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Pemanfaatan Sludge SPAM Terkalsinasi sebagai Supplementary Cementitious Material (SCM) pada Paving Block : Analisis Kelayakan Teknis
Kayla Putri Aulia, Ir. Suprapto Siswosukarto, Ph.D.
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

INTISARI

Sludge Sistem Penyediaan Air Minum (SPAM) merupakan residu hasil pengolahan air yang terus dihasilkan seiring meningkatnya kebutuhan air bersih. Pengelolaan *sludge* yang masih didominasi melalui penimbunan atau pembuangan menyebabkan material tersebut belum termanfaatkan secara optimal, padahal masih mengandung senyawa silika dan alumina yang berpotensi dimanfaatkan sebagai material pozzolan. Pemanfaatan *sludge* SPAM sebagai *supplementary cementitious material* (SCM) tidak hanya memberikan alternatif pengelolaan residu yang lebih bernilai tambah, tetapi juga berpotensi mengurangi penggunaan semen Portland pada material konstruksi.

Penelitian ini bertujuan menganalisis kelayakan teknis *sludge* SPAM terkalsinasi sebagai substitusi parsial semen pada *paving block*. *Sludge* SPAM dikalsinasi pada temperatur 825°C kemudian digunakan sebagai substitusi semen dengan variasi 0%, 5%, 10%, 15%, dan 20% dalam pembuatan benda uji *paving block*. Karakteristik *sludge* SPAM dianalisis menggunakan *X-ray Diffraction* (XRD) dan *Energy Dispersive X-ray Spectroscopy* (EDX). Hasil pengujian menunjukkan bahwa *sludge* SPAM didominasi oleh fase amorf dengan kandungan SiO_2 sebesar 43,58% dan Al_2O_3 sebesar 13,94%, yang mengindikasikan potensi reaktivitas pozzolan sebagai SCM. Kinerja teknis *paving block* kemudian dievaluasi melalui pengujian kuat tekan, ketahanan aus, dan daya serap air sesuai SNI 03-0691-1996.

Hasil pengujian teknis menunjukkan bahwa variasi substitusi *sludge* SPAM memberikan pengaruh terhadap seluruh parameter yang diuji. variasi 10% menghasilkan performa optimum dengan kuat tekan 25,0 MPa, ketahanan aus 0,112 mm/menit, dan daya serap air 5,83%, yang seluruhnya memenuhi mutu B berdasarkan SNI 03-0691-1996. Berdasarkan hasil tersebut, *sludge* SPAM terkalsinasi layak dimanfaatkan sebagai *supplementary cementitious material* (SCM) dengan kadar substitusi optimum sebesar 10% sebagai pengganti parsial semen pada *paving block*.

Kata kunci: *sludge* SPAM, kalsinasi, *supplementary cementitious material*, *paving block*, kelayakan teknis.

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ABSTRACT

Drinking Water Treatment Sludge (DWTS) is a residual by-product generated during drinking water treatment, the quantity of which continues to increase with the growing demand for clean water. The conventional management of DWTS through landfilling or disposal not only increases waste management burdens but also leaves its silica- and alumina-rich composition largely underutilized. Converting DWTS into a supplementary cementitious material (SCM) through thermal activation provides a promising approach to valorize this waste while reducing the consumption of Portland cement in construction materials.

This study aimed to evaluate the technical feasibility of calcined DWTS as a partial cement replacement in paving blocks. DWTS was calcined at 825°C before being incorporated into paving block mixtures at replacement levels of 0%, 5%, 10%, 15%, and 20% by cement weight. The mineralogical and chemical characteristics of the calcined DWTS were characterized using X-ray Diffraction (XRD) and Energy Dispersive X-ray Spectroscopy (EDX). The characterization results revealed that the calcined DWTS was dominated by an amorphous phase with 43.58% SiO_2 and 13.94% Al_2O_3, indicating a high pozzolanic reactivity and its suitability as an SCM. The technical performance of the paving blocks was subsequently evaluated through compressive strength, abrasion resistance, and water absorption tests in accordance with SNI 03-0691-1996.

The results demonstrated that the incorporation of calcined DWTS significantly influenced all evaluated technical properties. The 10% replacement level exhibited the optimum performance, achieving a compressive strength of 25.0 MPa, an abrasion value of 0.112 mm/min, and a water absorption of 5.83%, all satisfying the requirements for Grade B specified in SNI 03-0691-1996. These findings demonstrate that calcined DWTS is technically feasible as a supplementary cementitious material (SCM), with an optimum replacement level of 10% as a partial cement substitute in paving block production.

Keywords: Drinking Water Treatment Sludge (DWTS); calcination; supplementary cementitious material; paving block; technical feasibility.

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