Road and Environmental SAFEty related to water - pavement interactions

WP2 –
Experimental work for calibration and validation of REST

Deliverable 2.2

Field test report

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Lead Contributor	Filip Stanić, Vladan Ilić, Aleksandar Đukić
Other Contributors	Miloš Stanić, Anja Ranđelović, Sanja Fric
Reviewers	Goran Mladenović, Nenad Jacimovic

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2 Executive Summary

This report forms part of Work Package 2 of the RESAFE project and presents the laboratory testing of porous asphalt alongside field experiments designed to calibrate and validate the REST hydraulic and transport model on existing road infrastructure.

These experimental investigations were executed at two different scales, consisting of a smaller pilot scale on the University of Belgrade Faculty of Civil Engineering (GRFUB) parking lot and a larger real road network scale in Belgrade. At the pilot scale, a specialized experimental polygon measuring eight meters in length and just over half a meter in width was constructed with a five-centimetre thick porous asphalt layer overlying conventional impervious asphalt. During testing campaigns under simulated rainfall intensities ranging from 2 to 5 mm/min per minute, the porous asphalt reached saturation within minutes and initiated surface runoff. The observed runoff coefficient, which reached between 0.95 and 0.97 when combining surface and subsurface runoffs, confirmed that while the porous asphalt has poor water retention capacity, it is highly efficient at mitigating surface water film depth by rapidly evacuating water through its subsurface. To accurately quantify this total outflow, a siphon overflow system in the downstream collection reservoir was monitored using hydrostatic pressure sensors, yielding a calibrated siphon discharge coefficient of 0.395.

At the real road network scale, a pilot campaign was conducted using a vehicle-mounted mobile optical road sensor paired with a smartphone GPS to map forty-two point eight kilometres of the Belgrade road network during a summer rain event. The mobile sensing setup successfully georeferenced 95.8 % of the collected data and demonstrated clear wet-hazard detection capabilities, flagging localized lane flooding with water-film depth readings exceeding 1 mm at driving speed. However, the campaign also exposed critical physical and data boundaries of the optical sensor. Specifically, the optical sensor under-reads deep standing water, reporting only about 0.9 mm over a puddle deeper than 6 mm because it only senses the top film. It also exhibited hard-clipping at 6 mm during heavy rain. Additionally, because the positioning uncertainty of 4 to 8 meters cannot resolve exact driving lanes, video-derived dashcam tracks are required for precise lane-level attribution.

A portion of the originally planned chemical and environmental investigations had to be rescheduled due to economic shifts. Following a market assessment showing that laboratory unit costs for analysing heavy metals, PAHs, and other specific pollutants had increased by more than 80% since 2022, the testing program was restructured. The total number of analysed water and solid samples was optimized from 50 down to 36, and the planned operational road section investigation in Serbia was replaced by intensified field testing at the representative, traffic-exposed faculty parking lot. Due to these budget revisions and associated time constraints, the chemical analyses for the leaching and rapid clogging tests have been postponed to the period of July through September 2026, with the subsequent findings to be published in a standalone supplementary report.

Ultimately, the current field dataset provides a strong empirical foundation for calibration of the REST model on more realistic data, besides the experimental data obtained in the laboratory that have been already used for the model calibration in the initial stage. The future work will also focus on integrating the postponed chemical data and refining sensor interpretations to account for known measurement boundaries.

3 Introduction

This report forms part of Work Package 2 (WP2) of the RESAFE project and presents the experimental work related to laboratory testing of porous asphalt and field experiments conducted for the calibration and validation of the REST model on existing road infrastructure.

The experiments were carried out in the laboratories of GRFUB that participated in the hydraulic modelling activities within the project. The GRFUB Pavement Laboratory provided the necessary instrumentation and testing equipment for the characterization of various porous asphalt mixtures. In addition, optical road sensor logged surface condition by using a road-weather sensing for characterization of road-surface condition at network scale was performed as well.

3.1 Main objectives

The main objectives of this report can be summarized as follows:

- Provision of dataset for REST Model Calibration and Validation: To present the laboratory testing of porous asphalt and field experiments designed to calibrate and validate the REST model on existing road infrastructure.
- Quantifying Pavement Degradation: To focus on measuring and quantifying changes in the hydraulic and transport properties of porous pavement over time due to particulate clogging and structural changes from pollutant accumulation.

3.2 Scope and limitations

This report primarily focuses on testing hydraulic performance of porous asphalt under laboratory and field conditions and characterization of road-surface condition at network scale.

Initial plan was to analyse and quantify changes in the hydraulic and transport properties of porous pavement over time due to clogging by particulate matter and structural changes caused by pollutant accumulation, as well as quality of water that percolates or flows over the asphalt surface. The laboratory programme includes leaching tests, controlled cyclic clogging tests, and analyses of bulk water and solid samples collected from the field installation established on the parking area of the Faculty of Civil Engineering, University of Belgrade (GRFUB).

External accredited laboratories were planned to be contracted for advanced chemical analyses of water and solid samples collected during the experimental programme, including analyses of polycyclic aromatic hydrocarbons (PAHs), heavy metals, and selected specific pollutants. The original project proposal and budget were prepared based on market prices available in 2022, during the project proposal preparation phase. The initial testing plan included the analysis of a total of 50 bulk water and solid samples collected from porous asphalt systems, distributed approximately as follows: 40% of the samples from laboratory asphalt experiments, 10% from field tests conducted at the Faculty of Civil Engineering premises, and 40% from a field investigation on an operational road section in Serbia.

Following a market assessment conducted during the first half of 2026, it was established that the unit costs of laboratory analyses for heavy metals, PAHs, and specific pollutants had increased significantly (by more than 80%). Consequently, the testing programme and the engagement of an external accredited

laboratory had to be revised.

Under the revised experimental programme, the scope of chemical analyses performed on each individual sample remains unchanged; however, the total number of analysed samples has been reduced from the originally planned 50 to 36. One of the principal reasons for this reduction is that, due to various practical circumstances, the planned investigation on an operational road section in Serbia was cancelled. Instead, the project team intensified field investigations on the internal roadway and parking area of the Faculty of Civil Engineering, which was paved with porous asphalt as part of the RESAFE project implementation. These field experiments were assessed as being representative of real traffic conditions, since the paved area is subject to regular daily vehicular traffic.

Furthermore, to ensure controlled testing conditions, an artificial rainfall system was designed and constructed within the project for use on the porous asphalt test section. This installation enables the experimental programme to be conducted independently of natural weather conditions while allowing precise control of rainfall intensity and inflow volumes during testing, thus providing conditions for comprehensive testing.

The revised total of 36 samples represents an optimized number of samples for laboratory testing of porous asphalt specimens (including leaching tests and clogging tests) and field investigations carried out on the porous asphalt pavement of the Faculty's internal roadway and parking area. It is planned that approx. 50% of the analysed samples will originate from laboratory experiments, while the remaining approx. 50% will be collected during field investigations.

Due to time constraints and the need to await approval of the project budget revision, the chemical analyses of the bulk water and solid samples had not yet been carried out at the time of preparation of this report. These analyses are scheduled for the period July–September 2026, and the corresponding results will be presented in a separate report.