.38 reduced the reported strength to 34.50 MPa, while increasing it to 0.50 reduced the strength to 35.00 MPa. The result supports the selection of 0.45 as the working ratio for the subsequent PC30 programme.

4.2 Compressive Strength without Glass Fiber

For the F0 condition, the 28-day compressive strength increased from 28.31 MPa for MP F0 to 30.25 MPa for M3 F0. This represents an increase of approximately 6.9%

within the pervious-concrete series. The corresponding 7-day values increased from 20.24 to 22.51 MPa. The trend is consistent with the increased fine-aggregate content and the modified binder system in M1–M3, which provide a denser load-transfer skeleton and a greater proportion of reactive/filler materials in the cementitious phase.

Table 3. Compressive strength of pervious concrete without glass fiber.

| Mix | 7-day compressive strength (MPa) | 28-day compressive strength (MPa) |
|---|---|---|
| MP F0 | 20.24 | 28.31 |
| M1 F0 | 20.31 | 28.45 |
| M2 F0 | 21.41 | 29.33 |
| M3 F0 | 22.51 | 30.25 |

4.3 Effect of Glass Fiber on Compressive Strength

The glass-fiber series shows a generally positive effect on compressive strength. For M3, the 28-day compressive strength increased from 30.25 MPa at F0 to 31.39 MPa, 32.56 MPa and 32.85 MPa at F0.5, F1.0 and F1.5, respectively. For the MP control, the corresponding increase was more modest, from 28.31 MPa at F0 to 29.04 MPa at F1.5. The larger response in M3 suggests that fiber addition is more effective when the matrix contains the higher fine-aggregate and SCM combination used in that mix. However, the data should be interpreted as a mechanical trend rather than evidence of a universally optimum fiber dosage because the source document does not report fiber mass/volume fraction, dispersion quality, or statistical variability.

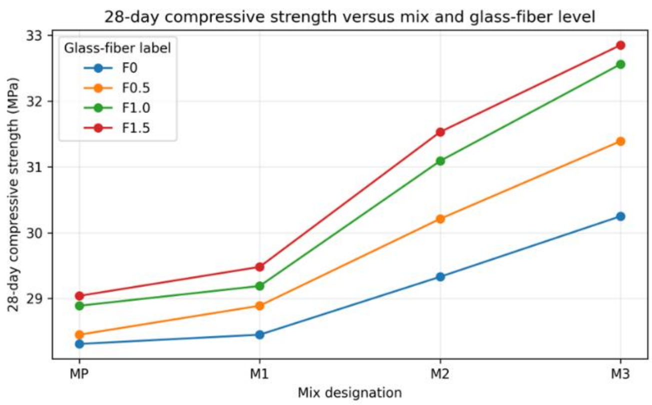


Figure 6. 28-day compressive strength versus mix designation and glass-fiber level.

Table 4. Complete compressive-strength dataset reported in the source document.

| Mix | 7-day compressive strength (MPa) | 28-day compressive strength (MPa) |
|---|---|---|
| MP F0 | 20.24 | 28.31 |
| M1 F0 | 20.31 | 28.45 |
| M2 F0 | 21.41 | 29.33 |
| M3 F0 | 22.51 | 30.25 |
| MP F0.5 | 20.39 | 28.45 |
| M1 F0.5 | 20.83 | 28.89 |
| M2 F0.5 | 22.29 | 30.21 |
| M3 F0.5 | 22.73 | 31.39 |
| MP F1.0 | 20.53 | 28.89 |
| M1 F1.0 | 21.41 | 29.19 |
| M2 F1.0 | 22.44 | 31.09 |
| M3 F1.0 | 23.03 | 32.56 |
| MP F1.5 | 20.68 | 29.04 |
| M1 F1.5 | 21.56 | 29.48 |
| M2 F1.5 | 22.59 | 31.53 |
| M3 F1.5 | 23.32 | 32.85 |

4.4 Split Tensile Strength

The split tensile results show a stronger sensitivity to the combined mix modifications than the compressive results. Without glass fiber, the 28-day split tensile strength increased from 2.57 MPa for MP F0 to 3.21 MPa for M3 F0. At F0.5, the corresponding values were 2.41, 2.78, 2.97 and 3.33 MPa for MP, M1, M2 and M3. At F1.0, M3 achieved 3.47 MPa, the highest value reported in that series. The F1.5 series also produced 3.47 MPa for M3, indicating that increasing the fiber level from F1.0 to F1.5 did not further increase the reported 28-day split tensile strength for the M3 mix.

Table 5. Complete split-tensile-strength dataset reported in the source document.

| Mix | 7-day split tensile strength (MPa) | 28-day split tensile strength (MPa) |
|---|---|---|
| MP F0 | 2.15 | 2.57 |
| M1 F0 | 2.19 | 2.76 |
| M2 F0 | 2.34 | 2.95 |
| M3 F0 | 2.38 | 3.21 |
| MP F0.5 | 2.01 | 2.41 |
| M1 F0.5 | 2.22 | 2.78 |
| M2 F0.5 | 2.36 | 2.97 |
| M3 F0.5 | 2.41 | 3.33 |
| MP F1.0 | 1.96 | 2.50 |
| M1 F1.0 | 2.24 | 2.85 |
| M2 F1.0 | 2.38 | 3.04 |
| M3 F1.0 | 2.34 | 3.47 |
| MP F1.5 | 2.01 | 2.59 |
| M1 F1.5 | 2.26 | 2.90 |
| M2 F1.5 | 2.41 | 3.16 |
| M3 F1.5 | 2.45 | 3.47 |

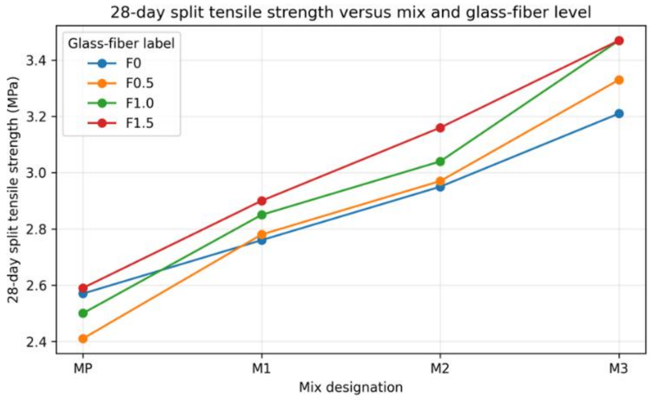


Figure 7. 28-day split tensile strength versus mix designation and glass-fiber level.

4.5 Overall Effect of Fine Aggregate and SCMs

Across the F0 series, increasing the fine-aggregate level from 0% in MP to 15% in M3 increased the 28-day compressive strength from 28.31 to 30.25 MPa and the 28-day split tensile strength from 2.57 to 3.21 MPa. The increase is attributed, within the limits of the reported dataset, to improved particle packing and a denser cementitious/aggregate skeleton. The SCM combination also contributes to binder modification through filler and pozzolanic effects. This interpretation agrees qualitatively with published research showing that strength in pervious concrete is strongly influenced by paste structure and porosity [3–10].

The dense M30 reference mix reached 38.27 MPa at 28 days, whereas the best pervious mixture reported here, M3 F1.5, reached 32.85 MPa. Thus, the modified pervious concrete improves substantially over the unmodified pervious control but does not fully recover the strength of the dense concrete reference. This is expected because the open pore network required for pervious functionality reduces the effective load-bearing cross-section.

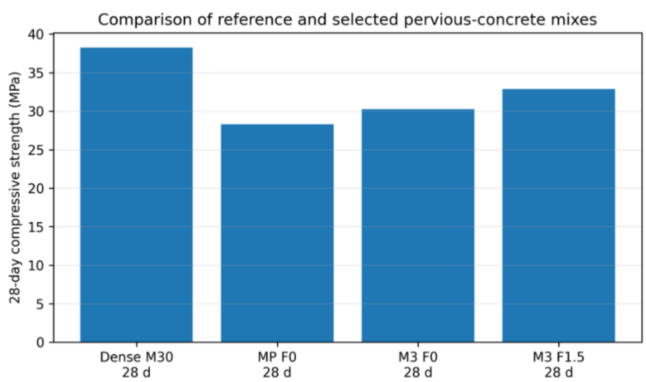


Figure 8. Comparison of 28-day compressive strength of dense M30 and selected pervious-concrete mixtures.

4.6 Identification of the Best Mechanical Mix

Based on the reported mechanical results, M3 F1.5 can be identified as the best overall compressive-strength mixture, with 32.85 MPa at 28 days. Its 28-day split tensile strength was 3.47 MPa, which is equal to the highest reported tensile value. Compared with MP F0, M3 F1.5 increased 28-day compressive strength by approximately 16.0% and split tensile strength by approximately 35.0%. Within M3 itself, increasing the glass-fiber level from F0 to F1.5 increased the 28-day compressive strength by approximately 8.6% and the split tensile strength by approximately 8.1%.

Table 6. Improvement from the unmodified pervious control MP F0 to the mechanically best-performing M3 F1.5 mix.

| Performance indicator | MP F0 | M3 F1.5 | Change |
|---|---|---|---|
| 7-day compressive strength (MPa) | 20.24 | 23.32 | +15.2% |
| 28-day compressive strength (MPa) | 28.31 | 32.85 | +16.0% |
| 7-day split tensile strength (MPa) | 2.15 | 2.45 | +14.0% |
| 28-day split tensile strength (MPa) | 2.57 | 3.47 | +35.0% |

## 5. Discussion of Practical Implications

The experimental results indicate that strength enhancement of pervious concrete can be achieved through simultaneous modification of the aggregate skeleton, binder chemistry, and fiber reinforcement. The increase in fine aggregate from 0% to 15% and the associated reduction in the 20 mm aggregate fraction appear to improve the mechanical skeleton, while the fly ash–GGBS–silica-fume combination provides a modified binder phase. Glass fibers provide an additional crack-bridging mechanism and are associated with modest further gains in compressive strength and more pronounced gains in split tensile strength in the reported dataset.

The principal engineering limitation is that the present dataset does not contain measured permeability, porosity, density, abrasion, freeze–thaw, chloride, sulphate, or acid-attack results. Consequently, the term 'optimum' should not be interpreted as a hydraulic or durability optimum. Published studies show that increases in strength can be accompanied by decreases in permeability when the pore system is densified [2–7,14].

For pavement application, the final mixture should therefore be selected by multi-objective optimization of strength, permeability, porosity, durability, cost, and environmental performance rather than compressive strength alone.

## 6. Conclusions

- A water-cement ratio of 0.45 produced the highest reported 28-day compressive strength of 38.27 MPa in the dense M30 trial mixture and was selected for the final experimental programme.
- The pervious-concrete control MP F0 achieved 20.24 MPa at 7 days and 28.31 MPa at 28 days, confirming the expected strength reduction associated with the porous structure relative to dense M30 concrete.
- Increasing fine aggregate from 0% in MP to 15% in M3 increased the 28-day compressive strength from 28.31 to 30.25 MPa and the split tensile strength from 2.57 to 3.21 MPa in the F0 series.
- The combined use of fly ash, GGBS and silica fume increased the reported mechanical performance of the modified pervious mixes compared with the pervious control.
- Glass-fiber addition produced a generally positive effect on compressive strength. The highest reported 28-day compressive strength was 32.85 MPa for M3 F1.5.
- The highest reported 28-day split tensile strength was 3.47 MPa, obtained for M3 F1.0 and M3 F1.5.
- M3 F1.5 improved 28-day compressive strength by approximately 16.0% and split tensile strength by approximately 35.0% compared with MP F0.
- The M3 F1.5 mixture is therefore the best-performing mixture in the supplied mechanical-strength dataset; however, it should not be called the overall optimum pavement mixture until permeability, porosity and durability requirements are also verified.
- The glass-fiber dosage notation F0.5, F1.0 and F1.5 should be defined explicitly in the final journal manuscript in terms of mass or volume fraction and units.

## 7. Limitations and Recommended Future Work

The present work is limited to the reported compressive and split tensile strength results, together with preliminary workability and mix-design observations. The source document itself recommends further studies on flexural strength, permeability, sulphate attack, corrosion, chloride penetration, acid attack, and elevated-temperature exposure. For journal publication, the next phase should include connected porosity, density, infiltration/permeability coefficient, abrasion resistance, freeze–thaw durability, and statistical analysis of replicate specimens. A factorial or response-surface design could also be used to distinguish the individual effects and interactions of fine aggregate, fly ash, GGBS, silica fume and glass fiber.

## Conflict of interest statement

Authors declare that they do not have any conflict of interest.

## References


[1] Chandrappa, A. K., and Biligiri, K. P., "Pervious concrete as a sustainable pavement material – Research findings and future prospects: A state-of-the-art review," Construction and Building Materials, vol. 111, pp. 262–274, 2016, doi: 10.1016/j.conbuildmat.2016.02.054.

[2] Ibrahim, A., Mahmoud, E., Yamin, M. M., and Patibandla, V. C., "Experimental study on Portland cement pervious concrete mechanical and hydrological properties," Construction and Building Materials, vol. 50, pp. 524–529, 2014, doi: 10.1016/j.conbuildmat.2013.09.022.

[3] Lian, C., and Zhuge, Y., "Optimum mix design of enhanced permeable concrete – An experimental investigation," Construction and Building Materials, vol. 24, no. 12, pp. 2664–2671, 2010, doi: 10.1016/j.conbuildmat.2010.04.057.

[4] Lian, C., Zhuge, Y., and Beecham, S., "The relationship between porosity and strength for porous concrete," Construction and Building Materials, vol. 25, no. 11, pp. 4294–4298, 2011, doi: 10.1016/j.conbuildmat.2011.05.005.

[5] Deo, O., and Neithalath, N., "Compressive behavior of pervious concretes and a quantification of the influence of random pore structure features," Materials Science and Engineering: A, vol. 528, no. 1, pp. 402–412, 2010, doi: 10.1016/j.msea.2010.09.024.

[6] Sumanasooriya, M. S., and Neithalath, N., "Pore structure features of pervious concretes proportioned for desired porosities and their performance prediction," Cement and Concrete Composites, vol. 33, no. 8, pp. 778–787, 2011, doi: 10.1016/j.cemconcomp.2011.06.002.

[7] Fu, T. C., Yeih, W., Chang, J. J., and Huang, R., "The influence of aggregate size and binder material on the properties of pervious concrete," Advances in Materials Science and Engineering, 2014, Article 963971, doi: 10.1155/2014/963971.

[8] Chen, Y., Wang, K., Wang, X., and Zhou, W., "Strength, fracture and fatigue of pervious concrete," Construction and Building Materials, vol. 42, pp. 97–104, 2013, doi: 10.1016/j.conbuildmat.2013.01.006.

[9] Ćosić, K., Korat, L., Ducman, V., and Netinger, I., "Influence of aggregate type and size on properties of pervious concrete," Construction and Building Materials, vol. 78, pp. 69–76, 2015, doi: 10.1016/j.conbuildmat.2014.12.073.

[10] Putman, B. J., and Neptune, A. I., "Comparison of test specimen preparation techniques for pervious concrete pavements," Construction and Building Materials, vol. 25, no. 8, pp. 3480–3485, 2011, doi: 10.1016/j.conbuildmat.2011.03.039.

[11] Rehder, B., Banh, K., and Neithalath, N., "Fracture behavior of pervious concretes: The effects of pore structure and fibers," Engineering Fracture Mechanics, vol. 118, pp. 1–16, 2014, doi: 10.1016/j.engfracmech.2014.01.015.

[12] Kevern, J. T., Biddle, D., and Cao, Q., "Effects of macrosynthetic fibers on pervious concrete properties," Journal of Materials in Civil Engineering, vol. 27, no. 9, Article 06014031, 2015, doi: 10.1061/(ASCE)MT.1943-5533.0001213.

[13] Akand, L., Yang, M., and Wang, X., "Effectiveness of chemical treatment on polypropylene fibers as reinforcement in pervious concrete," Construction and Building Materials, vol. 163, pp. 32–39, 2018, doi: 10.1016/j.conbuildmat.2017.12.068.

[14] Nazeer, M., Kapoor, K., and Singh, S. P., "Strength, durability and microstructural investigations on pervious concrete made with fly ash and silica fume as supplementary cementitious materials," Journal of Building Engineering, vol. 69, Article 106275, 2023, doi: 10.1016/j.jobe.2023.106275.

[15] "A review of utilization of industrial waste materials as cement replacement in pervious concrete: An alternative approach to sustainable pervious concrete production," Heliyon, vol. 10, no. 4, Article e26188, 2024, doi: 10.1016/j.heliyon.2024.e26188.

[16] Bureau of Indian Standards, IS 516, Methods of Tests for Strength of Concrete, New Delhi, India.

[17] Bureau of Indian Standards, IS 5816, Splitting Tensile Strength of Concrete—Method of Test, New Delhi, India.

[18] Bureau of Indian Standards, IS 1199, Methods of Sampling and Analysis of Concrete, New Delhi, India.

[19] Bureau of Indian Standards, IS 10262, Concrete Mix Proportioning—Guidelines, New Delhi, India.

[20] Bureau of Indian Standards, IS 12269, Ordinary Portland Cement 53 Grade—Specification, New Delhi, India.