INTERNATIONAL SEVEN JOURNAL
OF MULTIDISCIPLINARY
ISSN: 2764-9547

REUTILIZATION OF CONSTRUCTION AND DEMOLITION WASTE IN PERMEABLE PAVEMENTS: A SUSTAINABLE SOLUTION FOR URBAN INFRASTRUCTURE

https://doi.org/10.56238/isevmjv3n1-033

Receipt of the originals: 05/02/2024 **Acceptance for publication:** 28/02/2024

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ABSTRACT
The growing demand for environmentally sustainable solutions in civil construction has encouraged the reuse of construction and demolition waste (CDW) in innovative applications, such as the production of permeable pavements. These pavements allow rainwater to infiltrate into the ground, helping to mitigate flooding, relieve urban drainage systems, and promote aquifer recharge. Recent studies, including those by Rahman et al. (2015), Ossa et al. (2016), and Li et al. (2022), assessed the performance of materials such as recycled concrete, crushed bricks, and reclaimed asphalt in different compositions and combinations with geotextiles, demonstrating good hydraulic efficiency and pollutant filtration capacity. However, the presence of geotextiles may lead to progressive clogging, requiring continuous system maintenance assessment. Other studies, such as Strieder et al. (2022), evaluated permeable concretes with recycled aggregates, noting improvements in hydraulic properties, although with a reduction in mechanical performance. Field tests confirmed the feasibility of application, particularly with rigorous material quality control. In parallel, De Souza et al. (2021) emphasized the strategic value of patents in technological advancement, identifying 65 international patent records related to the use of CDW in permeable pavements, with the United States, Brazil, Japan, and China as leading applicants. Finally, Mohammadinia et al. (2017) demonstrated the effectiveness of lime stabilization to enhance the performance of CDW used in pavement base layers, especially for RCA and CB. The results point to a sustainable and technically viable alternative, contributing to the development of more resilient cities aligned with the principles of circular economy and sustainable urban development.

Keywords: Permeable pavements. Construction and demolition waste (CDW). Urban sustainability. Recycled aggregates. Green infrastructure.

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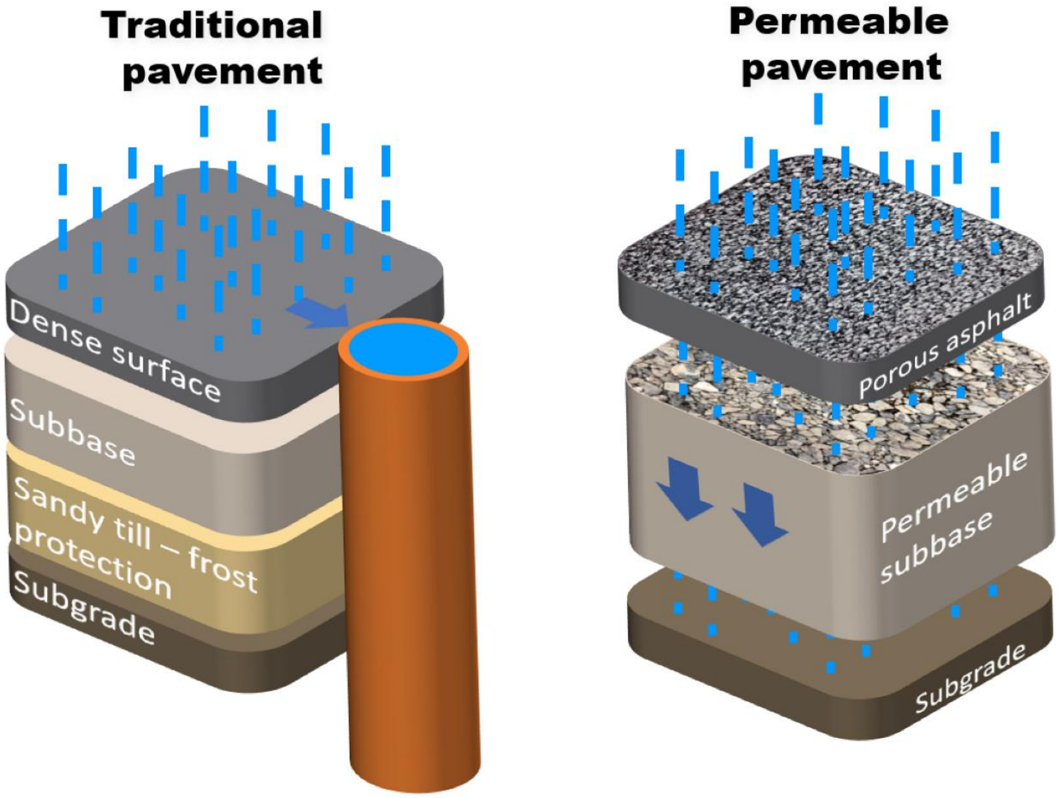
INTRODUCTION

The reuse of materials from demolition for the construction of permeable pavements stands out as an innovative and environmentally viable alternative in the construction sector. This process involves the recovery and reapplication of construction and demolition waste (CDW) to produce pavements that allow rainwater to infiltrate the soil, significantly helping to reduce surface runoff, flooding, and the overloading of urban drainage systems. Unlike conventional pavements, permeable ones facilitate the absorption of rainwater, promoting aquifer recharge and reducing the environmental impact associated with urban runoff. The use of materials such as concrete, bricks, and stones from demolished buildings represents a smart strategy that simultaneously reduces the extraction of new natural resources and avoids the disposal of large volumes of waste in landfills.

Figure 1: Principle sketch of a permeable pavement.



Source: Muttuvelu, Wyke & Vollertsen (2022).

In this context, Rahman et al. (2015) conducted a study to evaluate the use of recycled construction and demolition materials, such as crushed bricks (CB), recycled concrete aggregate (RCA), and reclaimed asphalt pavement (RAP), combined with nonwoven geotextiles, to assess their effectiveness as filter materials in permeable pavements. The researchers carried out various laboratory tests to examine the geotechnical and hydraulic properties of these materials, focusing on stormwater filtration capacity and clogging behavior over time. The results showed that recycled materials, when combined with geotextiles, performed similarly or even better than conventional granular aggregates, with a good ability to remove pollutants. However, it was observed that although geotextiles enhance filtration efficiency, they may contribute to progressive clogging due to sediment accumulation. The MUSIC (Model for Urban Stormwater Improvement Conceptualization) model was used to predict pollutant removal efficiency, and the results were experimentally confirmed.

Meanwhile, the research by Ossa, García, and Botero (2016) investigated the application of recycled CDW aggregates in the production of hot asphalt mixtures for urban road paving. Aiming to mitigate the environmental impacts caused by the improper disposal of construction waste, samples with different proportions (10% to 40%) of recycled aggregates were prepared. The asphalt mixture design followed the Superpave method, and the process was accelerated using the Ramcodes method, also known as the voids polygon method. The tests revealed that incorporating up to 20% of CDW in asphalt mixtures is a feasible alternative, contributing both to functional performance and environmental sustainability in urban paving.

From another perspective, Li et al. (2022) examined the feasibility of reusing CDW materials in the construction of permeable pavements with a focus on flood mitigation. Recycled brick aggregate (RBA) and recycled concrete aggregate (RCA) were used in varying proportions and gradations, combined with geotextiles for contaminant filtration. The authors conducted modified compaction tests, simulated rainfall events, and column leaching tests on a total of 15 samples. The results showed that the recycled materials are safe for underground applications, with heavy metal concentrations lower than those found in local soil. Hydraulic performance was best when 100% recycled concrete was used, while water storage capacity was higher with 100% brick aggregate. Although the geotextile reduced permeability by about 13%, it was effective in retaining more than half of the fine particles in stormwater. It was also noted that recycled concrete had better permeability performance compared to bricks, which were more susceptible to clogging due to fine particles.

Adding to this approach, Strieder et al. (2022) evaluated the behavior of pervious concrete produced with recycled concrete aggregates (RCA), focusing on environmental and economic sustainability. The study examined the impact of replacing natural aggregates with recycled ones on parameters such as porosity, hardened density, hydraulic conductivity, infiltration, compressive and tensile strength, abrasion resistance, modulus of elasticity, and Poisson’s ratio. Laboratory tests revealed that while RCA improved the hydraulic properties, it led to a decrease in mechanical performance. A test section was built using 100% RCA to evaluate field performance, where infiltration tests and deflection measurements using a Light Weight Deflectometer (LWD) were conducted. Comparing lab and field results, only compressive strength showed a significant difference, highlighting the importance of strict control over material properties.

In the field of technological prospecting, De Souza et al. (2021) conducted a study that linked growing environmental concerns to the depletion of natural resources and the accumulation of waste generated by the construction industry. The research emphasized the need for more knowledge production and commercialization of sustainable solutions, such as permeable pavements made with CDW. Through a patent survey in international databases — Google Patents, EPO (Espacenet), and WIPO (Patentscope) — 65 patents related to the topic were identified, with the United States, Brazil, Japan, and China being the leading patent holders. The study highlighted the strategic importance of patents in decision-making within the sustainable construction sector, promoting innovation and responsible resource use.

Finally, the investigation by Mohammadinia et al. (2017) analyzed the performance of lime-stabilized construction and demolition materials for use as pavement base layers. The study employed crushed bricks (CB), recycled concrete (RCA), and reclaimed asphalt pavement (RAP), incorporating between 1% and 5% hydrated lime into the mixtures. Laboratory tests such as particle size distribution, California Bearing Ratio (CBR), modified Proctor compaction, repeated load triaxial (RLT), and unconfined compressive strength (UCS) tests were performed, along with assessments of curing effects at different temperatures. The findings indicated that lime-stabilized RCA and CB met the technical requirements for subbase layers in pavements, while RAP did not demonstrate adequate performance. Microscale analyses using Scanning Electron Microscopy (SEM) and Energy-Dispersive X-ray

Spectroscopy (EDS) provided further insight into the stabilization mechanisms of the materials treated with lime.

Collectively, these studies reinforce the potential of reusing construction and demolition waste as an effective strategy for building more sustainable, technically viable, and environmentally responsible pavements, contributing to the development of more resilient and resource-conscious cities.

The reutilization of construction and demolition waste (CDW) in the production of permeable pavements emerges as a promising alternative to address contemporary environmental and urban challenges. The reviewed studies demonstrate that materials such as recycled concrete, crushed bricks, and reclaimed asphalt exhibit satisfactory technical performance in terms of permeability, filtration capacity, and environmental safety, especially when combined with geotextiles. This practice not only contributes to flood reduction and relief of urban drainage systems but also promotes circular economy by minimizing the extraction of natural resources and the improper disposal of large volumes of waste.

In addition to the environmental and hydraulic benefits, the incorporation of CDW in permeable pavements represents an advance in the economic and technological sustainability of the construction sector. Patent research reveals a growing international interest in innovation within this field, highlighting the market potential for green solutions. However, mechanical performance still poses challenges, requiring strict control of material properties and ongoing efforts for improvement. Therefore, consolidating this technique as a common practice depends on investment in research, adequate standardization, and incentives for the adoption of sustainable technologies in urban projects.

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