

Highway Acoustic Panel - Herzebrock-Clarholz

Resource-Optimized Textile Reinforced Concrete (TRC) Noise Barrier

Executive Summary:

This project developed a resource-efficient precast highway noise barrier element using HITEX non-metallic carbon textile reinforcement to significantly reduce material consumption while maintaining structural performance under wind and traffic-induced loading.

Conventional reinforced concrete noise barriers are durable but material-intensive and susceptible to long-term corrosion. The optimized TRC solution replaces steel reinforcement with carbon textiles and adopts a load-bearing T-shaped cross-section, enabling substantial reductions in concrete volume and embodied carbon.

Full-scale structural validation at TU Dortmund confirmed the feasibility of the concept. The developed element reduced concrete volume to 34% of a comparable steel-reinforced element, while cement-related CO₂ emissions were reduced to 58% of the conventional solution .

The project demonstrates the structural, environmental, and industrial scalability potential of carbon textile reinforced concrete in transport infrastructure.

Project Background

Context

Highway noise barriers are exposed to significant environmental and mechanical actions, including wind pressure, suction, vehicle-induced aerodynamic effects, temperature gradients, and long-term durability demands.

Traditional steel-reinforced concrete systems require substantial concrete cover to protect against corrosion, increasing element thickness and material consumption.

To address sustainability objectives and improve material efficiency, a collaborative research initiative between industry and academia developed a thin-section textile reinforced concrete (TRC) acoustic panel optimized for prefabrication and structural efficiency.

The development and structural behavior were documented in a peer-reviewed publication (Beton- und Stahlbetonbau, 2021, DOI: 10.1002/best.202100061)

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Location

Development and validation were carried out in Germany:

- Precast production partner: EUDUR-Bau GmbH, Herzebrock-Clarholz
- Full-scale testing: Technische Universität Dortmund, Structural Engineering Laboratories

Scope and Objectives

Scope:

- Structural optimization of a precast noise barrier wall element
- Integration of HTC variant of **Hitexbau** carbon textile reinforcement
- Development of an efficient T-shaped cross-section
- Large-scale load testing (4.85 m span)
- Evaluation of material and CO₂ reduction performance

Objectives:

- Minimize concrete volume
- Eliminate steel reinforcement and corrosion risk
- Maintain structural capacity under wind loading
- Enable scalable industrial prefabrication
- Reduce embodied CO₂ emissions

Methods and Materials

1. Structural Strengthening Concept

The optimized acoustic panel uses a T-shaped load-bearing cross-section to increase bending efficiency while minimizing material use.

Key geometric parameters :

- Plate thickness: 20 mm
- Web width: 50 mm
- Element height: 1.50 m
- Test span: 4.85 m

The thin TRC plate acts as the primary bending flange, while the web provides shear transfer and stiffness.

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The governing design actions for the panel include:

- Self-weight
- Wind pressure and suction
- Traffic-induced aerodynamic loads

Wind action is typically the governing load case for highway installations.

2. Materials

The reinforcement system combines textile and non-metallic bar reinforcement:

- Primary textile reinforcement: HITEXBAU HTC 20/50-80-T
- Shear textile reinforcement: HITEXBAU HTC 50/50-80
- Supplementary reinforcement: Ø 12 mm GFRP bars

The non-metallic reinforcement system allows:

- Reduced concrete cover
- Improved crack width control
- Corrosion-free durability
- Long-term resistance in exposed infrastructure environments

3. Experimental Validation

Full-scale bending tests were performed on elements with a span of 4.85 m .

The experimental program validated:

- Ultimate load-bearing capacity
- Crack development behavior
- Stiffness and deformation performance
- Suitability for prefabricated production

The results confirmed that structural performance comparable to conventional steel-reinforced elements can be achieved with significantly reduced material use.

Execution

The development process followed a structured workflow:

1. Structural analysis and cross-section optimization
2. Prototype fabrication in precast facility
3. Integration of **HITEXBAU** carbon textiles and GFRP bars
4. Controlled casting of thin TRC sections
5. Full-scale structural load testing
6. Performance evaluation and design refinement

The focus was on balancing mechanical performance, manufacturability, and sustainability.

Challenges and Solutions

Material Efficiency

Challenge: Reduce material consumption while maintaining structural integrity.

Solution: T-shaped geometry combined with high-performance carbon textiles.

Corrosion Elimination

Challenge: Avoid long-term deterioration due to steel corrosion.

Solution: Fully non-metallic reinforcement system (carbon textiles + GFRP).

Structural Verification

Challenge: Demonstrate full-scale performance equivalence.

Solution: 4.85 m span bending tests under laboratory conditions.

Industrial Scalability

Challenge: Ensure compatibility with existing precast production processes.

Solution: Prototype fabrication and iterative design adaptation.

Outcomes

Material Reduction

- Concrete volume reduced to 34% of a comparable steel-reinforced concrete element
- Cement-related CO₂ emissions reduced to 58% of conventional solution

Structural Performance

- Validated load-bearing capacity under bending
- Controlled crack development
- High stiffness-to-weight efficiency

Sustainability Impact

The TRC acoustic panel demonstrates that carbon textile reinforcement can significantly reduce embodied carbon in transport infrastructure without compromising structural performance.

Conclusion

The development of this resource-optimized TRC highway acoustic panel confirms the technical and environmental advantages of replacing steel reinforcement with **HITEXBAU** carbon textiles in precast infrastructure elements.

By combining:

- A structurally efficient T-shaped cross-section
- Thin 20 mm TRC plate sections
- Non-metallic reinforcement
- Industrial prefabrication

the project achieved substantial reductions in concrete volume and CO₂ emissions while maintaining mechanical reliability.

This case establishes textile reinforced concrete as a scalable, corrosion-free alternative for next-generation highway noise barrier systems.

