Construction of an automatic flushing system for retention tanks in urban stormwater drainage systems using sluice gate devices

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Introduction

The discharge of rainwater through sewer systems, particularly during intense, short-term events, often overloads the system, leading to flooding. Climate change exacerbates these issues, increasing the frequency and intensity of such events. Retention tanks are critical for managing rainwater in urban drainage systems, reducing flood risk, enabling water reuse (e.g., for irrigation), and providing mechanical pretreatment by removing suspended solids. This study presents an autonomous flushing system for retention tanks using sluice gate devices, which leverages the stored energy of the water column to flush sedimentary contaminants efficiently.

System Features:

- Automated flushing via sluice gates with pneumatic drives and liquid level sensors
- Low energy consumption: approximately 0.05 kWh per flushing cycle
- Simple configuration with channel sluice gates, reducing failure risk and maintenance needs
- Cost-effective operation with readily available spare parts
- High efficiency in removing accumulated sediments

Figure 1: Physical model of the retention tank with installed sluice gates and control panel

Technological Tests

Rainwater contains variable concentrations of suspended solids, making it challenging to define a standard granular composition for testing. After reviewing literature, a substrate mimicking typical sludge was prepared (see Fig. 1). The substrate was spread over a 46 m^2 area per tank track (length 17 m, width 2.91 m, thickness 0.015 m), with 750 kg per track (1500 kg total). Tests evaluated flushing efficiency under different conditions:

- Three sluice gates per tank track
- Configurations with and without separating walls
- Water levels: Tmax = 2.4 m, Tmin = 1.5 m
- Gate openings: a = 0.1 m, a = 0.2 m

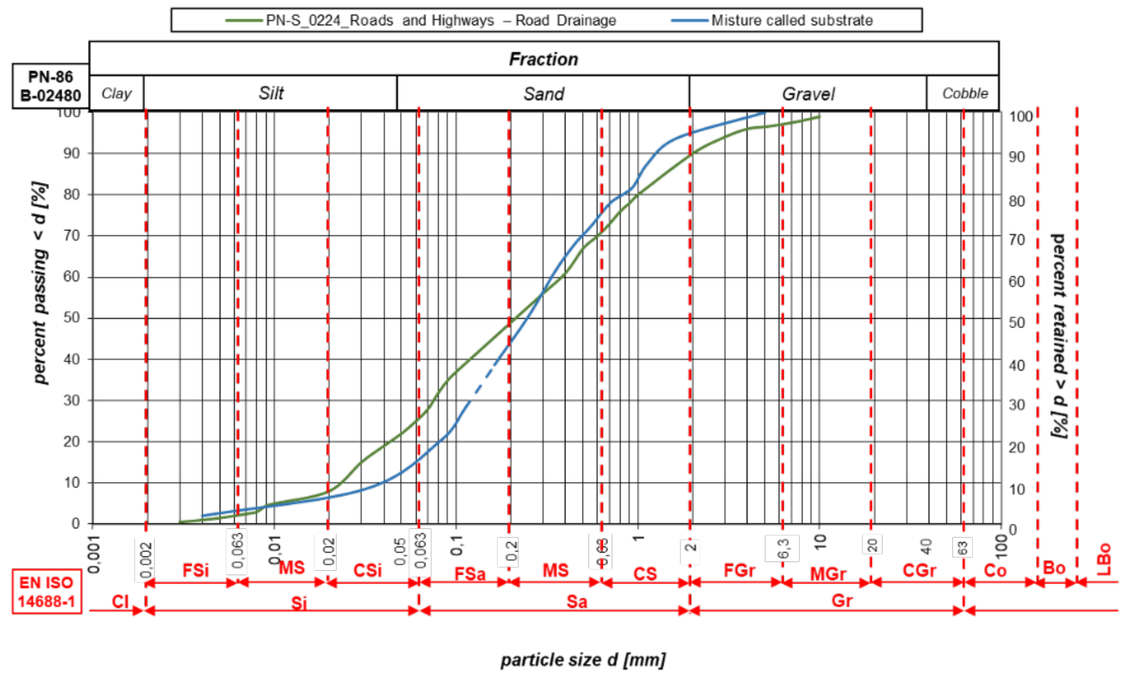

Figure 2: Grain size distribution curve for the substrate used in testing

Test Results

Tests demonstrated the flushing system's effectiveness (see Fig. 3). The substrate was fully flushed at T = 2.4 m with a gate opening of a = 0.2 m, achieving 100% efficiency. Efficiency was calculated by comparing the initial substrate mass (1500 kg) to the remaining mass after flushing (see Table 1).

Table 1: Flushing wave efficiency for substrate removal (1500 kg per test, without walls)

Lp.	Flow q (m^3/ms)	Water level T (m)	Gate opening a (m)	Substrate mass M_s (kg)	Efficiency EF (%)
1	0.79	2.4	0.2	16.59	99
2	0.41	2.4	0.1	219.51	85
3	0.62	1.5	0.2	599.05	60
4	0.32	1.5	0.1	755.12	50

Figure 3: Flushing process at T = 2.4 m, a = 0.2 m, showing 100% substrate removal

Summary

The flushing system achieved high efficiency, with optimal performance at T = 2.4 m and a = 0.2 m, removing 99% of the substrate. The water column height significantly influences gravitational flushing effectiveness. Using three sluice gates per tank track proved effective. The system's low energy use, simple design, and cost-effectiveness make it a practical solution for retention tank maintenance in urban stormwater systems.

Benefits:

- Higher water levels improve flushing efficiency
- Gate opening of 0.2 m is optimal
- Three sluice gates per track are sufficient
- System is energy-efficient and easy to maintain

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