



International Journal of Innovative Research in Science Engineering and Technology (IJIRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 8.699

Volume 14, Issue 9, September 2025

Experimental Investigation on Structural Integrity of Pervious Concrete with Low-Quality Aggregates

Kamble Mahesh Maruti¹, Dr. Sourabh Kumar Singh², Dr. Anuj Kumar Purwar³

Research Scholar, Department of Civil Engineering, Shri JJT University, Churela, Jhunjhunu, Rajasthan, India¹

Ph.D. Guide, Department of Civil Engineering, Shri JJT University, Churela, Jhunjhunu, Rajasthan, India²

Ph.D. Co-Guide, School of Engineering and Technology, IGNOU, New Delhi, India³

ABSTRACT: Pervious concrete has emerged as a sustainable pavement material due to its ability to facilitate groundwater recharge and reduce surface runoff. However, its structural performance is often influenced by the quality of aggregates used. This study presents an experimental investigation into the structural integrity of pervious concrete prepared with low-quality or marginal aggregates. A series of concrete mixes were developed by partially or fully replacing conventional aggregates with locally available low-grade materials. Laboratory tests were conducted to evaluate key mechanical properties, including compressive strength, flexural strength, and durability characteristics, along with permeability performance. The results indicate that although the inclusion of low-quality aggregates leads to a reduction in mechanical strength, optimized mix proportions can still achieve acceptable structural performance for light to moderate traffic applications. Additionally, the study highlights a balance between permeability and strength, demonstrating that careful gradation and mix design can enhance overall efficiency. The findings suggest that the use of marginal aggregates in pervious concrete is a viable and cost-effective solution for sustainable infrastructure, particularly in resource-constrained regions.

KEYWORDS: Pervious concrete, low-quality aggregates, structural integrity, compressive strength.

I. INTRODUCTION

This review aims to inform researchers about the fundamentals and potential advantages of concrete that has been pervious as a sustainable construction material. Significant opportunities exist in this field to support environmental preservation and groundwater conservation. In today's urban settings, paved areas are so prevalent that their environmental impact is often overlooked. However, increasing surface coverage with impermeable materials such as roads, driveways, parking areas, and walkways hinders the natural absorption of rainwater. This shift disrupts ecological balance, giving rise to various environmental issues, including soil erosion, urban flooding, reduction of groundwater levels, and contamination of surface water bodies. As stormwater traverses these impermeable surfaces, it collects pollutants like oil residues, road salts, and chemical fertilizers.

Eliminating impermeable surfaces altogether could mitigate these challenges but such an approach is impractical due to the essential role of pavements in urban infrastructure. As an alternative, many communities, municipalities, and private enterprises are adopting Concrete that has been pervious and porous pavement technologies. These materials offer the durability and economic advantages of conventional pavements while managing stormwater on-site and aiding in the replenishment of local aquifers. Pervious pavement functions by enabling rainwater to pass through interconnected voids, allowing it to be absorbed into the soil beneath. Often, roads and parking lots made of permeable concrete serve two purposes: they control water and act as a traffic surface. This means that traditional flood infrastructure like retention ponds and sewer lines are not needed as much.

Where Permeable Concrete Is Being Used

Although Concrete that has been pervious pavements may still be unfamiliar in certain parts of the country, they have been in use across Florida and other southeastern regions since the 1970s as a method to manage stormwater runoff, prevent soil erosion, and mitigate flooding. Florida, according to the Florida Concrete & Products Association, has

played a pioneering role in utilizing concrete that has been pervious for pavement construction. Across the state, numerous installations have been successfully implemented, with many surfaces remaining functional for over a decade. In recent years, the West Coast has also begun adopting concrete that has been pervious due to its positive environmental impact. For instance, in California and Washington, concrete that has been pervious is aiding local communities in replenishing groundwater resources while simultaneously reducing pollutants that enter coastal waters, which are crucial to aquatic biodiversity and human health

II. REVIEW OF LITERATURE

Temitope Awolusi (2024): Concrete that has been pervious has demonstrated considerable effectiveness in improving water quality and limiting surface runoff by promoting efficient infiltration and percolation. In nations such as Nigeria, which are susceptible to flooding, the adoption of Concrete that has been pervious could serve as a critical solution for flood mitigation. Nonetheless, its use is challenged by structural limitations including weak bonding and concerns over durability due to the entry of harmful materials.

Papy, S (2023): This study investigates the effect of iroko wood chips on the mechanical and physical characteristics of concrete with the goal of promoting its use in construction. After initial material characterization, concrete was formulated using the Dreux-Gorisse method and wood chips were substituted for aggregate by volume. The specimens underwent mechanical and physical testing. Results revealed that wood chip inclusion substantially lowered the density, Strength at Compression, and tensile splitting strength of concrete by 34%, 89%, and 45% respectively.

Adenuga, O (2022), The natural decline observed in many major oilfield reserves, along with the substantial capital requirements for upstream exploration and project execution, has shifted industry interest toward smaller oilfields, commonly termed marginal fields. These fields offer operators a chance to initiate exploration and production activities while requiring minimal effort in terms of system design, installation, and operational processes.

Diagne, M. (2021), This investigation was conducted to identify the optimal proportion of fillers in hydraulic concrete and to analyze how these fillers influence both its mechanical performance and rheological properties. Initial characterization confirmed that the aggregates satisfied the criteria outlined in the Dreux-Gorisse formulation method for hydraulic concrete. The concrete mixture was standardized to one cubic meter, containing 350 kg/m³ of cement. Mineral fillers—limestone, basalt, and sandstone—were incorporated at 4%, 5%, and 3% by weight, respectively, to enhance the concrete's properties.

III. METHODOLOGY

The research methodology for the study titled “Experimental Investigation on Structural Integrity of Pervious Concrete with Low-Quality Aggregates” is based on an experimental approach to evaluate the effect of marginal aggregates on concrete performance. Initially, low-quality aggregates are collected and tested for basic properties such as gradation, water absorption, and strength characteristics. Cement and other materials are also examined to ensure suitability for mix preparation. Concrete mixes are then designed by replacing conventional aggregates with low-quality aggregates in varying proportions while maintaining the required porosity of pervious concrete. The water-cement ratio is carefully controlled to achieve adequate bonding and permeability. Standard specimens such as cubes and beams are cast using proper mixing and minimal compaction techniques to preserve void structure. After casting, the specimens are cured under controlled conditions for different time intervals, typically 7 and 28 days. Post-curing, tests such as compressive strength and flexural strength are conducted to evaluate structural integrity. Additional tests like permeability may also be performed. The results are analyzed and compared to determine the suitability of low-quality aggregates in pervious concrete. Conclusions are drawn regarding strength performance and practical applicability in sustainable construction.

IV. RESULTS

It show the connection between the fresh and hardened densities of various concrete that has been previously mixed. Because there is more water in the early phases before the hardening process, the fresh density is somewhat greater than the dry density. Both the fresh and cured densities of pervious concrete drop as the aggregate cement ratio rises.

Table 1: Density of Concrete that has been pervious

Sl. No.	Mix	Fresh Density (kg/m ³)	Hardened Density (kg/m ³)
1	A3CS1	2314	2206
2	A4CS1	2282	2123
3	A5CS1	2172	2099
4	A6CS1	2117	2020
5	A7CS1	2093	2003
6	A3CS2	2305	2192
7	A4CS2	2245	2139
8	A5CS2	2139	2066
9	A6CS2	2070	1998
10	A7CS2	2049	1982
11	A3CS3	2285	2186
12	A4CS3	2194	2108
13	A5CS3	2146	2070
14	A6CS3	2052	1982
15	A7CS3	2032	1933

If change the amount of gravel and cement in the mix, the solid density of the S1, S2, and S3 mixes goes down from 2206 kg/m³ to 2003 kg/m³, from 2192 kg/m³ to 1982 kg/m³, and from 2186 kg/m³ to 1933 kg/m³. The reduction up to 4% was observed in hardened density for all aggregate mix from fresh density. The ability to estimate hardened Concrete that has been pervious properties from fresh unit weight will be useful for better quality control.

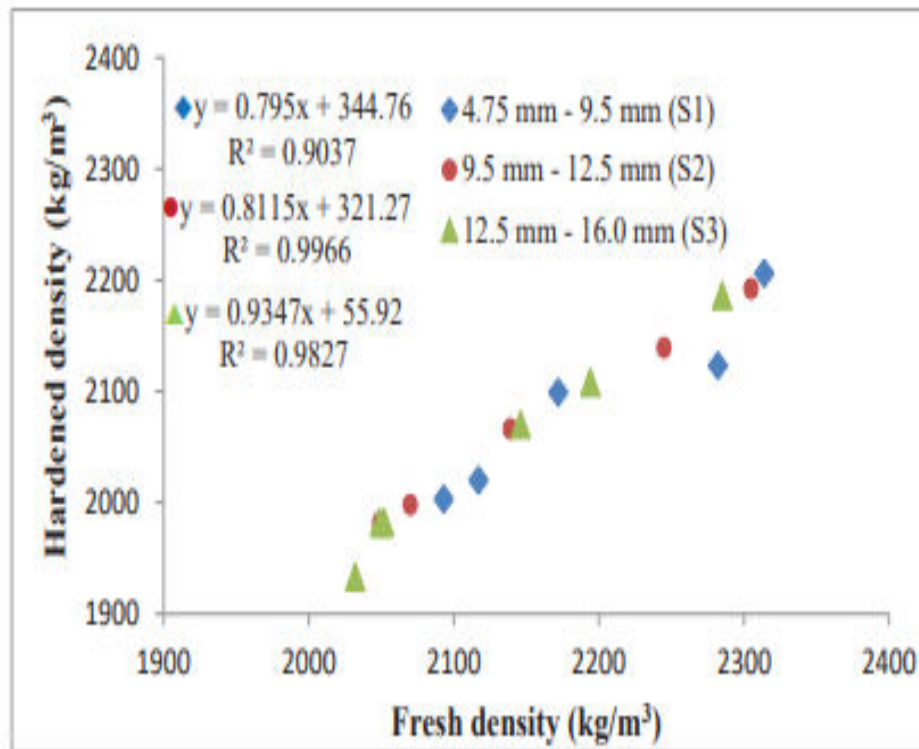


Figure 1: Density of Concrete that has been pervious

The density of Concrete that has been pervious plays a vital in both strength and hydraulic properties. The change in density is due to aggregate, cement and water content and compaction of mix etc. Each mix's density rises as a result of using less coarse aggregate, which has a lower specific gravity than Portland cement.

Table 2: Percentage increase in Strength at Compression after adding nano-silica

w/c Ration	% of NS	7 Days			28 Days		
		G-1	G-2	G-3	G-1	G-2	G-3
0.28	1	25.56	30.75	25.42	13.08	14.1	14.76
0.28	2	43.19	28.69	48.85	33.57	15.23	16.99
0.28	3	61.62	47.63	58.55	44.62	26.92	27.42
0.28	4	77.31	64.12	68.96	54.4	48.19	43.37
0.28	5	67.79	51.96	64.55	47.75	25.04	28.2
0.3	1	25.51	25.74	23.32	13.81	14.59	14.76
0.3	2	39.33	39.51	41.3	28.45	27.28	30.29
0.3	3	60.57	61.18	65.11	42.24	42.41	45.59
0.3	4	77.41	78.53	77.1	51.33	51.48	56.46
0.3	5	64.68	63.97	64.99	40.14	39.04	35.98
0.32	1	29.88	20.6	25.25	12.55	19.29	17.28
0.32	2	42.12	41.7	40.55	28.65	29.58	29.44
0.32	3	63.22	63.58	68.35	43.82	41.99	43.41
0.32	4	87.44	95.03	80.67	55.29	64.39	66.89
0.32	5	75.55	81.95	69.7	48.58	53.3	44.26
0.35	1	26.44	21.25	20.82	20.33	18.51	9.94
0.35	2	42.15	39.87	39.34	28.39	27.56	23.17
0.35	3	62.89	61.65	66.91	43.98	43.12	44.93
0.35	4	88	89.59	81.91	62.28	68.81	61.19
0.35	5	80.44	84.13	69.89	59.87	55.62	40.28

Table shows the rise in the strength at compression of concrete that was achieved by adding nano-silica. At 7 days, the rate of increase in Strength at Compression for NSPCOBBA mixes is much higher than for UNPCOBBA mixes. This rate of increase is also much higher than the rate of increase after 28 days of healing. Based on this result, we can say that adding nano-silica to the porous concrete mix makes it stronger at a young age. NS particles can speed up the setting of cement because they have a big surface area and a surface that reacts quickly with water. When NS is added to cement, the C3S content hydrates much more quickly because it has faster pozzolanic activity and a high surface energy (Ghafari et al., 2014). When 1% NS is added to the pervious mixes, the Strength at Compression goes up by 20–30% after 7 days, but it only goes up by 10–20% after 28 days. Similarly, when 2% NS is added to the pervious mixes, the Strength at Compression goes up by about 30–40% after 7 days and by 20–30% after 28 days.

V. CONCLUSION

The study concludes that fresh density is slightly higher than hardened density due to moisture loss during curing, with an average reduction of about 4%. Density decreases as the aggregate–cement ratio increases, significantly influencing both strength and permeability of pervious concrete. Lower coarse aggregate content improves density because of the higher specific gravity of cement. Additionally, the incorporation of nano-silica enhances compressive strength, especially at early ages, due to its high reactivity and accelerated hydration. Strength gains are more prominent at 7 days than at 28 days. Therefore, optimizing mix proportions and nano-silica content is essential for improving both mechanical and durability properties of pervious concrete.

REFERENCES

1. Adama, S (2022), "Physical and Mechanical Characteristics of Ash Concrete from Palm Nut Shells: Pozzolanic Effect." Open Journal of Applied Sciences, ISSN: 2165-3925 Vol.12 No.10, 1595-1603.
2. Faiz Habib Anwar (2022), "Meta-Analysis of the Performance of Pervious Concrete with Cement and Aggregate Replacements." Buildings. ISSN 2075-5309.
3. Li, J (2024), "Three-Dimensional Multi-Phase Microscopic Simulation of Service Life of Recycled Large Aggregate Self-Compacting Concrete." Journal of Materials Science and Chemical Engineering, ISSN: 2327-6053 Vol.12 No.4, 126-135.
4. Mbida, P.(2023), "Influence of the Partial Substitution of Bitumen by a Mixture of Sulphur and Tyre and Plastic Bottle Powders on the Behaviour of Bituminous Concrete." Journal of Minerals and Materials Characterization and Engineering, ISSN: 2327-4085 Vol.11 No.6, 213-223.
5. Najam, Z(2019), "Experimental Study of Heat Transfer in a Real Scale Building Incorporating PCM in the Air Layer of the Vertical Walls." Journal of Power and Energy Engineering, ISSN: 2327-5901 Vol.7 No.5, 14-25.
6. Olusunle, S (2015), "Effect of Organic Waste on Crystal Structure and Mechanical Properties of Concrete." Journal of Minerals and Materials Characterization and Engineering, ISSN : 2327-4085 Vol.3 No.5, 427-434.
7. Pacheco, M (2023), "Determination of the Sound Absorption Capacity of Hydraulic Concrete Mixtures Added with Waste Tire Rubber." Journal of Minerals and Materials Characterization and Engineering, ISSN Online: 2327-4085 Vol.11 No.5 197-211.
8. Serifou, M (2024), "Study of the Evolution of Properties of Concrete Containing Used Tire Aggregates." Geomaterials, ISSN: 2161-7546 Vol.14 No.4, 49-58.
9. Temitope Awolusi(2024), "Evaluation of the Properties of Fiber-Reinforced Pervious Concrete Pavement Incorporating Glass Powder and Kaolin." The Open Civil Engineering Journal. ISSN: 1874-1495.
10. Torres, A.(2020), "Developing High Strength Pervious Concrete Mixtures with Local Materials." Journal of Materials Science and Chemical Engineering, ISSN : 2327-6053 Vol.8 No.1, 20-34.



INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  ijirset@gmail.com



www.ijirset.com

Scan to save the contact details