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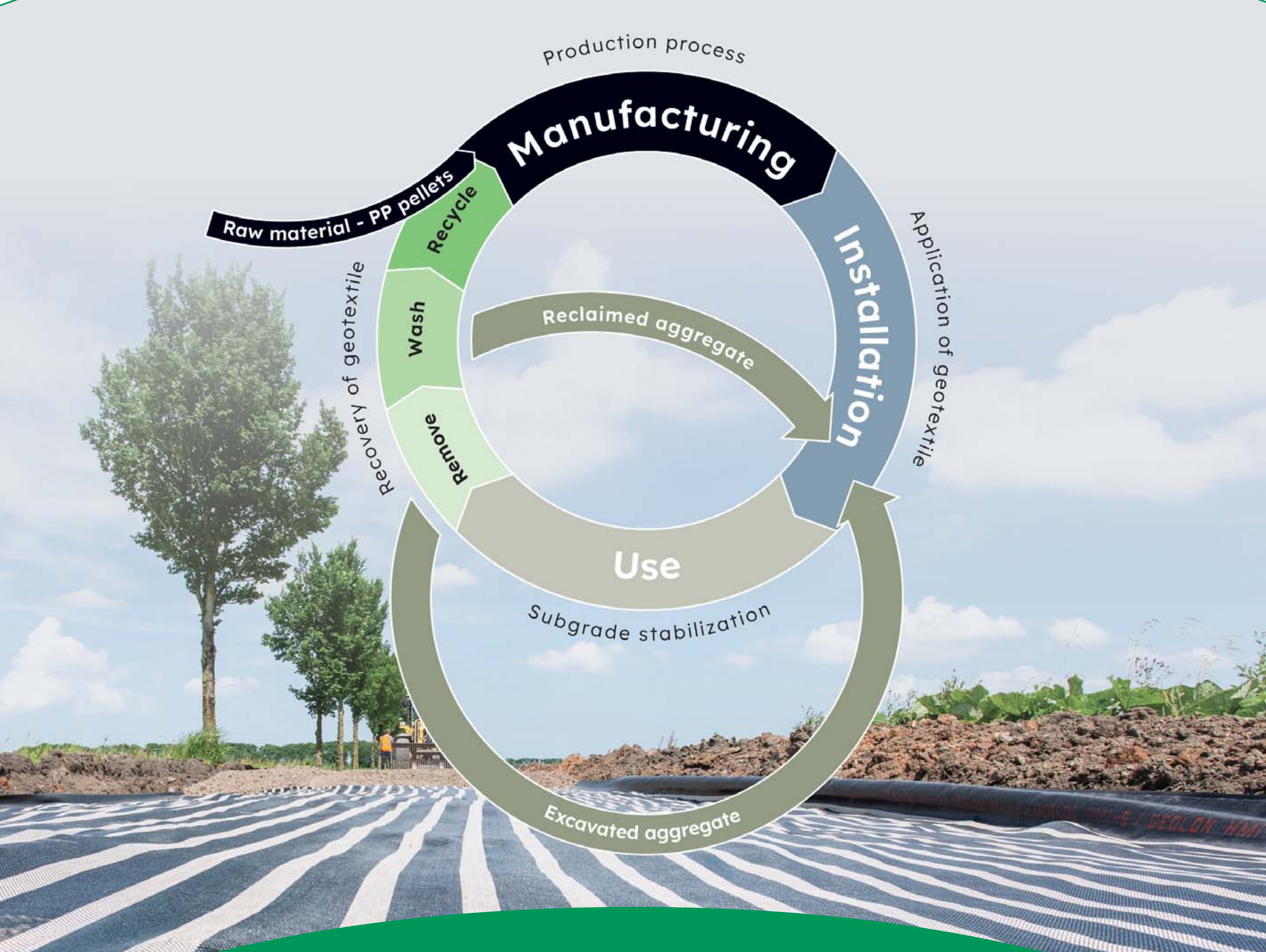

FROM WASTE TO RESOURCE: SCALING CIRCULAR GEOTEXTILE RECYCLING IN INFRASTRUCTURE

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PREFACE

Dear GEObuild readers,

Stimulating the use of sustainable materials and solutions in the construction sector is a priority. This topic is playing an increasingly important role across Europe, especially in the Netherlands. For NGO-IGS Netherlands, sustainability is a key focus area. Applications using geotextiles as high-quality geo-building materials can make a significant positive contribution to the civil engineering sector's sustainability goals, such as reducing CO_2 emissions compared to traditional building techniques.

Geo-building materials are essential for the development of circular infrastructure, as they enable construction projects to be dismantlable, allowing aggregates and other resources to be efficiently recovered and reused. A longstanding challenge, however, has been how to manage geotextiles at the end of their life. To minimize environmental impact, we must shift from the linear use of materials to a truly circular approach.
For the civil engineering sector, achieving greater sustainability and closing the loop for all building materials is a major challenge. This means that after their usage phase, materials should be decomposed and reintroduced into the production chain for the creation of new geo-building products. Although this sounds straightforward, when it comes to geotextiles it is particularly challenging. Several research initiatives on this topic are currently underway in Europe.

In relation to sustainability and circularity, this edition of GEObuild features a very interesting article by Gijs Groen, titled *"From Waste to Resource: Scaling Circular Geotextile Recycling in Infrastructure."* The article discusses the challenges of proper geotextile removal from sites, material separation and incoming material checks, shredding, washing, and upgrading to re-granulated

PP material, which can be reused for geotextile production. Beyond the technical hurdles, it also highlights that collaboration across the entire value chain is crucial. A key milestone has already been achieved: the successful recycling of 500,000 m² of geotextiles as part of sustainable infrastructure projects. This achievement illustrates how innovation and cooperation can transform complex waste streams into valuable new resources.

Now, it is time to take the next steps to upscale the circular use of high-quality geo-building materials as part of a sustainable future. Who will take up the challenge?

Do you have an exciting (international) project or research topic on geo-building materials that you would like to share? Please send an email to events@ngo.nl to spotlight your project or topic. NGO-IGS Netherlands will be happy to facilitate this.

We hope you enjoy this edition and find it inspiring.
Be smart. Be sustainable.

Rijk Gerritsen *Editor-in-chief GEObuild*

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Gijs Groen
Sustainability Manager EMEA at Solmax

FROM WASTE TO RESOURCE: SCALING CIRCULAR GEOTEXTILE RECYCLING IN INFRASTRUCTURE

Building a circular infrastructure

Across Europe, the construction sector is undergoing a significant transformation driven by stringent climate objectives and increasing demands for material efficiency. Engineers, project owners and contractors are being challenged to construct high-performance infrastructure and focus on full life cycle materials management. These developments reflect the broader shift towards a circular economy, which aims to replace the traditional 'take-make-waste' model with strategies based on reuse, regeneration and closed material loops (Geissdoerfer et al., 2017). While considerable progress has been made in reusing bulk materials such as concrete, steel and asphalt, geosynthetics remain a relatively untapped resource within this emerging paradigm.

Geosynthetics – used for filtration, separation, reinforcement, stabilization and drainage – are critical to infrastructure durability and performance. Their technical benefits are well established: improved bearing capacity, reduced deformation and longer service life. Yet at the end of their functional period, these products are typically incinerated or dumped in landfill sites due to the absence of recycling pathways and a lack of supporting infrastructure.

This situation is beginning to shift. In the Netherlands, a landmark initiative successfully demonstrated the closed-loop recycling of 500.000 m^2 of geotextiles, recovering all installed geotextile from various projects where the geotextile manufacturer Solmax originally supplied all materials. The manufacturer reintroduced the recycled geotextile into its production chain. Initially deployed in temporary construction roads for a high-voltage grid upgrade by TenneT – the national electrical transmission system operator – these materials were recovered, processed, and reintroduced into production via an integrated ecosystem of contractors, manufacturers, and recycling specialists. The project overcame significant technical, logistical and cost-related barriers. Moving towards sustainability involves shifting geosynthetics in temporary projects away from the linear 'take-make-waste' model and towards circular solutions where materials are reprocessed and reintroduced.

Project description

The project site, situated in the northern provinces of the Netherlands, involved construction activities on soft, clay-rich agricultural soils. These subsoils present bearing capacity challenges when subject to heavy construction traffic. To mitigate settlement and rutting, the engineering design incorporated high-modulus woven geotextiles, which offered substantial structural benefits for the temporary access roads.

The selected geotextile MIRAFI® HMi was engineered to reduce the granular subbase thickness. In this case a reduction of 50% compared to a layer without a reinforcing geotextile, resulting in lower sand transport volumes and associated CO_2 emissions. Its distinct woven strips made it visually identifiable, aiding both installation accuracy and material traceability during dismantling. The geotextile is suitable for recycling as it can be dismantled and handled in a controlled manner, and it consists of only one polymer, making it more suitable for recycling. When a product consists of two or more types of polymers that cannot be separated easily from each other, recycling is nearly impossible.

In line with circular construction principles, the contractor consortium SWITCH (Strukton, Mobilis, and Oosterhof Holman) reused all temporary sand, concrete slabs and steel plates of the temporary access roads, and recycled steel and concrete from decommissioned pylons. However, the geotextile remained the only major material stream without a clear end-of-life pathway. Addressing this gap required the creation of a new dedicated recycling process.

Closing the loop

Driven by TenneT's sustainability ambitions, the contractor consortium collaborated with the geotextile manufacturer and a regional recycling partner to develop and trial a recovery pathway. Geotextile removal followed conventional procedures but with stricter on-site sorting to prevent

Figure 1 – Example structure of a temporary construction road using a geotextile.

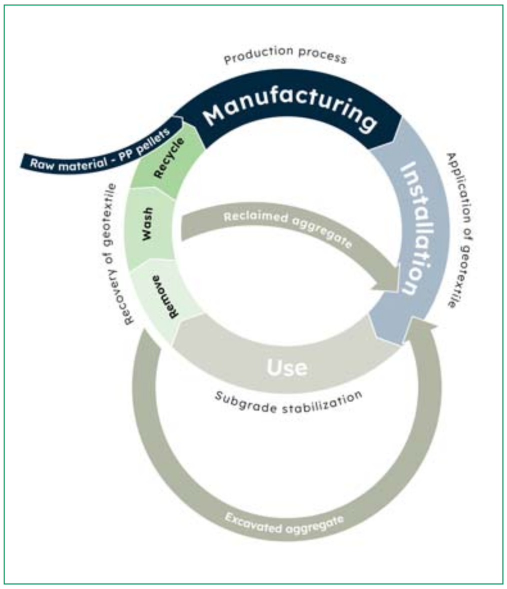

Figure 2 – Closed-loop system for recycling geotextiles and reusing aggregates for an access road.

SUMMARY

Across Europe, the push for more sustainable infrastructure is gaining momentum, yet geosynthetics have often been overlooked in circular economy strategies. This article highlights a ground breaking initiative in which the project owner, contractors, and manufacturer set out to recycle all geotextiles from a major infrastructure project — a goal that was successfully achieved.

In total, 500.000 m² of geotextile were recovered from different projects and transformed from a challenging waste stream into a valuable raw material, demonstrating the potential for circular solutions in geotechnical applications. The project proves geotextile recycling to be feasible and scalable through collaboration along the value chain.

Figure 3 – Removal of a temporary construction road.

Figure 4 – Stockpile of geotextiles after removal.

contamination from wood, PVC, and other non-recyclables.

The recycling process involves five critical stages:
1. Removal: The contractor dismantles the temporary access road following standard procedures. This involves first removing the aggregate layer placed on top of the geotextile and then extracting the geotextile itself – either in large sections or smaller pieces, depending on the site conditions. The contractor must ensure no other materials, such as PVC pipes or wooden pickets, are mixed into the geotextile pile to preserve the purity of the waste stream for recycling.

2. Storage and preparation: Once removed, the geotextile is delivered to a waste management facility. Upon delivery, the contractor receives a designated waste stream number as formal confirmation that the material has been properly registered and accepted. The facility then stores the material and prepares it – for example, removing large chunks of attached clay – to ensure it can be efficiently handled by the recycling facility.

3. Shredding: At the recycling facility, the geotextile is then shredded into smaller pieces using specialized equipment. This step presents notable challenges due to the geotextile's high tensile strength and the heavy soil contamination embedded in the fibres. Long lengths of material can entangle the shredder's mechanisms, while the abrasive soil content accelerates blade wear. To overcome these issues, the process was optimized using reinforced blades and a controlled, continuous dosing system. This ensures a consistent material flow and prevents overloading, thereby improving reliability and efficiency.

4. Washing: Washing has proven to be the most technically demanding stage, as soil is not only present on the surface but also deeply embedded within the yarns of the geotextile. At the outset of the project, no proven method existed to clean this material effectively. Conventional plastic recycling systems are designed for rigid items like bottles or flexible packaging, which are relatively easy to clean due to their flat surfaces and predictable volumes. These systems are not suitable for geotextiles. The manufacturer, therefore, partnered with a specialist recycling company, Healix, located in the Netherlands, which has experience in handling fibre-based materials with high levels of contamination. Using newly developed cleaning methods and Healix's technical expertise, the geotextile could be cleaned to a satisfactory level. While recycling is now feasible, ongoing efforts by the manufacturer and the recycler aim to further improve the process efficiency and product quality.

5. Reuse: The cleaned fibres are processed into regranulate, which is reintroduced by the geotextile manufacturer into their production chain. As the quality of regranulate is typically lower than that of virgin material, it can only partially replace virgin inputs, depending on the technical requirements of the final product. The main objective is to use the recycled content in new geosynthetics – a goal that has already been successfully realized. In cases where the quality of a batch falls short of the standards for geosynthetic production (which was particularly the case during early-stage recycling trials), the material is instead repurposed into plastic accessories used within the manufacturing process or during transportation. An example could be the production of a plastic core for the geotextile roll, which can be recycled after use. These products are also designed to be recyclable at the end of their life cycle.

Importantly, the separated soil – the attached soil can significantly increase the total weight, sometimes amounting to three or four times the weight of the geotextile itself – was also recovered and reused in other construction projects. This additional material recovery further reinforced the circularity of the process. To reduce environmental impact, the recycling facility operated a closed-loop water system powered by renewable energy, minimizing emissions and water consumption.

Building a collaborative ecosystem for geosynthetic recycling

The successful recycling of geosynthetics requires far more than technical capability, it depends on a well-functioning ecosystem of collaboration. An innovation ecosystem is a structured network of interdependent actors — such as organizations, institutions, and individuals — that align around a common value proposition, jointly create value through collaboration and competition, and are strategically designed in terms of who is involved, how they interact, and what goals they co-create — enabling outcomes that no single actor could achieve alone (Adner, 2017; Talmar et al., 2020).

To develop an ecosystem for recycling — from dismantling to reusing granulate materials — requires the actors to jointly address sustainability issues and facilitate the systemic change with effective solutions. Circularity in construction can be achieved only when all stakeholders along the value chain actively participate and align their efforts. From the earliest design phases to end-of-life processing, stakeholder engagement is critical to creating a closed-loop system.

A structured approach was taken to establish the collaborative framework in this Dutch geotextile recycling initiative. The manufacturer did act as the dominating orchestrator, directed at the strategic role played by one or more actors, who guide, coordinate, and facilitate interactions among ecosystem participants to achieve collective outcomes (Reypens, et al 2021).

The first step involved identifying all relevant stakeholders, including project owners, contractors, material producers, waste handlers, and recycling specialists. Each stakeholder plays a vital role in developing an ecosystem that brings together all the necessary elements for an effective recycling process. This process involves several interdependent steps, from the removal of the material to its handling, and ultimately its recycling. Among these stakeholders, the recycling specialist had the most challenging task, as geotextiles had never been recycled at this scale before. This was largely due to the material's high tensile strength compared to other fibre materials such as fishing nets, and the significant presence of soil contamination, which complicates processing.

Next, a thorough analysis was conducted to understand how each stakeholder influences the recycling process and how their actions impact one another. This made it possible to pinpoint leverage points, determine whom to engage, and define how best to support or encourage their involvement. For example, the contractor requires a designated location to deliver the removed geotextile, as direct delivery to the recycler is not feasible due to limited storage capacity. This led to a partnership with a waste management facility that could temporarily store the material. The waste management facility also pre-screens incoming loads to ensure they consist solely of geotextile, helping to prevent contamination issues during recycling.

Figure 5 – Shredded geotextile material prepared for the washing and recycling process.

Figure 6 – Washing stage of shredded geotextile material to remove embedded soil.

Each stakeholder group contributes to the circular ecosystem, with specific responsibilities and requirements that must be aligned to enable successful recycling and material reuse.
Project owners must be willing to invest in sustainable alternatives and incorporate recycling requirements into their procurement and tendering processes.

Contractors are responsible for following dismantling and handling protocols that ensure materials remain suitable for recycling.
Manufacturers and recycling partners must provide technical expertise, innovate processing technologies, and ensure the reintegration of recycled materials into new products.

By addressing each stakeholder's concerns and demonstrating the long-term benefits of collaboration, the project was able to foster a sense of joint ownership and shared purpose.

This ecosystem approach proved to be a cornerstone of success. It ensured that recycling geosynthetics became not just a one-off initiative, but a replicable and scalable solution that integrates circularity into the heart of infrastructure development. Such collaboration models are critical for embedding circular practices across the construction sector and turning sustainability ambitions into operational reality.

Systemic challenges to scale

The successful recovery of 500.000 m^2 of geotextiles has proven that large-scale recycling is not only feasible but technically sound. Still, barriers remain. Recycling currently remains more expensive than landfilling – depending on the context, costs can be up to 2.5 times higher. However, this typically results in only several thousand euros in additional expenses, which is often negligible within the overall project budget if considered during early planning, as already demonstrated by multiple projects.

This cost gap is primarily driven by three interrelated factors. First, there are significant upfront investments required to develop and implement recycling processes. While these costs can be optimized over time through scaling, they remain a substantial barrier at the initial stage. Second – and most critically – the production of regranulate from recycled geotextiles is currently more expensive than virgin polypropylene due to the complexity of processing, particularly in cleaning and restoring heavily soiled materials. This creates a price-value mismatch, as the market price of recycled content is closely linked to the price of virgin polypropylene. When virgin prices are low, recycled materials become relatively more expensive to produce, yet their market value is also suppressed, as buyers continue to benchmark against the cheaper virgin alternative. In this case, the manufacturer has chosen to absorb part of the pricing gap to ensure the recycler receives a financially viable return, enabling the process to move forward despite market limitations as the price of virgin granulate could increase – whether due to carbon taxation or broader market dynamics – the cost competitiveness of recycled alternatives is then expected to improve significantly.

Third, the environmental and social costs of virgin material production and end-of-life practices such as landfilling or incineration are not yet fully internalized in current pricing structures.

This imbalance places additional pressure on recycling initiatives, particularly in the face of persistently low virgin material prices. In the Netherlands, this has contributed to the financial instability of several recycling facilities, leading to multiple bankruptcies, further exacerbated by delays in the implementation of new recycling regulations that could have strengthened the industry. Addressing these challenges will require targeted subsidies to support recycling infrastructure and mitigate financial risk. In parallel, the introduction of taxation based on environmental and social impact could help level the playing field, accelerating the shift towards circular solutions.

Beyond cost, design choices and tender requirements often fail to prioritize recyclability. To make circularity the norm, material selection, traceability, and modular construction principles must be embedded from the earliest design stages.

Policy support will be also essential. Mandating recycling for materials with proven pathways, offering targeted tax incentives, and adapting procurement criteria to value circularity will help level the playing field. A shift away from lowest-cost evaluation toward whole-life cycle value is essential – using tools such as the Milieu Kosten Indicator (MKI, Environmental Cost Indicator), while also integrating additional criteria highlighted by Het Nieuwe Normaal (HNN, Circular Building as Standard) (Cirkelstad, 2024), such as detachability, which refers to the ease with which a product can be disassembled and removed from a project at end-of-life, and residual value, which expresses the potential of a product based on its end-of-life scenario, including its capacity for reuse, recycling, or retained functionality.

Figure 7 – Regranulated material ready for reintegration into new product manufacturing.

Scaling impact

This Dutch pilot is not an isolated success – it represents a scalable model that is already being implemented in Germany and explored in other regions. To enable broader adoption, it will be essential to develop harmonized specifications, robust traceability frameworks, and certification schemes such as product passports that ensure material identity and recyclability throughout the lifecycle.

For engineers and contractors, regulation is evolving that infrastructure must not only perform reliably during its service life but also be designed with end-of-life recovery in mind. This means selecting materials that are traceable, separable, and recyclable, and considering disassembly and reuse strategies from the earliest design stages. By embedding circular principles into planning and procurement, infrastructure can become a source of secondary materials, rather than a future waste stream.

While the current focus is on temporary infrastructure projects, the approach holds strong potential for application in long-term projects that will eventually be dismantled. In parallel, ongoing investigations aim to expand recycling capabilities to include a wider range of geotextile types, further advancing the shift toward a circular construction sector.

Conclusion

The successful recycling of 500.000 m^2 of geotextiles is a significant milestone in sustainable infrastructure. It illustrates how targeted innovation and collaboration can transform even the most challenging waste streams into resources.

As the sector moves towards climate neutrality, geosynthetics will play a critical role by reducing the emissions of infrastructure projects. Some geosynthetics can no longer be viewed as single-use materials. This project shows that a circular future is possible — not through idealism but through practical, scalable, real-world engineering and the will to invest in its development.

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