MULTI-LAYER RECYCLED CONCRETE SOLUTIONS FOR URBAN CYCLING INFRASTRUCTURE

Alessandro P. Fantilli[1], **Daria Jóźwiak-Niedźwiedzka**[2]

[1] *DISEG, Politecnico di Torino, Corso Duca degli Abruzzi 24, 10129 Torino, Italy*
[2] *Institute of Fundamental Technological Research, Polish Academy of Sciences, Pawińskiego 5b, 02-106 Warsaw, Poland*

Corresponding author: alessandro.fantilli@polito.it, djozwiak@ippt.pan.pl

The transition towards climate-neutral and circular cities requires a profound transformation of construction materials, particularly concrete, which remains the most widely used construction material worldwide. Conventional concrete production is associated with high consumption of natural resources and significant CO_2 emissions, mainly due to cement manufacturing and the extraction of virgin aggregates. In response to these challenges, the European research and innovation project SMILE CITY (Sustainable Materials for Innovative, Low Emissions applications in the Circular CITY) proposes integrated solutions based on the extensive use of recycled materials in urban infrastructure, with a strong focus on concrete-based applications.

The project demonstrates that circular concrete solutions can be effectively implemented in large-scale urban infrastructure, including prefabricated elements for cycling and urban mobility systems. This contribution focuses on recycled concrete solutions developed within SMILE CITY, highlighting material strategies and preliminary performance outcomes.

In the first phase of the project, tailored concrete mix designs incorporating recycled concrete aggregates, recycled rubber particles, and recycled steel fibres from end-of-life tyres were developed in compliance with structural and exposure class requirements for urban environments. Two types of cement were used Portland limestone cement CEM II/A-LL 52.5 R and blast furnace cement CEM III/A 42.5 N. Natural aggregates included quartz sand (0–2 mm), granite sand (0–4 mm), and coarse gravel (4–14 mm), as aggregates were used. Recycled constituents comprised recycled concrete aggregates (RCA 0–4 mm), recycled steel fibres (Flexofiber FX-20), and recycled rubber particles (0–8 mm). A superplasticizer was used to ensure adequate workability. Concrete mixtures were produced from recycled steel fibres and with partial replacement of natural aggregates with RCA or rubber particles.

Mechanical performance was assessed through uniaxial compression tests, providing compressive strength, elastic modulus, and fracture toughness, as well as three-point bending tests to determine flexural strength and residual postcracking behaviour. Durability-related properties included carbonation resistance, gas permeability (air permeability using the Torrent method and nitrogen permeability using the Cembureau method), and water absorption. Microstructural characterization was performed using optical microscopy, scanning electron microscopy (SEM), and mercury intrusion porosimetry (MIP).

The results confirm that high levels of recycled content can be achieved without compromising mechanical performance or durability-related properties, supporting the feasibility of recycled-based concretes for urban cycling infrastructure.

In the next stage of the project, concrete mixes will be produced with partial replacement of natural aggregates by recycled plastic pellets, and the performance of reinforcement made of plastic bars in glass fiber reinforced polymer (GFRP) elements will be investigated.

Keywords: recycled materials, end-of-life tiers, rubber, fibres, concrete

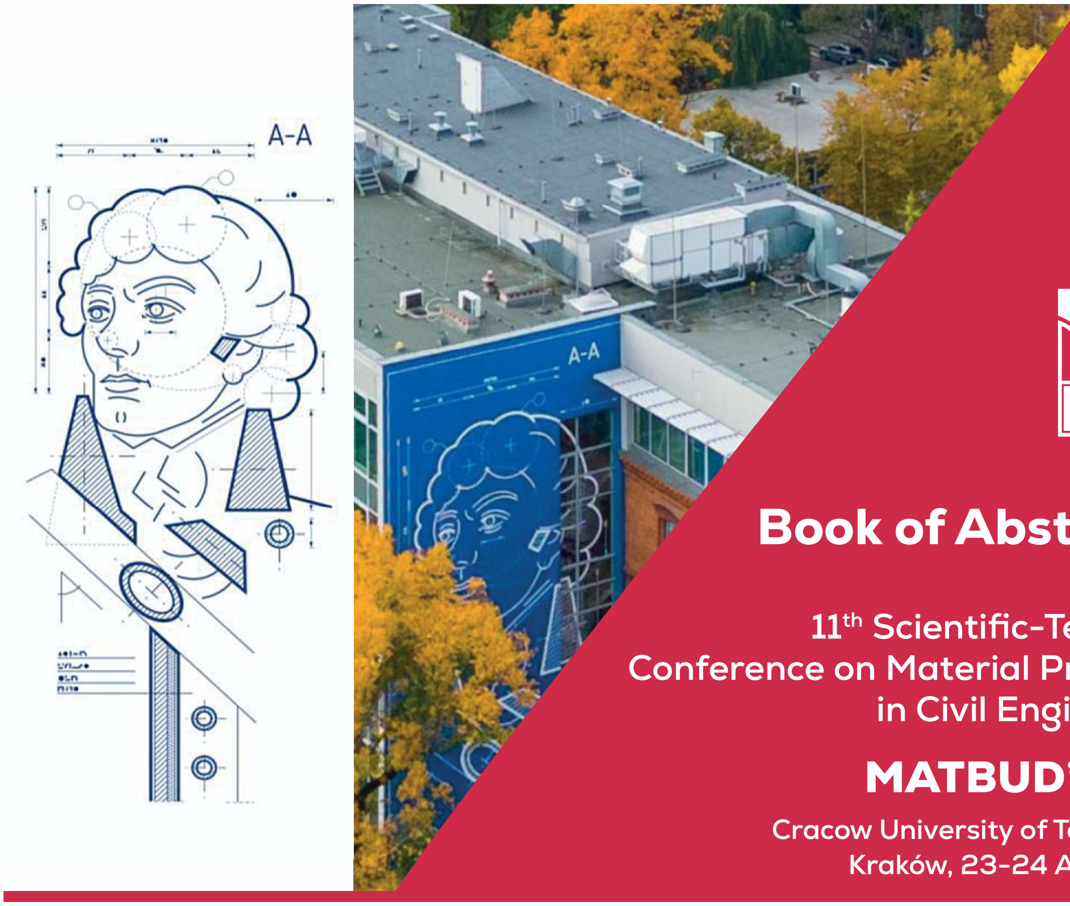
References:

[1] J. Nilimaa, (2023). Smart materials and technologies for sustainable concrete construction, Dev Built Environ, 15, 100177.

[2] UNEP. (2022). Global Status Report for Buildings and Construction: Towards a Zero-Emissions, Efficient and Resilient Buildings and Const. Sector.

Acknowledgments

The research presented in this article was funded by the European Commission under the HORIZON EUROPE project entitled "SMILE CITY-Sustainable materials for innovative low-emission applications in a circular city", GA 101135406.



Book of Abstracts

11th Scientific-Technical Conference on Material Problems in Civil Engineering

MATBUD'2026

Cracow University of Technology
Kraków, 23-24 April 2026

Izabela Hager and Elżbieta Stanaszek-Tomal
Editors

MATBUD'2026

Organized and supported by:

Cracow University of Technology

Nantes Université

Book of Abstracts

11th Scientific-Technical Conference on Material Problems in Civil Engineering MATBUD'2026

Kraków, 23-24 April 2026

Izabela Hager and Elżbieta Stanaszek-Tomal
Editors

TYPESETTING
Małgorzata Murat-Drożyńska

ISBN 978-83-68481-18-1

Wydawnictwo PK, ul. Skarżyńskiego 1, 31-866 Kraków; tel. 12 628 37 25
e-mail: wydawnictwo@pk.edu.pl ▢ www.wydawnictwo.pk.edu.pl
Postal address: ul. Warszawska 24, 31-155 Kraków

Printed and bound at the Polygraphy Department of the Cracow University of Technology

Order no. 70/2026 Printed in 130 copies