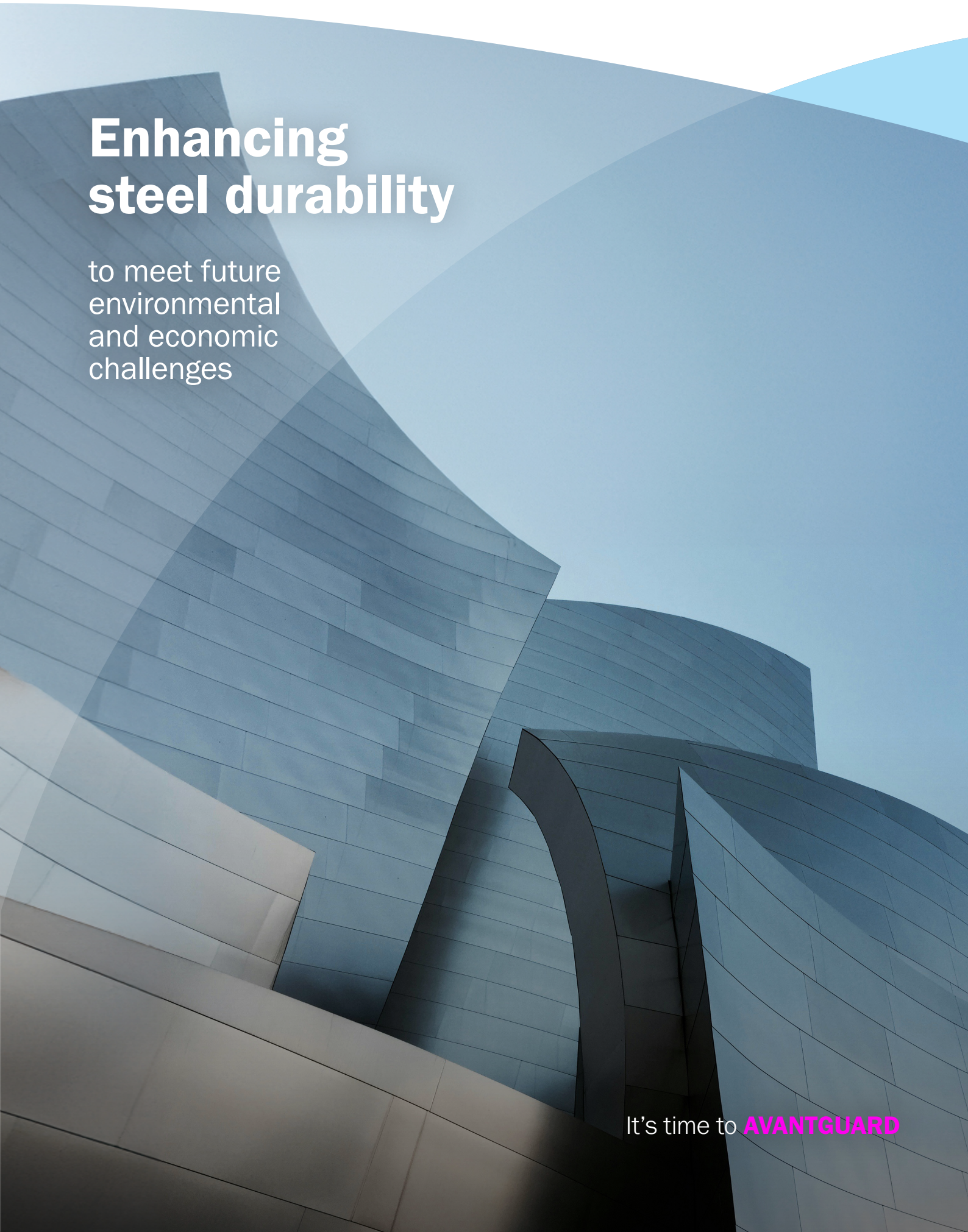
HEMPEL
Trust is earned

Enhancing steel durability

to meet future environmental and economic challenges



It's time to AVANTGUARD

Why we must **prioritise protection of steel**

Steel is not just a fundamental material in construction; it is a crucial alloy in addressing future environmental and economic challenges. Renowned for its strength and versatility, steel is indispensable in creating infrastructure that is both resilient and adaptable.

Its application spans from the core framework of towering skyscrapers to the intricate support structures of bridges, marking its presence in virtually every significant construction project.

Steel's ability to be recycled without degradation of quality underscores its circular nature, making it a fine choice in sustainable building designs – if its entire lifecycle is taken into consideration.

Steel facts[1]

#1 Steel is a permanent material that can be infinitely recycled and is 100% recyclable without loss of quality

#2 Steel is the most recycled material in the world

#3 Steel is the most commonly used material in the world

#4 The steel industry generates between 7% and 9% of direct emissions from the global use of fossil fuels – primarily from the chemical reaction of steelmaking.

[1] https://worldsteel.org/about-steel/steel-facts/

The steel dilemma in the construction industry

Steel plays a crucial role in modern construction, providing strength and durability to structures worldwide. However, steel manufacturing presents substantial environmental challenges, being one of the highest CO_2 emitting industries globally, accounting for around 7-9% of worldwide emissions.

Indeed, being 100% recyclable is an excellent feature of steel. Once produced and used, steel can be recovered, recycled, and reused forever. However, these processes are still resource and energy-intensive, generate waste and pollute. Therefore, according to the widely accepted circularity and sustainability practices, we should focus first on waste prevention then on reuse and refurbishing, and later on recycling and finally disposal. Therefore, innovations aimed at optimising the use of steel, protect and preserve it, and extending the lifespan of constructions, are vital for reducing emissions and promoting sustainability in the construction sector.

This whitepaper examines how enhancing the durability of steel can significantly impact sustainable development and operational efficiency in construction practices.

Challenges in steel durability

As global steel demand is projected to rise, particularly in developing regions, the environmental footprint of this sector is likely to escalate unless substantial measures are taken to limit emissions. While the steel industry continues to invest in new and innovative steels, allocating 6.3% of its revenue to capital projects, research, and process improvements in 2022[2], this alone cannot work as an isolated solution for decarbonisation. Instead, it is more impactful to focus on implementing circular practices which is a cost-effective component of the industry's pathway towards sustainability.

Keeping materials in use for as long as possible is a key principle in the concept of circular economy. However, the preservation of steel structures encounters a significant challenge: corrosion. First, let's explore the economic and environmental consequences of corrosion before discussing potential solutions.

World crude steel production 1950 to 2022

million tonnes, crude steel production[3]

YEARS	WORLD	YEARS	WORLD	YEARS	WORLD
1950	189	**2001**	852	**2012**	1563
1955	270	**2002**	905	**2013**	1653
1960	347	**2003**	971	**2014**	1675
1965	456	**2004**	1063	**2015**	1624
1970	595	**2005**	1148	**2016**	1633
1975	644	**2006**	1250	**2017**	1737
1980	717	**2007**	1350	**2018**	1828
1985	719	**2008**	1345	**2019**	1877
1990	770	**2009**	1241	**2020**	1882
1995	753	**2010**	1435	**2021**	1962
2000	850	**2011**	1540	**2022**	1885

[2] https://worldsteel.org/about-steel/steel-facts/

[3] https://worldsteel.org/data/world-steel-in-figures-2023/

The environmental and economic impact of steel corrosion

Corrosion is a natural but challenging process that affects steel structures. It occurs when steel reacts with environmental elements, such as oxygen, moisture, salt, and pollution, leading to the formation of rust. This reaction gradually weakens the metal, compromising the integrity and safety of infrastructure, and ultimately necessitating costly steel maintenance and replacements over time.

PRODUCTION OF STEEL

7-9%

OF TOTAL ENERGY EMISSIONS

Environmental costs of replacing corroded steel

The production of steel is essential for modern infrastructure, but we cannot ignore that it is also a significant driver of climate change. In fact, steel is responsible for approximately 2.8 gigatonnes of CO_2 emissions annually, representing about 7-9 % of total energy emissions[4]. The necessity to replace corroded steel adds a substantial burden, with projections indicating that steelmaking for this purpose could account for an additional 4.1–9.1% of total emissions by 2030, considering the European Union and recent U.S. greenhouse gas reduction targets[5].

The carbon footprint of steel corrosion encompasses more than the direct emissions from steel production; it includes the lifecycle emissions from mining, manufacturing, and disposing of the steel used to replace corroded structures. Recent estimates suggest that globally, a significant portion of steel production—up to a third—is dedicated to replacing corroded steel[5]. This cycle of production and replacement intensifies the environmental impact, particularly in terms of CO_2 emissions associated with material loss to corrosion.

COST OF CORROSION

3-4%

OF THE GLOBAL GDP

Economic costs of replacing corroded steel

Economically, the direct costs of corrosion are also significant, amounting to approximately 3-4% of the global GDP[5]. These costs are primarily associated with the maintenance, repair, and replacement of corroded steel, which not only affect the construction sector but also have a widespread impact on infrastructure, manufacturing, and transportation industries. The indirect costs, including production delays, loss of efficiency, and premature failure of structures, further exacerbate the financial burden, suggesting that a substantial portion of these economic losses could be mitigated through improved corrosion protection and management practices.

By focusing on enhancing steel durability, the construction industry can better meet the pressing environmental and economic challenges of our time. In the following section, we will explore innovative practices in corrosion protection that are paving the way for a more sustainable future.

[4] https://worldsteel.org/climate-action/climate-change-and-the-production-of-iron-and-steel/
[5] https://www.nature.com/articles/s41529-022-00318-1.pdf

Advancements in protection methods and adoption barriers

It's essential that all companies take their share of the responsibility to protect the environment by adopting innovative and sustainable technologies. A significant advancement in steel protection is the development of advanced protective coating systems such as Hempel's Avantguard® technology.

Avantguard combines zinc, hollow glass spheres and a proprietary activator in a unique patented technology, which triples the activation of the zinc. This results in significantly longer-lasting protection with reduced environmental impact due to lower zinc content or reduced material consumption.

Read more about the patented Avantguard® corrosion protection technology

Barriers to adopting new corrosion protection methods

Adopting innovative corrosion protection technologies like Avantguard, despite their proven performance and sustainability benefits, can be challenging due to the industry's reliance on traditional standards.

For instance, ISO 12944 is the key global standard for the corrosion protection of steel structures using paint systems, providing essential guidelines to ensure reliable protection across diverse environments.

However, Part 5 of this standard sets specific requirements—such as zinc content and dry film thickness (DFT)—based on traditional methods. While these criteria help maintain consistency and safety, they can make it difficult to introduce innovative solutions like Avantguard.

A paradigm shift in focus

To maximise the potential of advanced technologies, the construction industry could benefit from placing more emphasis on Part 6 of ISO 12944, which focuses on performance testing rather than specific material requirements. This shift enables the validation of new technologies that achieve superior protection with a reduced environmental impact.

The 2018 revision of ISO 12944 supports this approach by acknowledging that innovative solutions may provide equivalent corrosion protection using less material, provided they prove their performance through rigorous testing. By embracing performance-based criteria, the industry can adopt more sustainable and effective corrosion protection solutions.

Explore our paper **Standards and the adoption of new technologies in corrosion protection** to learn more.

The future of steel in construction

As economies grow around the world, the demand for steel is booming. Yet, the steel industry remains committed to its promise to cut down on carbon emissions and meet the goals of the Paris Agreement. The path to reducing emissions is undeniably complex, with no single solution offering a way out. Still, by embracing innovation and collaboration, the industry is ready to turn this challenge into a chance to build a more sustainable future.

Breakthrough and emerging technologies

The steel industry is on the verge of a transformative era, driven by breakthrough and emerging technologies aiming to reduce up to 50% of CO_2 emissions, which will revolutionise the current routes of production[6].

Currently, steel production predominantly utilises two methods: the blast furnace-basic oxygen furnace (BF-BOF) route (when the molten iron is converted into steel by blowing oxygen through it to reduce carbon content and impurities) and the electric arc furnace (EAF) route (when scrap steel is melted using electric arcs)[6].

Readily available solutions improve the efficiency of BOF and focus on the increase of steel scrap in BOF and EAF. However, there are limitations to the availability of recycled feedstock, and energy efficiency measures cannot provide a complete decarbonisation pathway for the steel industry.

Breakthrough technology such as scaling of Direct Reduced Iron (DRI) in combination with EAF and the use of green hydrogen will replace the need for fossil fuels and allow the production of carbon neutral steel[7]. For BOF, biomass reductants, carbon capture and storage (CCS) and carbon capture and utilisation (CCU) technologies are the remaining long-term mitigation options.

While these methods are currently expensive and not yet scalable, ongoing advancements and investments are expected to enhance their viability and integration into mainstream steel manufacturing[7]. In the meantime, while we await scalable new decarbonisation pathways, adopting the circular economy model and efficient use of steel are essential components of sustainability strategies in the construction industry.

[6] World Steel Association. https://worldsteel.org/steel-topics/sustainability/sustainability-indicators-2023-report

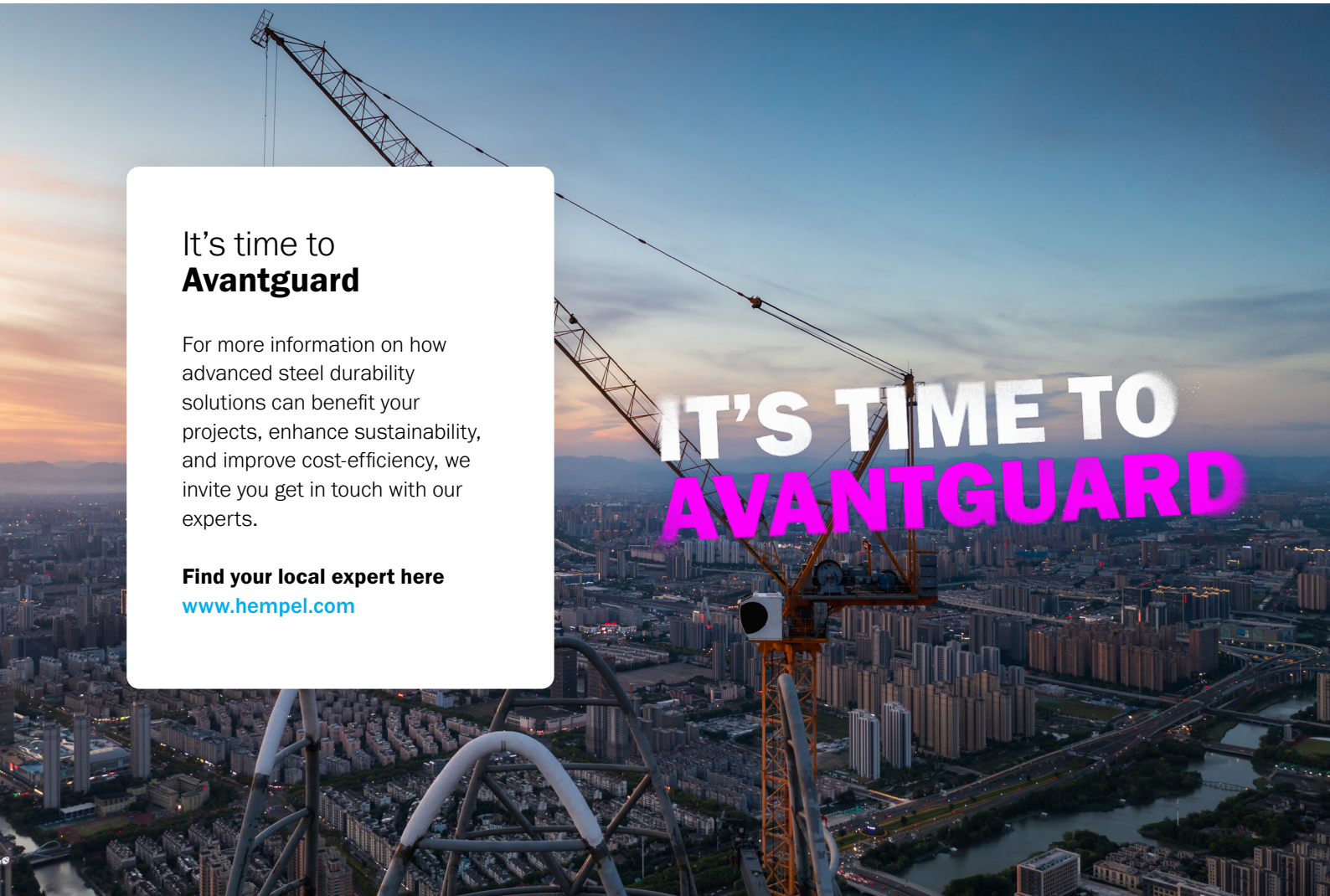
[7] McKinsey & Company. (2022). Net zero steel in building and construction: The way forward. Retrieved from https://www.mckinsey.com/industries/metals-and-mining/our-insights/net-zero-steel-in-building-and-construction-the-way-forward

Conclusion

The construction industry's reliance on steel is essential for building resilient infrastructure and fostering societal development, but it also poses significant environmental challenges due to the high CO_2 emissions associated with steel production.

Therefore, prioritising the preservation and durability of existing steel structures is crucial to addressing these challenges effectively. This whitepaper has highlighted the need for innovative corrosion protection solutions to extend the lifespan of steel, reducing both environmental impact and economic costs.
Adopting advanced coating technologies like Avantguard is vital for the construction industry to meet future environmental and economic challenges.

By integrating advanced corrosion protection methods, the construction and steel industries can contribute to a more sustainable future while maintaining structural integrity and safety of infrastructure.



As a world-leading supplier of trusted coating solutions, Hempel is a global company with strong values, working with customers in the protective, marine, decorative, container and yacht industries. Hempel factories, R&D centres and stock points are established in every region.

Across the globe, Hempel's coatings protect surfaces, structures and equipment. They extend asset lifetimes, reduce maintenance costs and make homes and workplaces safer and more colourful. Hempel was founded in Copenhagen, Denmark in 1915. It is proudly owned by the Hempel Foundation, which ensures a solid economic base for the Hempel Group and supports cultural, social, humanitarian and scientific purposes around the world.

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