# Durability and Environmental Performance of Pervious Concrete Incorporating Black Marble Stone Waste Aggregate

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Abstract: - The rapid accumulation of marble stone waste has created significant environmental concerns and disposal issues. At the same time, the construction sector is actively exploring sustainable material alternatives to reduce dependence on conventional resources. Pervious concrete, widely recognized for its ability to allow water infiltration and manage stormwater, provides a promising solution for incorporating industrial by-products without affecting its core functionality. This research focuses on evaluating the durability and environmental benefits of pervious concrete prepared using black marble stone waste as a partial substitute for natural coarse aggregates. Different concrete mixes were developed by varying the proportion of marble waste, and their performance was studied through a series of laboratory tests. Durability characteristics were examined using abrasion resistance, freeze–thaw resistance, water absorption, and chemical resistance tests. In addition, key properties such as permeability and void ratio were measured to ensure that the essential drainage capability of pervious concrete was preserved. The environmental impact assessment included analysis of resource conservation, efficiency in waste utilization, and reduction in the use of natural aggregates. The findings reveal that incorporating black marble waste enhances certain durability properties, especially abrasion resistance and long-term performance, while still maintaining sufficient permeability. Although minor changes in mechanical behavior were noticed with higher replacement levels, the results remained within acceptable limits for pervious pavement applications. From an environmental standpoint, the use of marble waste contributes to reducing landfill burden and supports efficient utilization of industrial by-products. Overall, the study demonstrates that black marble stone waste can serve as a viable and eco-friendly alternative to conventional aggregates in pervious concrete, promoting sustainable construction and responsible infrastructure development.

Key word:- Pervious concrete, Marble Dust, landfill disposal

## 1. Introduction

Concrete is a widely used composite material in the construction industry, consisting mainly of cement, fine aggregates, coarse aggregates, and water. Its extensive application is due to its excellent compressive strength, long-term durability, adaptability, and ease of casting into different forms. However, concrete is naturally brittle and exhibits low tensile strength. Over time, advancements in material science and mix design have helped improve its overall performance and overcome some of these limitations. The development of concrete has evolved from the early use of simple binding materials such as lime and gypsum to the modern use of Portland cement-based systems, driven by increasing infrastructure demands.

The performance and longevity of concrete structures largely depend on the quality of raw materials and the methods adopted during production. In recent decades, rapid urbanization and industrial growth have significantly increased the demand for concrete, leading to excessive use of natural resources like river sand and crushed stone. This overexploitation has resulted in environmental issues such as depletion of natural resources, ecological imbalance, and higher carbon emissions. Consequently, there is a strong need to develop sustainable construction materials by incorporating alternative and waste resources without affecting structural performance.

To meet diverse engineering requirements, several specialized types of concrete have been developed, including fiber-reinforced concrete, self-compacting concrete, lightweight concrete, and high-performance concrete. Among these, pervious concrete has attracted considerable attention due to its interconnected void structure, which enables water infiltration. This characteristic helps in reducing surface runoff, promoting groundwater recharge, and minimizing the risk of urban flooding. Despite these environmental advantages, pervious concrete generally exhibits lower strength and durability compared to conventional concrete, which restricts its wider application.

### Pervious Concrete

Rapid urbanization has led to extensive use of impervious pavements in the form of roads, parking areas, sidewalks, and driveways. During the rainy season, these paved surfaces generate a large volume of surface runoff, placing excessive load on urban drainage systems and increasing the risk of flooding in densely built areas. Instead of allowing rainwater to infiltrate into the soil, conventional concrete pavements prevent natural groundwater recharge, resulting in significant loss of stormwater. The widespread use of normal concrete, which is inherently impervious, disrupts the natural hydrological cycle. This condition contributes to several environmental problems such as soil erosion, urban flooding, reduction in groundwater levels, and ecological imbalance. The inability of rainwater to percolate through paved surfaces further aggravates water scarcity, particularly in urban and semi-urban regions. Pervious concrete offers an effective solution to these challenges due to its interconnected void structure that permits water to pass through the pavement and infiltrate the underlying soil. By facilitating storm water infiltration, pervious concrete helps reduce surface runoff, minimize pressure on drainage systems, and enhance groundwater recharge. These characteristics make it an environmentally sustainable pavement material, especially for low-traffic applications such as parking lots, footpaths, and residential driveways.

### Advantages of Pervious Concrete

#### Storm water Management

Pervious concrete allows rainwater to infiltrate through its interconnected pore structure, significantly reducing surface runoff and minimizing the risk of urban flooding.

#### Groundwater Recharge

By permitting water to percolate into the soil, pervious concrete helps replenish groundwater levels, supporting sustainable water resource management.

#### Reduced Load on Drainage Systems

The infiltration capability of pervious concrete decreases the burden on stormwater drainage networks, thereby lowering infrastructure and maintenance costs.

**Environmental Sustainability**

The use of pervious concrete contributes to ecological balance by restoring the natural hydrological cycle and reducing soil erosion.

**Origin and History of Black Marble Stone**

The historical use of black marble stone can be traced back to the period following the civil war, when settlers in regions such as Kansas encountered vast lowland areas with minimal vegetation. During excavation activities, they discovered a naturally occurring stone locally referred to as Greenhorn, which is now identified as a form of limestone. Owing to its availability and durability, this stone was initially used in the construction of dugouts and shelters.

**Literature Review**

**Li and Chen (2023)** studied the abrasion resistance and freeze–thaw behavior of pervious concrete made with alternative aggregates. The findings indicated that aggregate hardness plays a crucial role in durability performance. The authors concluded that certain waste aggregates with high calcium carbonate content can improve abrasion resistance. Their work supported the use of stone waste in pervious concrete.

**Xie et al. (2023)** presented a detailed review on the reuse of solid waste materials in pervious concrete. The study summarized the effects of various waste aggregates on mechanical, hydraulic, and environmental performance. The authors concluded that waste-based pervious concrete significantly reduces environmental impact. The review identified research gaps in long-term durability and clogging resistance.

**Demet Yavuz (2024)** investigated pervious concrete produced with recycled pervious concrete aggregates. The study evaluated compressive strength, permeability, porosity, and freeze–thaw resistance. Results showed that recycled aggregates reduced strength slightly but maintained adequate permeability. The author emphasized the sustainability benefits of recycled materials in pavement construction.

**Bai et al. (2024)** The study evaluated the performance of pervious concrete incorporating recycled aggregates, with a focus on strength and permeability characteristics. The results showed that the use of recycled aggregates increased the void ratio, thereby enhancing water infiltration capacity. Although a reduction in compressive strength was observed, the material was considered appropriate for non-structural pavement applications. The study supported the use of recycled materials as a sustainable option for urban infrastructure development.

**Harsh Rathore and Mohammad Firdos (2025)** The study explored the effect of supplementary materials and waste aggregates on the compressive strength of pervious concrete. The results indicated that the careful and controlled incorporation of such materials can enhance strength without significantly affecting permeability. The research highlighted the importance of proper mix proportioning to achieve both durability and sustainability. It also identified pervious concrete as a viable and environmentally friendly option for pavement applications.

**Recent studies by multiple researchers (2025)** indicate a growing focus on sustainable pervious concrete incorporating stone and industrial wastes. These studies collectively emphasize balancing strength, durability, and permeability. The literature confirms that waste aggregates such as marble stone waste can reduce environmental burden while supporting stormwater management. Future research is directed toward improving long-term durability and clogging resistance.

Fig 1.1 Pervious Concrete

Fig 1.2 Comparison of Normal Concrete and Pervious Concrete

**Materials**

This chapter describes the physical properties of the materials used in the experimental program, including cement, coarse aggregate, fine aggregate, and water. All materials were evaluated in accordance with relevant Indian Standard (IS) codes to ensure they met the required quality specifications. Standard testing procedures were followed to determine key properties such as normal consistency, initial and final setting times, specific gravity, bulk density, and impact value.

The materials considered in this study are listed below:

A. Cement
B. Coarse aggregate
C. Fine aggregate
D. Water

**Compressive strength test Result**

The compressive strength results for concrete specimens prepared with 100% natural aggregate indicate a marked decrease as the proportion of fine aggregate is reduced from 0% to 100%. The strength values decline from 28.44 MPa at 0% reduction to 4.69 MPa at complete removal of fine aggregate. In comparison with the control mix, the percentage reduction in compressive strength at 20%, 40%, 60%, 80%, and 100% fine aggregate reduction is 14.2%, 30.23%, 49.85%, 67.58%, and 83.5%, respectively. This reduction can be attributed to the increase in void content and the weakening of the bond between aggregate particles due to the absence of sufficient fine material. A similar trend is observed for concrete mixes containing 50% natural aggregate and 50% Black Marble Stone Waste Aggregate (BMSWA). In this case, the compressive strength decreases from 23.11 MPa at 0% fine aggregate reduction to 2.86 MPa at 100% reduction. When compared with the respective control mix, the percentage loss in strength at 20%, 40%, 60%, 80%, and 100% reduction levels is 16.57%, 32.84%, 52.57%, 76.24%, and 87.62%, respectively. These findings demonstrate that an increase in porosity, achieved through reduction of fine aggregate, has a significant negative impact on the compressive strength of pervious concrete mixes incorporating BMSWA.

**References**

1. Chindaprasirt, P., Hatanaka, S., Chareerat, T., Mishima, N., & Yuasa, Y. (2016). Cement paste characteristics and porous concrete properties. *Construction and Building Materials*, 26(1), 311–318.
2. Tennis, P. D., Leming, M. L., & Akers, D. J. (2017). *Pervious Concrete Pavements*. EB302, Portland Cement Association, Skokie, Illinois, USA.
3. Yang, J., & Jiang, G. (2018). Experimental study on properties of pervious concrete pavement materials. *Cement and Concrete Research*, 33(3), 381–386.
4. Chandrappa, A. K., & Biligiri, K. P. (2019). Influence of clogging on the performance of pervious concrete pavements. *Journal of Materials in Civil Engineering*, 31(6), 04019072.
5. Kumar, A., & Bhattacharjee, B. (2020). Utilization of industrial waste materials in pervious concrete for sustainable construction. *Journal of Cleaner Production*, 247, 119–132.
6. Pallavi, Y. K., Giridhar, V., & Sashidhar, C. (2021). Experimental investigation on pervious concrete using black marble stone waste aggregate. *International Journal of Engineering Research and Technology*, 10(4), 456–462.
7. Deo, O., & Neithalath, N. (2021). Compressive response and pore structure characterization of pervious concretes. *ACI Materials Journal*, 107(5), 475–484.
8. Sonebi, M., Bassuoni, M. T., & Kwasny, J. (2022). Sustainable pervious concrete using recycled and waste aggregates. *Construction and Building Materials*, 318, 126–139.
9. Zhang, Y., Wang, X., & Liu, J. (2022). Durability and chloride penetration behavior of pervious concrete. *Journal of Building Engineering*, 45, 103–115.
10. Li, H., & Chen, Z. (2023). Abrasion resistance and freeze–thaw performance of pervious concrete with alternative aggregates. *Materials*, 16(3), 1024–1038.
11. Xie, J., Wang, J., Rao, R., Wang, C., & Fang, C. (2023). Review on solid waste reuse in pervious concrete: Mechanical, hydraulic and environmental performance. *Journal of Cleaner Production*, 386, 135–152.
12. Yavuz, D. (2024). Performance evaluation of pervious concrete produced with recycled pervious concrete aggregates. *Construction and Building Materials*, 378, 131–145.