E-BOOK OF EXTENDED ABSTRACT

THE 14TH INTERNATIONAL INVENTION, INNOVATION & DESIGN COMPETITION 2025

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INNOVATION OF POROUS CONCRETE WITH LDPE PLASTIC AGREGATE AS AN ECO-FRIENDLY SOLUTION FOR SUSTAINABLE CONSTRUCTION

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ABSTRACT

The increasing volume of plastic waste, particularly from food packaging and beverage bottles, has become a significant environmental challenge. One innovative solution to mitigate this impact is the utilization of plastic waste as a construction material, such as in previous concrete. This study aims to evaluate the effect of substituting coarse aggregate with low-density polyethylene (LDPE) plastic waste on the compressive strength of previous concrete. The LDPE content variations used in the mixtures were 10%, 20%, 30%, 40%, and 50% by volume of coarse aggregate, targeting a compressive strength equivalent to Class II quality concrete (16–24 MPa) for precast drainage channels. The mix design was calculated based on the Indonesian National Standard (SNI) 2834:2000, and compressive strength tests were conducted on concrete beams measuring 15 × 15 × 60 cm. The results indicated that the higher the LDPE content, the lower the compressive strength of the concrete. Normal concrete recorded the highest compressive strength at 25.31 MPa, whereas concrete with 50% LDPE substitution only reached 5.47 MPa. Although the strength did not meet Class II standards, mixtures with 10% to 40% LDPE content still fulfilled the requirements for Class I quality concrete, suitable for non-structural applications. Therefore, LDPE plastic waste has potential as an alternative coarse aggregate in environmentally friendly previous concrete.

Keyword: *beton berpori, limbah plastik, LDPE, agregat alternatif, konstruksi berkelanjutan*

1. INTRODUCTION

Plastic waste, particularly from food packaging and beverage bottles, has become a serious environmental issue. Global waste generation is estimated at 1.7 to 1.9 billion metric tons per year and is projected to rise to 27 billion metric tons by 2050, with a significant portion originating from Asia (Fayshal, M. A., 2024). Poorly managed plastic accumulation can lead to severe consequences, including flooding due to blocked drainage systems, soil contamination from microplastics, and threats to wildlife. Additionally, the socio-economic impact of this issue is substantial, especially in developing countries that suffer economic losses due to flooding.

Such impacts include reduced income, loss of assets, and an exacerbation of the poverty cycle, particularly in Asian regions that experience floods almost annually (Kawasaki, A., & Shimomura, N., 2024). To address the dual challenges of plastic waste and flooding caused by inadequate water infiltration, pervious concrete utilizing plastic waste—particularly Polyethylene Terephthalate (PET)—has emerged as an innovative solution. Previous studies have demonstrated that plastic waste such as High-Density Polyethylene (HDPE), Low-Density Polyethylene (LDPE), and PET can be used as construction materials, including in concrete and paving blocks, in proportions of up to 30% (1,5,10–12).

In this study, the concrete is designed with a high-porosity structure that enables rainwater to seep into the ground, thereby reducing the risk of surface runoff and flooding. Plastic waste is used as coarse aggregate in the concrete mix, resulting in good porosity and permeability, while maintaining compressive strength within acceptable standards. The production process generally involves melting and molding the plastic waste into gravel-like particles, mixing with cement, and casting into concrete forms. This approach not only reduces plastic pollution in the environment but also contributes to improved water management, making pervious concrete a sustainable solution to both environmental and urbanization challenges.

2. METHODOLOGY

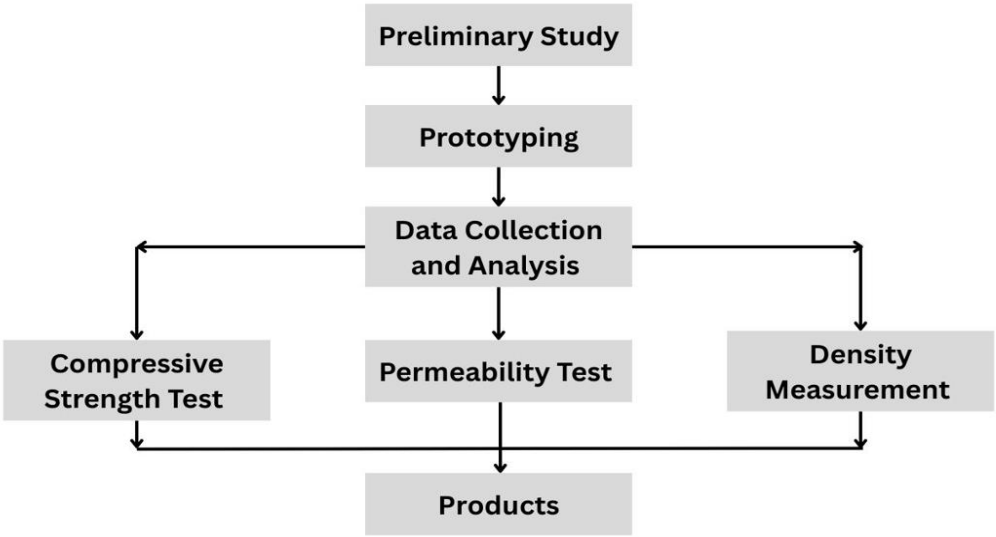

Figure 1. Flowchart Penelitian

3. FINDINGS

This study serves as an argument to assess the feasibility of replacing conventional aggregates with plastic aggregates in pervious concrete. It employs four variations of PET plastic waste content in the concrete mix, with substitution levels of 10%, 20%, 30%, 40%, and 50%. The objective is to produce concrete of equivalent quality to Class II (compressive strength of 16–24 MPa), in accordance with standards for precast drainage channels.

The mix proportion calculations in this research are based on the Indonesian National Standard (SNI) 2834:2000, to ensure methodological accuracy and compliance with national guidelines. The test specimens used are concrete beams with dimensions of 15 × 15 × 60 cm, having a total volume of 0.0135 m^3. Compressive strength tests were conducted for each mixture variation to obtain representative values. The compressive strength test results for each variation are presented in Table 1, which indicates that the average compressive strength of the concrete decreases as the level of LDPE substitution increases.

Table 1.Results of the compressive strength test on the sample

Sample Variation	Compressive strength (MPa)			Average (MPa)
	Sample 1	Sample 2	Sample 3	
Baseline	27,99	24,43	23,51	25,31
Variasi LDPE 10%Variation	12,49	11,92	8,2	10,87
Variasi LDPE 20% Variation	6,75	8,5	7,16	7,47
Variasi LDPE 30% Variation	6,64	7,4	8,1	7,38
Variasi LDPE 40% Variation	9,01	6,12	7,36	7,50
Variasi LDPE 50% Variation	5,26	5,4	5,74	5,47

Based on the data, it is evident that the compressive strength of the specimens after 28 days decreased as the percentage of plastic bag (LDPE) content in the mixture increased. The normal concrete (baseline) exhibited the highest compressive strength, with an average value of 25.31 MPa. However, with the addition of LDPE at substitution levels ranging from 10% to 50%, a significant reduction in compressive strength was observed.

For the concrete mixture with 10% LDPE, the average compressive strength dropped to 10.87 MPa, representing a 57.05% decrease compared to the baseline value. This decline became more pronounced in the 20% LDPE mixture, where the average compressive strength decreased to 7.47 MPa. The downward trend continued in the 30% and 40% variations, with average compressive strengths of 7.38 MPa and 7.50 MPa, respectively. Although there was a slight increase in the 40% mixture compared to the 20% and 30% mixtures, the value remained significantly lower than that of normal concrete.

The most substantial decline occurred in the 50% LDPE variation, with an average compressive strength of only 5.47 MPa, marking the lowest value recorded in this study. Overall, it can be concluded that the higher the percentage of LDPE substitution, the lower the resulting compressive strength of the concrete.

Nevertheless, concrete mixtures containing 10% to 40% LDPE still meet the minimum compressive strength requirements for Class I concrete (non-structural), which is commonly used for blinding layers and light vehicle pavements. Therefore, plastic bags (LDPE) show potential as an alternative coarse aggregate substitute in environmentally friendly concrete mixtures, although the target compressive strength of 24 MPa for structural applications was not achieved.

4. CONCLUSION

This study demonstrates that the use of LDPE plastic waste as a substitute for coarse aggregate in pervious concrete significantly affects the material's compressive strength. The results indicate a clear inverse relationship: as the percentage of LDPE substitution increases, the compressive strength decreases. Normal concrete (without LDPE) recorded the highest compressive strength at 25.31 MPa, while the mixture with 50% LDPE substitution exhibited the lowest value at 5.47 MPa.

Although none of the variations met the target strength range for Class II concrete (16–24 MPa), mixtures containing 10% to 40% LDPE still complied with the standards for Class I concrete, which is suitable for non-structural applications such as blinding layers and light-traffic pavements. Therefore, LDPE plastic waste has potential as an alternative coarse aggregate in environmentally friendly previous concrete, provided it is used in applications that align with its compressive strength capacity.

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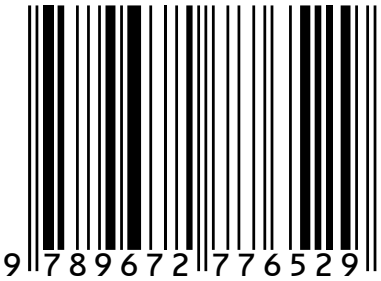

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