



The railway sleepers of 21st century



Greenrail - The railway sleepers of 21st century

Greenrail was born in 2012 as a startup, from an innovative idea of its founder Giovanni De Lisi: an eco-sustainable, technological and durable railway sleeper, with a significant added value and high potential for development and exportation.

Greenrail sleeper uses a mix of rubber collected from End of Life Tires (ELT) and recycled plastics from urban waste.

Today, Greenrail is a consolidated company, which operates in the international railway sector. Its technology's intellectual property is currently protected on a world scale in 64 countries. The firm handles the designing, prototyping and testing of the products, respecting specific needs of each solution. It designs and supplies industrial plants for the production of Greenrail sleepers.

It develops and activates partnerships in technological and innovative environment to give an impulse to the Research&Development activities, and be able to quickly respond to the contemporary needs.

Greenrail designs and produce railway sleepers in secondary raw material.

Advanced technology, which characterizes this product, makes Greenrail highly competitive. Research, development, innovation and sustainability are the principles, which make the foundation of Greenrail strategy, able to design and develop a requalification of the railway system to enhance the efficiency and productivity of the entire infrastructure.



Greenrail Sleepers- What makes them special



Greenrail is a composite, innovative and sustainable railway sleeper made of an inner core in concrete and an outer shell made of recycled plastic and powder obtained from end of life tyres (ELTs)



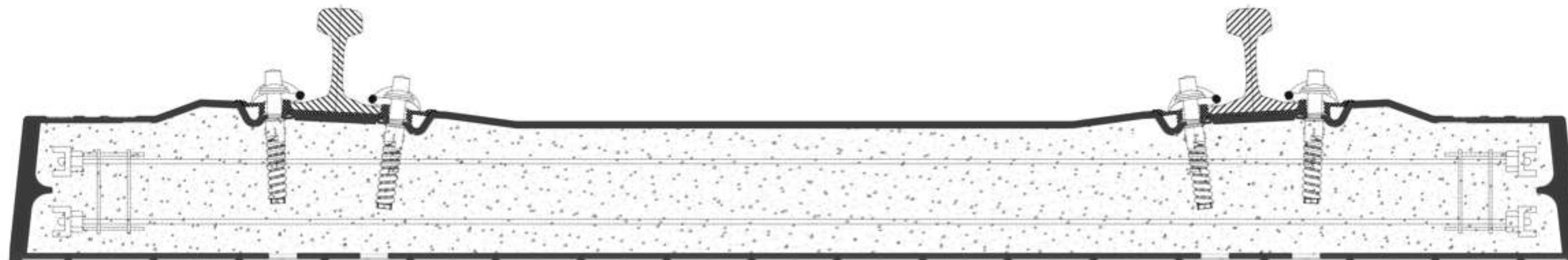
One of the principal characteristics of the Greenrail Sleeper is its ability to comply with various client's needs. It is a tailor made product, which can meet international technical specifications.



Greenrail allows quick installation and the possibility to use the common automated systems for the renewal and the laying of the tracks.



Greenrail Technology supports the Circular Economy principles through the reuse of plastic waste and end of life tyres. Each Km of railway line built with Greenrail sleepers is able to reuse up to 35 tons of urban waste.



Greenrail Sleepers- What makes them special

Overview

Greenrail sleepers consist of an outer shell made of a blend of "end of life tyres" (ELTs) and recycled plastic, and an inner core made of pre-stressed reinforced concrete. This innovative, exclusive and patented solution guarantees all the mechanical characteristics of the railway sleepers, offering at the same time an array of meaningful advantages:

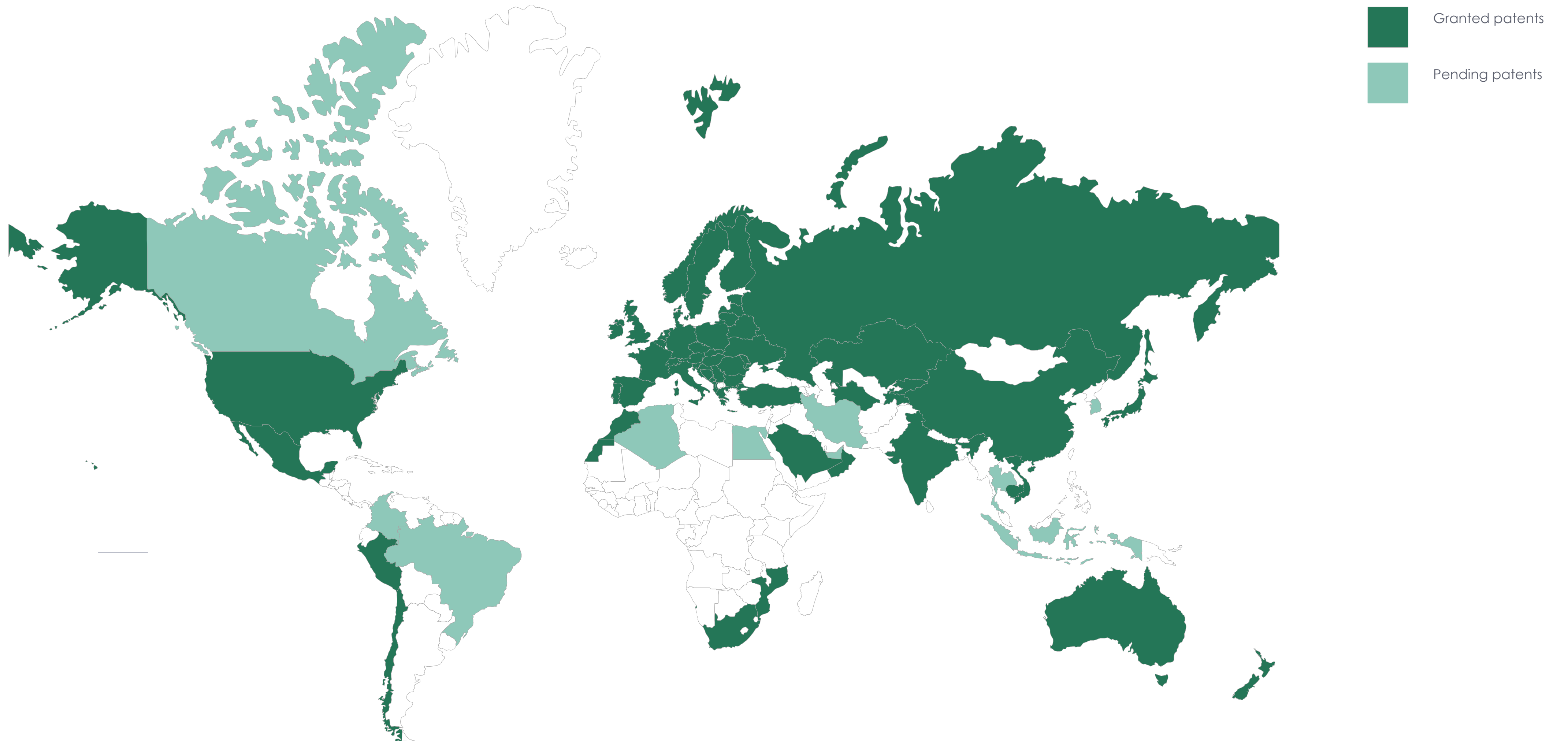
- ◆ **Reduced pulverization of the ballast (-50%)**
- ◆ **Reduction in life cycle maintenance costs (-40%)**
- ◆ **Longer lifespan under all conditions (40/50years)**
- ◆ **Greater resistance to lateral displacement of the track**
- ◆ **Significant electrical isolation effect**
- ◆ **Greater resistance to the freezing/thawing phenomenon**
- ◆ **No thermal expansion problems**
- ◆ **Concrete and metal inner core's protection**
- ◆ **Meaningful reduction in vibration (-40%)**
- ◆ **Noticeable reduction in noise levels (-30%)**
- ◆ **Product's traceability with embedded RFID solution**
- ◆ **Proper recycling and reuse of hundreds of thousand of ELTs**
- ◆ **Proper recycling and reuse of tonnes of other plastic**
- ◆ **Approximately 35 tons of rubber from end-of-life tires and plastic from urban waste reused every km.**
- ◆ **Reduction of CO2 emissions up to 30% less in the life cycle**
- ◆ **Reduction of up to 20% in energy consumption on life cycle**



Intellectual Property Protection - Active Patents

Patents

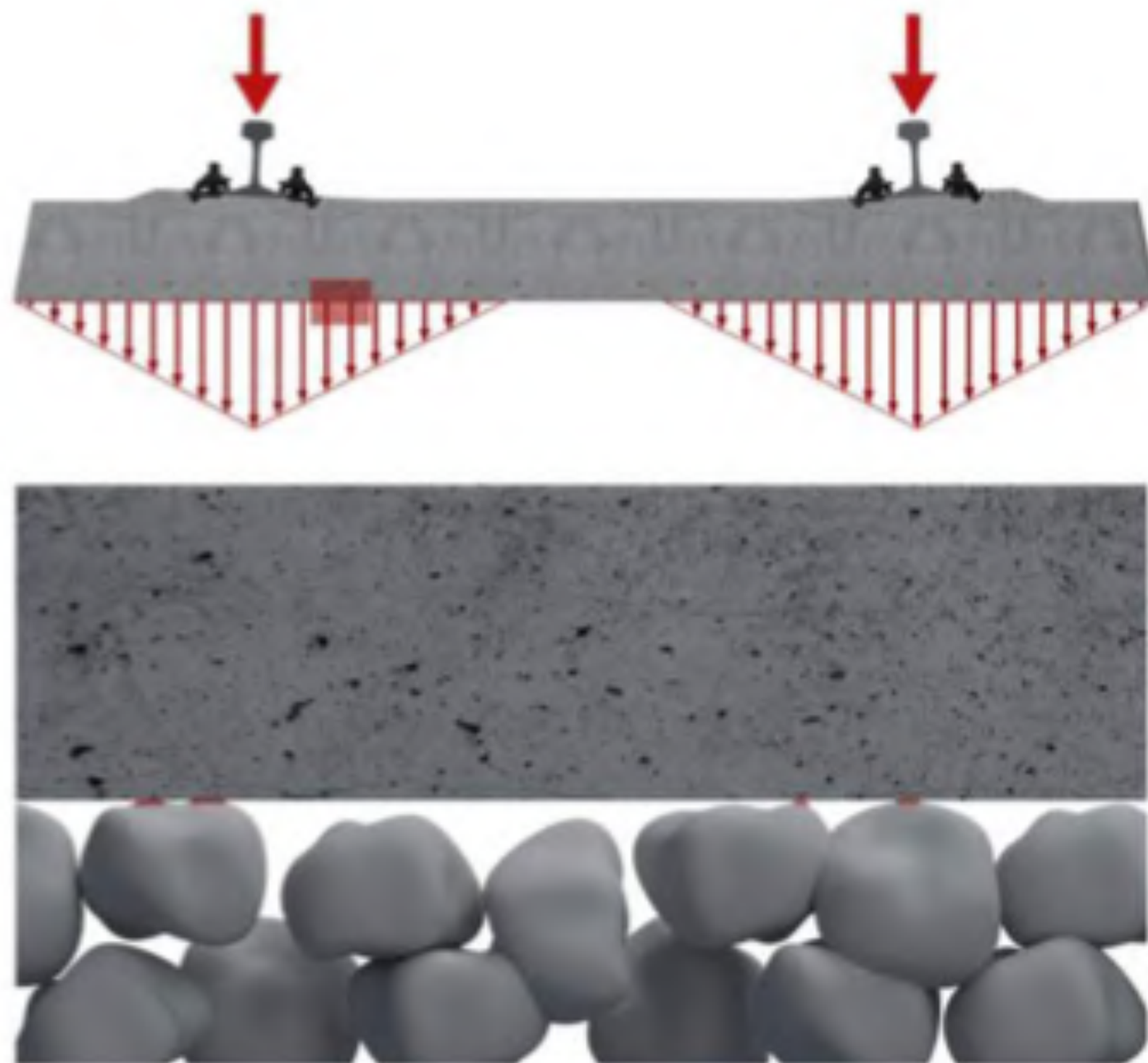
The intellectual property of Greenrail is protected on a worldwide scale, with patents covering 80 countries. The advanced exclusive technology which characterizes this product makes Greenrail highly competitive.



Technical Advantages - Vertical Load

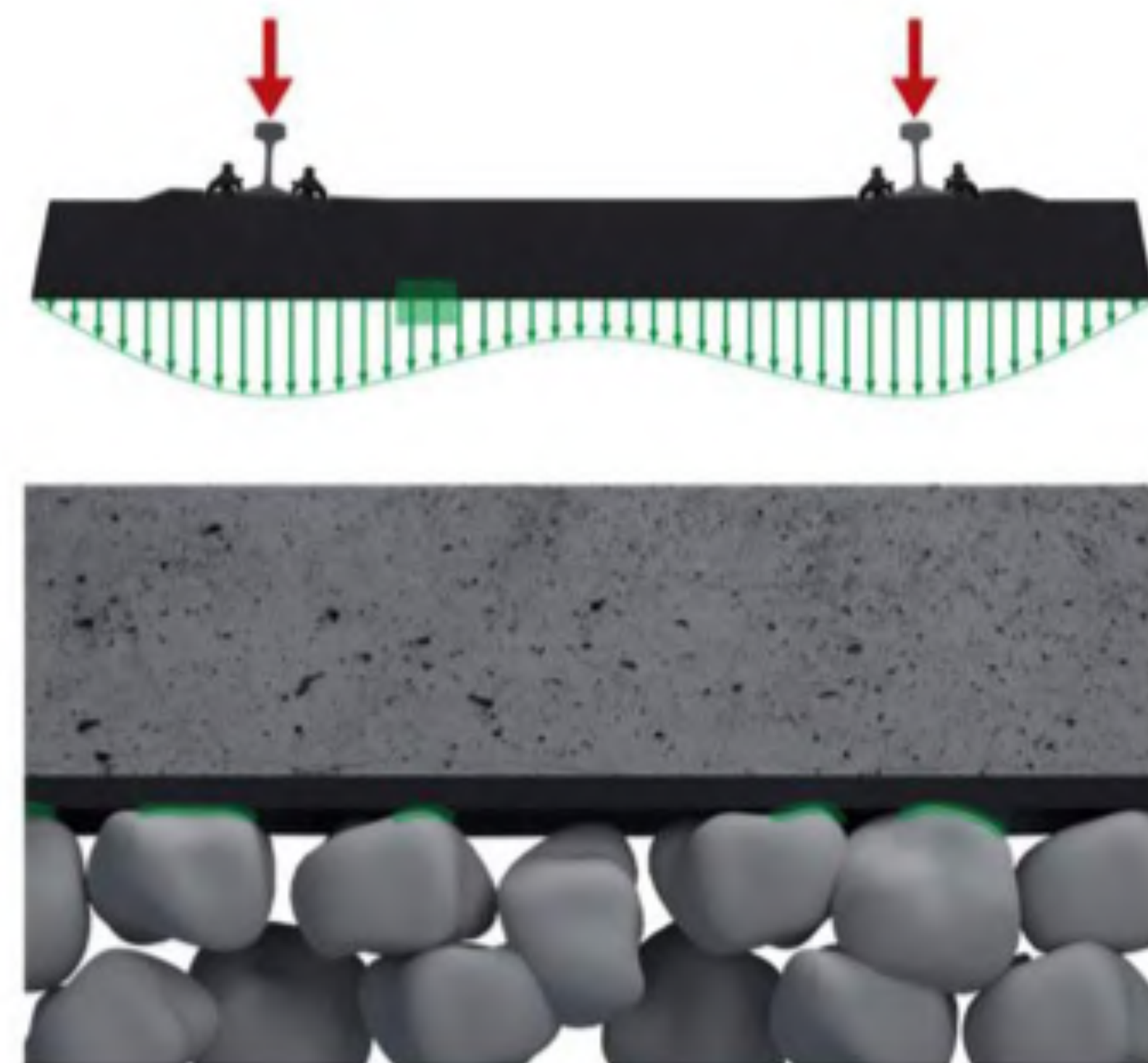
The increase of the contact area leads to a better load distribution reducing peak values.

CONCRETE SLEEPER



The sleeper-ballast contact is minimal and the features of the two elements does not permit the inerts penetration reducing load diffusion.

GREENRAIL



The outer shell in elastic material permits the inerts penetration increasing the contact area and dissipative properties

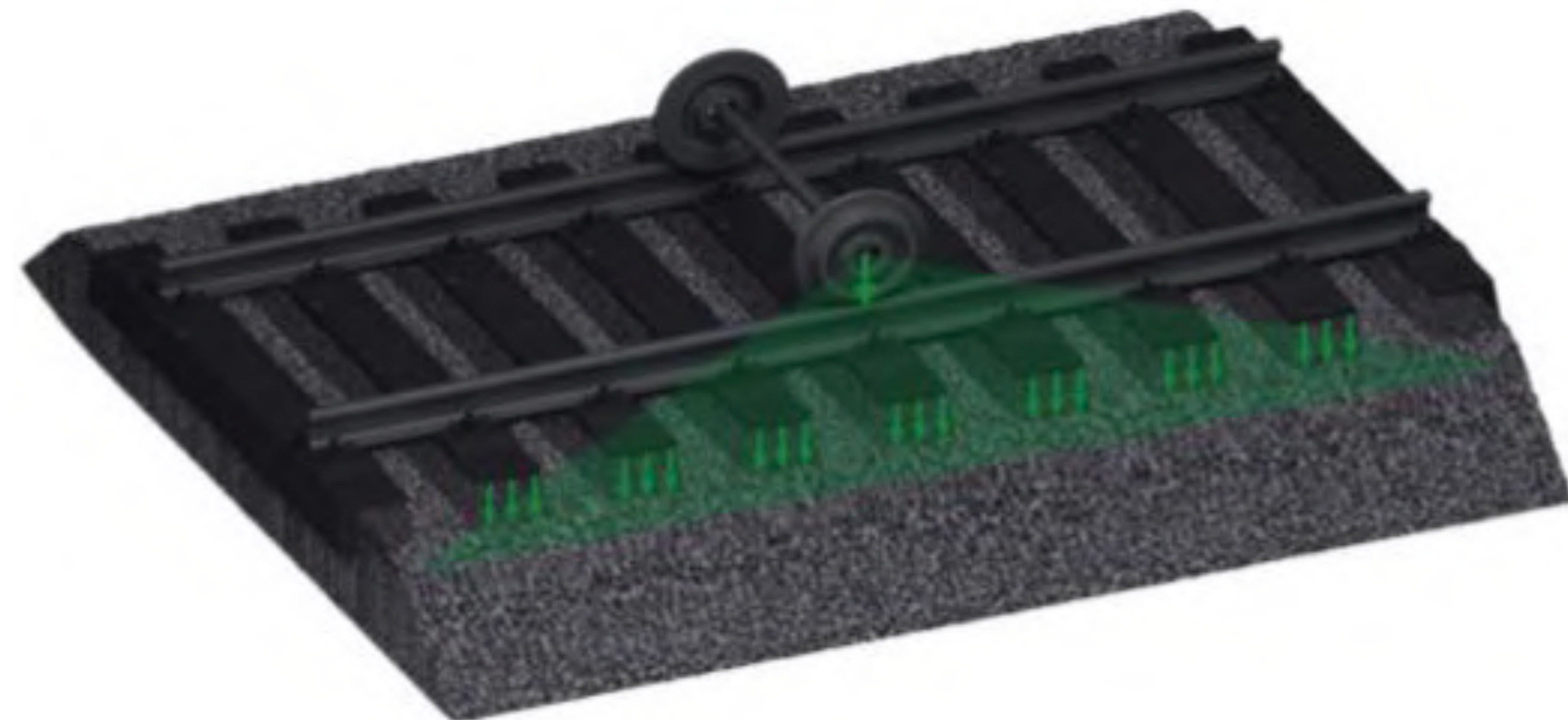
Technical Advantages - Vertical Load

The Greenrail sleepers generate a system capable of redistributing the vertical load of the vehicles to a greater number of sleepers. The increase of the reagent area reduces the unit stress below every sleeper.

CONCRETE SLEEPER



GREENRAIL

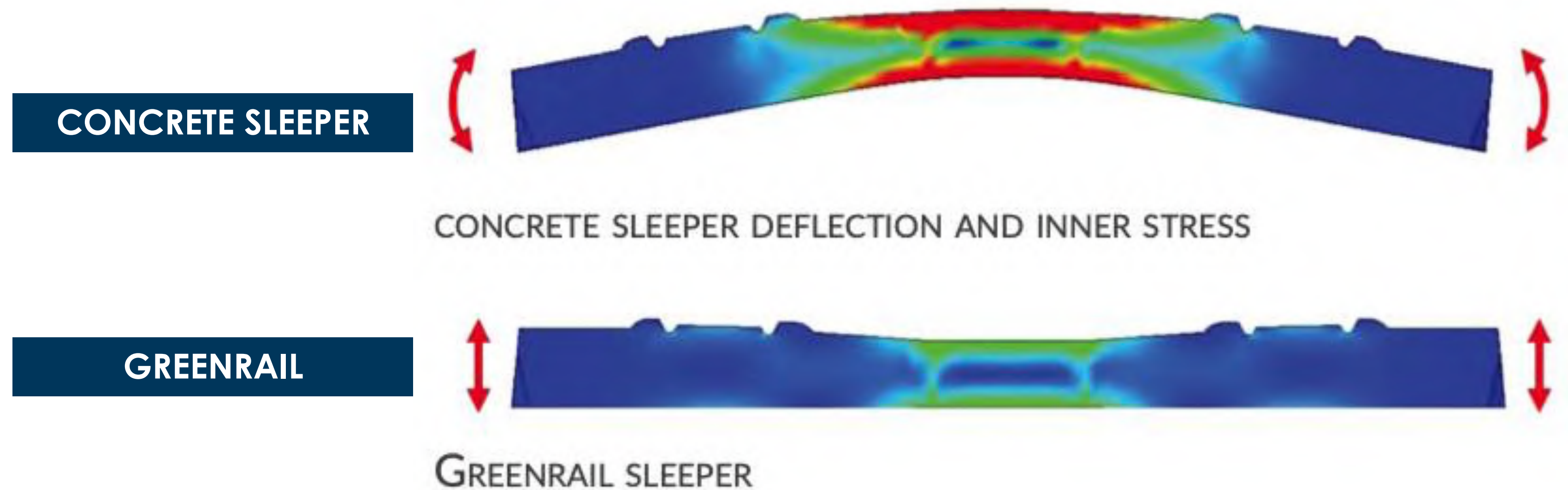


Technical Advantages - Vertical Load

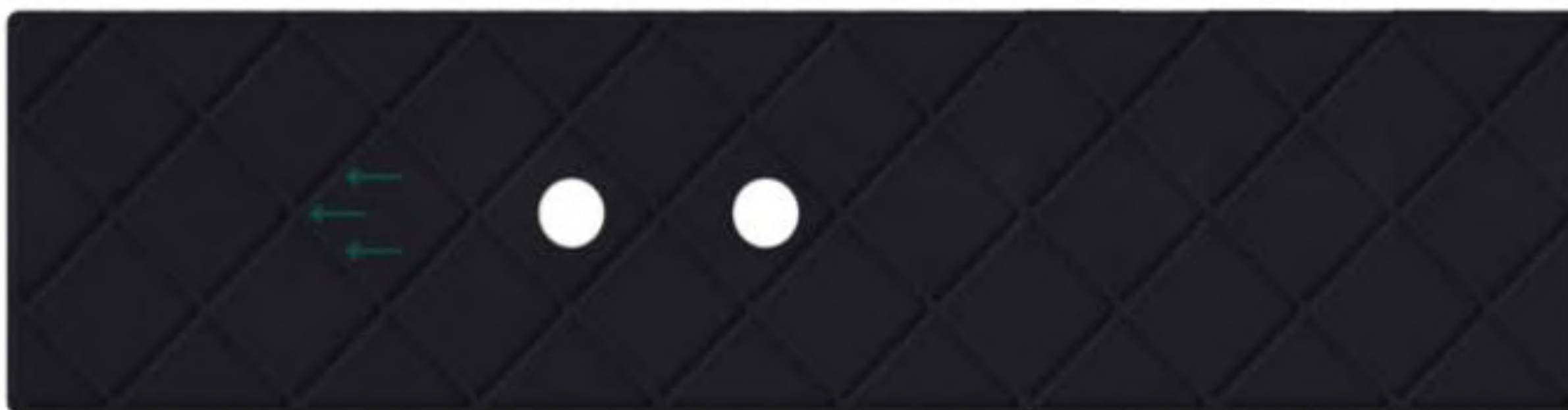
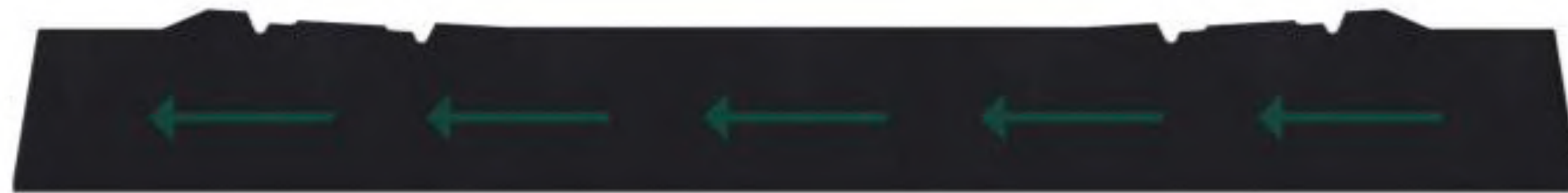
Over time, hollow areas appear submitting the sleeper to high deflection stress. The outer shell avoids a hard interface with the ballast, allowing the stones to bed into the compound. Greenrail technology avoids excessive contact forces, leading to a better stability, less settlement and reduced wear of the track components.



Detail of hallow area



Technical Advantages - Transverse Load



The employing of Continues Welded Rails (CRW) causes huge thermal longitudinal forces in the rails leading to track lateral movements.

This problem amplifies in low radius curve sections where the horizontal wheel load is added.

Concrete sleepers do not develop enough ballast adherence to withstand these stresses.

Greenrail sleeper, with its outer shell and its particular design of the base, allows a better adherence to the ballast ensuring the necessary resistance.



Technical Advantages - In case of Sandstorm

CONCRETE SLEEPER



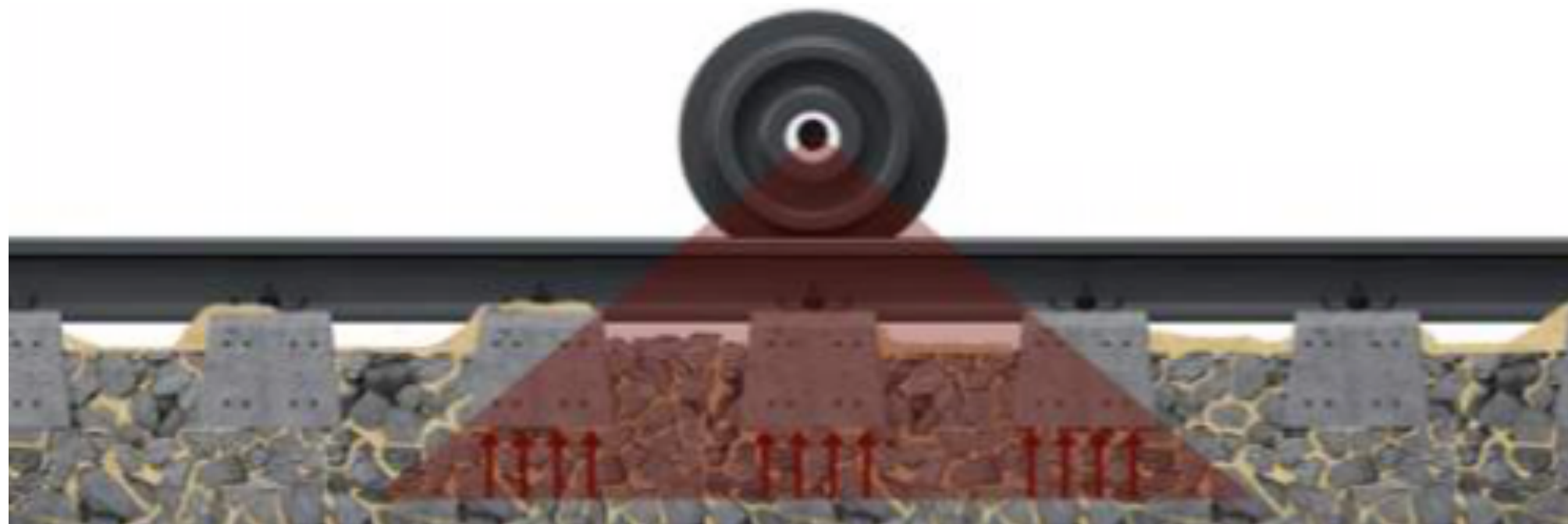
In a ballasted track, load due to the rail - wheel contact is discharged into few sleepers.

GREENRAIL



Greenrail sleeper, with its elastic outer shell, guarantees a better stress diffusion, diving load to more elements.

SANDSTORM ON CONCRETE RAILWAY LINE



A ballast polluted, due to the insertion of sand into empty spaces, significantly the stiffness of the railway superstructure. The effect is an increase of the stress into the single sleeper and consequently a reduction of the load diffusion area.

SANDSTORM ON GREENRAIL RAILWAY LINE



In case of ballast polluted, Greenrail is able to mitigate the effects, as the outer shell works like a damping material.

Technical Requirements vs Greenrail test results - UNI EN

The tables below show a comparison between Greenrail technical features and various technical specifications such as UNI EN and AREMA requirements. As an example, the third table describes a comparison between Greenrail and a potential market, in this case the Indian one. As the tables show, the results of the tests conducted on Greenrail sleepers exceed the regulations' requirements.

TECHNICAL SPECIFICATION REQUIRED BY <u>EN 13230</u> - EU MARKET	REQUIREMENTS	GREENRAIL TEST RESULTS
Under rail static test - Fr R	> 190 KN	228 KN
Under rail static test - Fr 0.05	> 342 KN	400 KN
Under rail static test - Fr B	> 475 KN	530 KN
Midspan static test - Positive bending - Fc R	> 35 KN	85 KN
Midspan static test - Positive bending - Fc B	> 87.5 KN	150 KN
Midspan static test - Negative bending - Fc R	> 50 KN	95 KN
Midspan static test - Negative bending - Fc B	> 125 KN	140 KN
Under rail dynamic test - Fr 0.05	> 252 KN	320 KN
Under rail dynamic test - Fr 0.5	> 369 KN	400 KN
Under rail fatigue test - Fr 0	< 0.1 mm	0.03 mm
Under rail fatigue test - Fr 0.05	< 0.05 mm	0.01 mm
Under rail fatigue test - Fr B	> 416 KN	550 KN
Electrical resistance test	> 10 KΩ	130 KΩ
Outer-shell Pull out test	> 0.79 KN	1.2 KN

Technical Requirements vs Greenrail test results - AREMA

TECHNICAL SPECIFICATION REQUIRED BY <u>AREMA</u> - US MARKET	REQUIREMENTS	GREENRAIL TEST RESULTS
Modulus of Elasticity	> 1170 Mpa	31,492 Mpa
Modulus of Rapture	> 13.8 Mpa	28.3 Mpa
Rail Seat Compression	< 6.35 mm	3.31 mm
Screw pullout test	> 22.2 KN	126 KN
Electrical impedance	> 20,000	39.500



**INNOVATION IS THE ENGINE OF A CHANGE TOWARDS SUSTAINABLE FUTURE.
THE VISION OF GREENRAIL IS BASED ON A MANAGEMENT OF RAILWAY
INFRASTRUCTURE IN EFFECTIVE AND INNOVATIVE WAY, FOUNDED ON
IMPROVEMENT OF QUALITY.**



- Patent license concession
- Trademark concession
- Know-how transfer
- Sleeper's design
- Design, supply and installation of production plants



**LOCAL INDUSTRIAL
COMPANY**

- Up-front fee / Equity
- Royalties
- Dividend (if invested)
- Purchase of production plant's machineries

The local industrial company could belong to: a licensee, or 100%, owned by Greenrail or through a JV between Greenrail and a local shareholder.

Greenrail is able to set up manufacturing plants in each target markets.

Competitive positioning of Greenrail

Greenrail sleepers offer several competitive advantages - including reduced vibration and less lateral displacement, longer product life and lower maintenance costs compared to other types of sleepers on the market. Currently, on the market, the Greenrail sleeper is the only eco-sustainable sleeper that can become a new standard.

There are other types of plastic or synthetic sleepers that can enter the market only to replace the old wooden sleepers. These sleepers cannot replace concrete sleepers, primarily due to the weight and the type of rail fastening system. Furthermore, they showed many problems related to thermal expansion.

Type of Sleepers	Greenrail	Concrete + USP	Wood	Concrete	Plastic /Polymeric
Duration (years)	40-50	30-35	15-20	25-30	40
High-speed lines and Heavy Loads	✓	✓	X	✓	X
Direct Fastening system	✓	✓	X	✓	X
Vibration and noise mitigation	✓	✓	X	X	✓
Eco-sustainability	✓	X	X	X	✓
Resistance to Thermal Expansion	✓	✓	✓	✓	X

Environmental benefits of Greenrail Sleepers

A business model perfectly aligned to circular economy goals

Nowadays the development of new business models able to meet the environmental-sustainability and green economy pillars is a key factor: Greenrail, with its production process of sleepers, allows to achieve new standards of “environmentally sustainable” in the sector.

Greenrail circular business model offers a strong upside according to environmental perspective, as **the production of sleepers requires a larger amount of urban waste and End of Life Tyres.**

This supply demand of waste material could be leveraged in order to achieve an **active and efficient waste management strategy and an improvement of the reuse and recycling of waste in the country.**



Greenrail addresses the increasing need to recycle and re-use: End-of-Life Tyres And Plastic

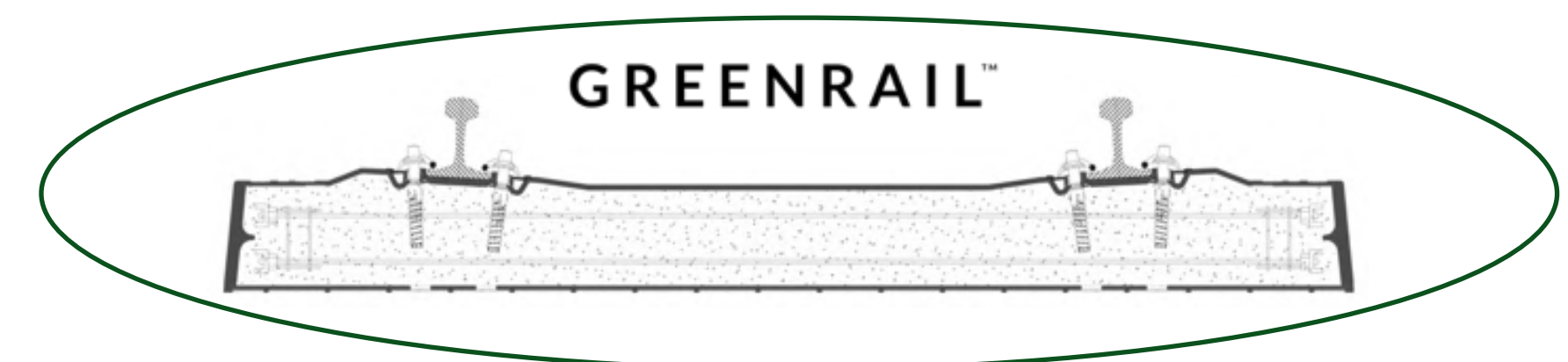
1 billion waste tyres per year are generated worldwide



8 million tonnes of plastic per year end up in the oceans



Each railway line KM equipped with Greenrail sleepers allows recovering up to 35 tons of End of Life Tyres (ELT) and recycled plastic



Environmental benefits of Greenrail sleepers

Greenrail sleepers provide an effective effort to European Green New Deal, as they offer economic, technical and environmental advantages: they allow a reduction of railways maintenance costs of 40% compared to standard concrete sleepers, granting a reduction of noise/vibration, a lower ballast pulverization and an improvement in track stability.

1 Transitioning of industry to a clean and/or circular economy (including waste prevention and/or recycling)

2 Building and renovating in an energy and resource efficient way

3 Accelerating the shift to sustainable and smart mobility



- Supply chain enlargement related to the reuse of ELT plastic sand with positive impacts on the employment



- Reuse of 35 tons of waste for 1 km



- - 19% consumption of natural resources
- tons of verging ballast saved per year



- - 30% CO2 emissions
- million tons of CO2 emissions reduced per year



- - 20% of Cumulative Energy Demand (CED)

1 km of Greenrail track equals:

-146 Tonnes of CO2
emissions reduced



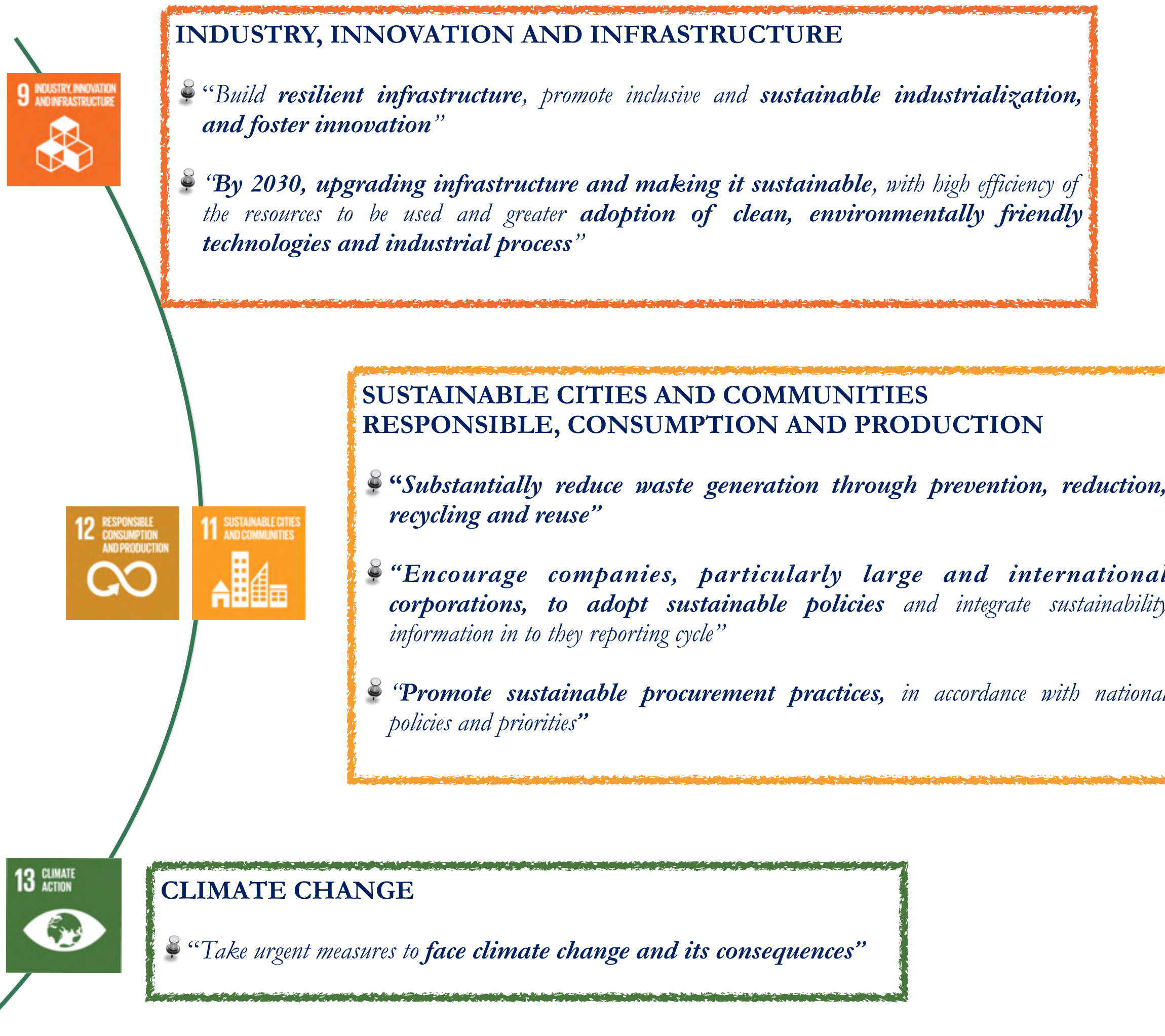
SDGs matched by Greenrail

In 2015, more than 150 international leaders endorsed the 2030 Agenda to promote a sustainable development plan, the essential elements of which have been declined into 17 so-called "Sustainable Development Goals" (SDGs).

Greenrail, contributes to the achievement of these goals:



SDGs matched by Greenrail



Greenrail promotes the **sustainable and innovative development of railway infrastructure**, contributing to the reduction of costs in economic and environmental terms.

The Greenrail sleepers relies on a **technology developed in Italy and patented in 80 countries worldwide**.

Unique in its kind, **capable of becoming the industry standard**, it contributes to **responsible consumption and production** by using up to 35 tons/km of secondary raw materials (plastic from urban waste and rubber from end of life tyres).

Greenrail Technology **reduces the need for maintenance by up 40% compared to a standard concrete sleeper**.

SDGs matched by Greenrail




CLEAN ENERGY

- “ *Improve international cooperation to facilitate access to energy research and technology, including renewable energy, energy efficiency, and advanced cleaner than fossil fuel technology, and promote investment in energy infrastructure and clean energy technologies*”



SUPPORTO PARTNERSHIP

- “ *Strengthen implementation arrangements and revitalize the global partnership for sustainable development*”
- “ *Promote the development, trasfer, and diffusion of environmentally friendly technologies in developing countries*”

The R&D activity carried out by Greenrail in recent years in its start up phase, has led to the **development of a solar sleepers (now in pre-industrial phase) able to integrate a PV panel and transform railway lines into a sustainable energy source.**

Greenrail is a **member of the World Alliance for Efficient Solutions**, a worldwide alliance of 1000 **sustainable solutions to climate change**, founded by the Solar Impulse Foundation.

“We believe collaboration in the key to success. Solutions exist but they hidden in startups who needs business partnerships to implement and scale their technologies. This is one of the key reasons why we created the World Alliance for Efficient Solutions: to create synergies between our members”. Bertrand Piccard - Cahairman of Solar Impulse Foundation and World Alliance for Efficient Solutions.

R&D Plans and Activities - Greenrail Lab

On top of its unique sleepers for the rail infrastructure, Greenrail over the last years has been developing also other new ideas and projects. Two of the most interesting ideas join together sleepers and technology at the highest level: Greenrail Solar and Greenrail LinkBox.

R&D - New products

- ✓ **Greenrail Solar™** : involves the fusion between a sleeper and photovoltaic module, in this way it is possible to exploit the track network rail not only for its primary scope but also to produce green energy;
- ✓ **Greenrail LinkBox™**: involves using new sensors, data collection technology and telecommunication systems to perform strategic and valuable data analysis and make rail infrastructure management cheaper and safer;

Greenrail Solar™

Greenrail Solar™ is a Greenrail sleeper, which integrates a photovoltaic module allowing to transform the railway in photovoltaic power stations, with a high productivity of sustainable energy.



Greenrail LinkBox™

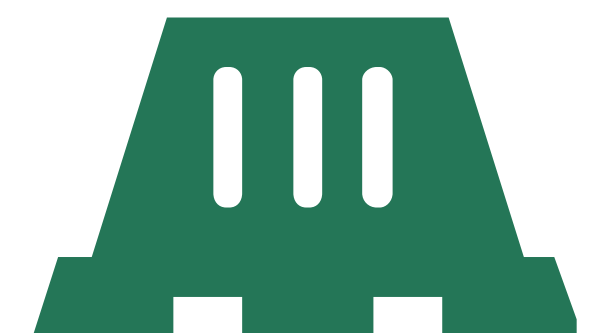
Greenrail LinkBox™ is a Greenrail Solar sleeper, which integrates various types of systems, both for transmission of control or security data, and telecommunication.



Continuing developing

Greenrail Team is constantly researching new solutions for track rail infrastructure. The company is currently also studying new ways to apply its technology to:

- Tunnels;
- Jersey barrier;
- And more...



On 7th September 2018, Greenrail presented the first smart railway track in Italy, realized with FER Ferrovie Emilia Romagna on their line in Reggio Emilia. The pilot stretch is 1 kilometre long and has been foreseen as one of the European Commission's Horizon2020 SME Instrument Phase 2 Project activities. It consists of Greenrail Basic, Greenrail Solar and Greenrail LinkBox sleepers.

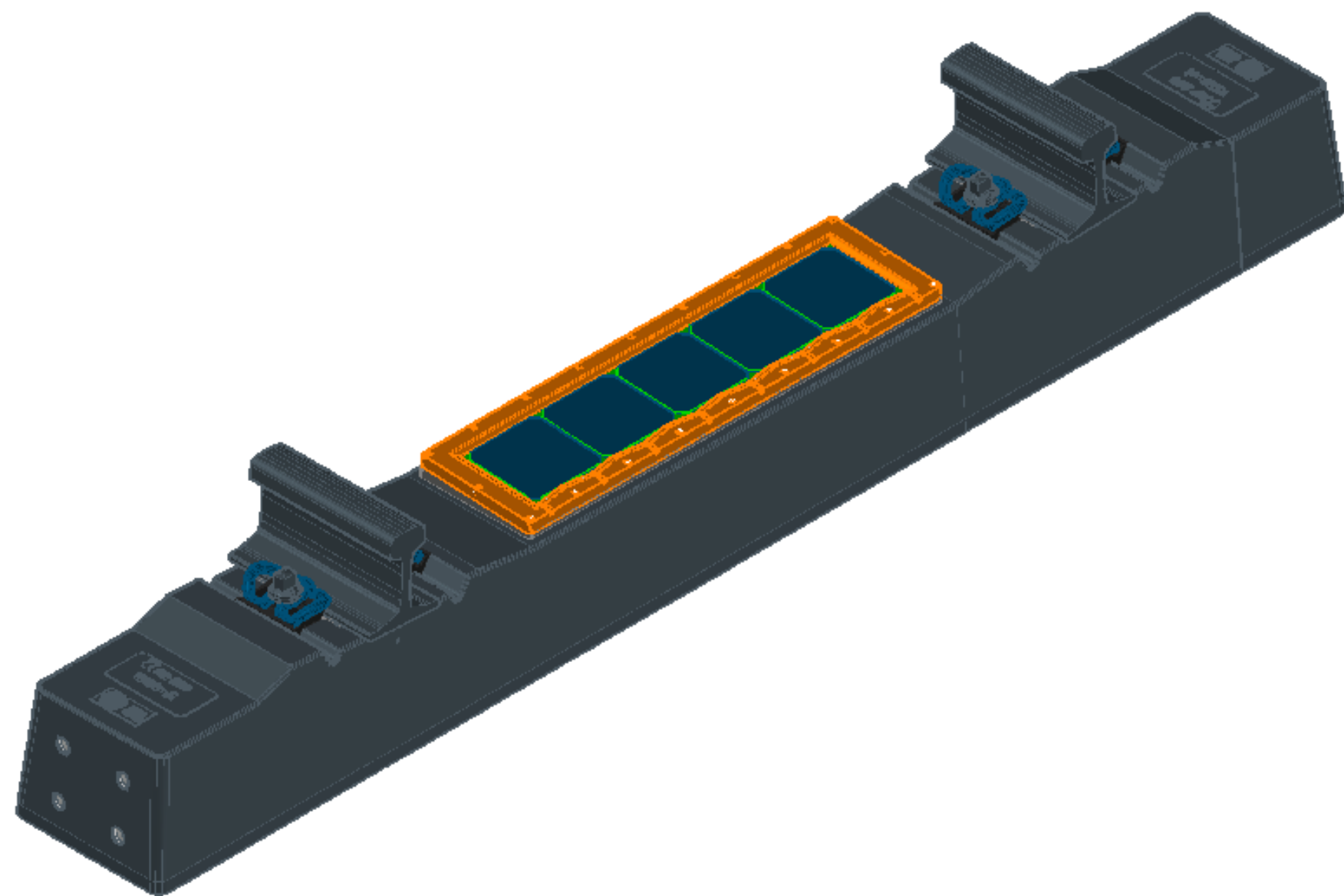
Greenrail R&D activities never stop...

Relying on its new sleepers for the rail infrastructure, Greenrail over the last years has been developing new ideas and projects. One of the most interesting ideas join together sleepers and technology at the highest level: Greenrail Solar.

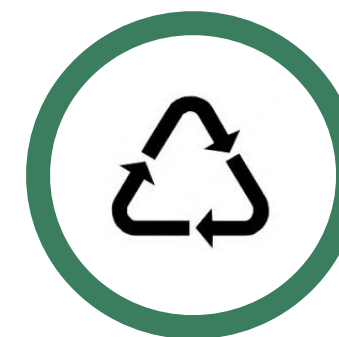
Greenrail Solar™

1 Km = 44 Mw/h per Year

25 Km of Greenrail Solar = 1 MW PV Plant



25 Km =



875 Tons of
recycled
Rubber and
Plastics used



1 100 Mw/h per
year



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