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HOT DIP GALVANIZING TODAY

89

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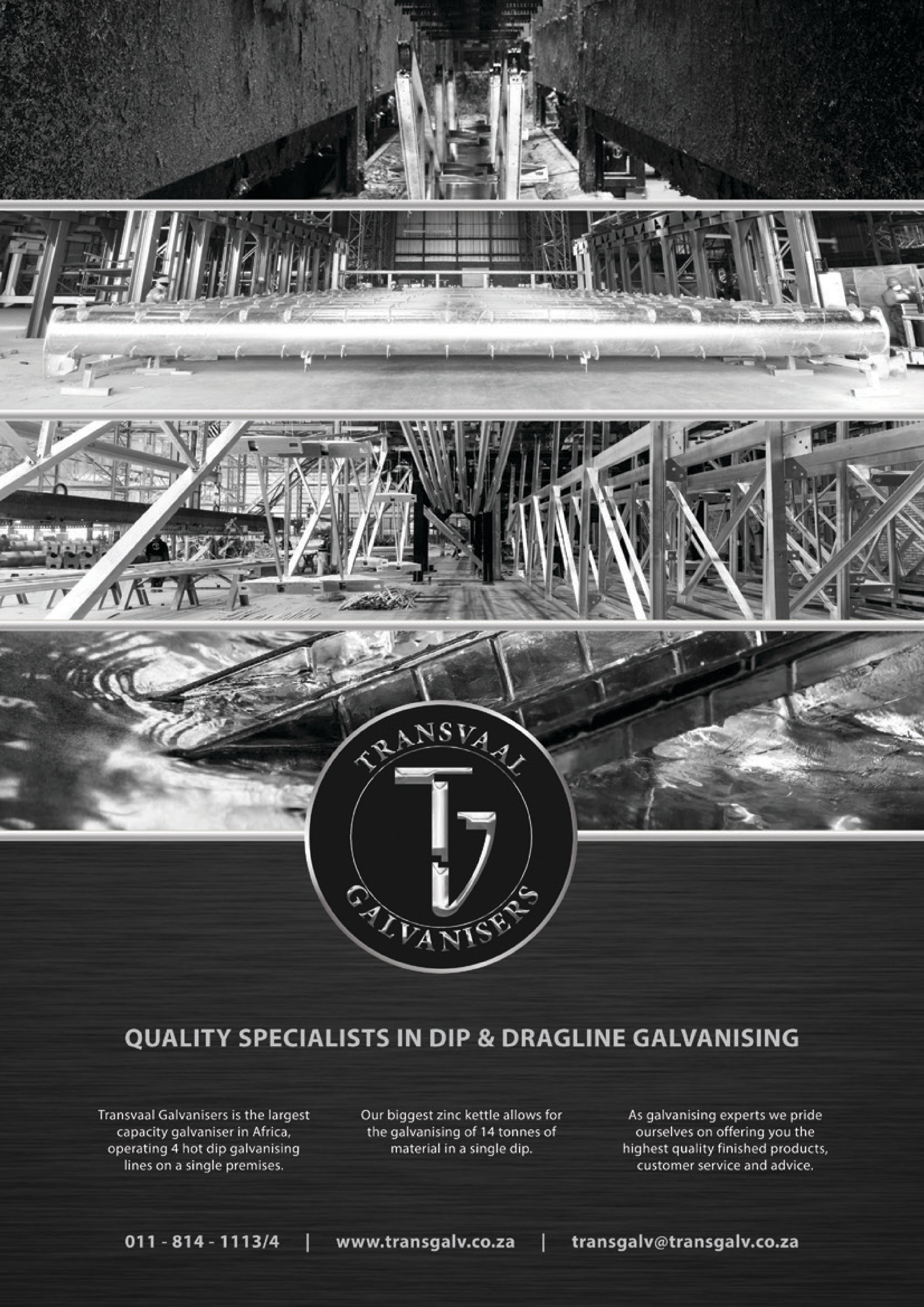
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EXECUTIVE DIRECTOR'S
Comment: Managing the gap

Every picture tells a story, or does it?

Methods for determination of coating thicknesses on hot dip galvanized articles are well described and results easy to assess. However, the HDGASA is engaged from time to time to comment on the physical appearance of hot dip galvanized surfaces. Such a request might come from a customer or end user merely seeking clarity as to whether specification for surface conditions has been met. In some instances, formal documentation is forwarded categorically claiming non-conformance to specifications.

In such matters the HDGASA proceeds with extreme caution when selected photographs are used as illustration of the areas of concern or actual potential defects. This is so since almost inevitably photos provide little by way to illustrate frequency, scale or intensity of the surface condition. A physical inspection of all articles is always best to determine compliance (or otherwise) to the standard, or whether renovation may be recommended, should surface anomalies fall within allowable parameters for repair.

The above conundrum is in part the reason that the SANS121:2024 – ISO1461:2022 standard specifies, in paragraph 5, that an acceptance inspection shall be undertaken before products leave the galvanizers custody. The standard furthermore specifies the test method of inspecting for visual appearance compliance. This method is to perform a visual inspection on all visible significant surfaces of the articles, examining with normal or corrected vision from a distance of not less than 1m. This prescription is at times considered to be contentious and written in favour of the galvanizer; however, the reason is that the zinc coating provides both a barrier to corrosion but as importantly provides cathodic protection to the steel should small breaches of the coating exist. That is, the zinc will sacrifice itself to protect the steel. Minor coating anomalies will not adversely affect service life. This is unlike in organic, or applied coating applications which serve as barrier protection only and on which a micro inspection is appropriate.

Wishing all our members, associates and general readership a happy Chistmas and best wishes for 2026.

Robin Clarke

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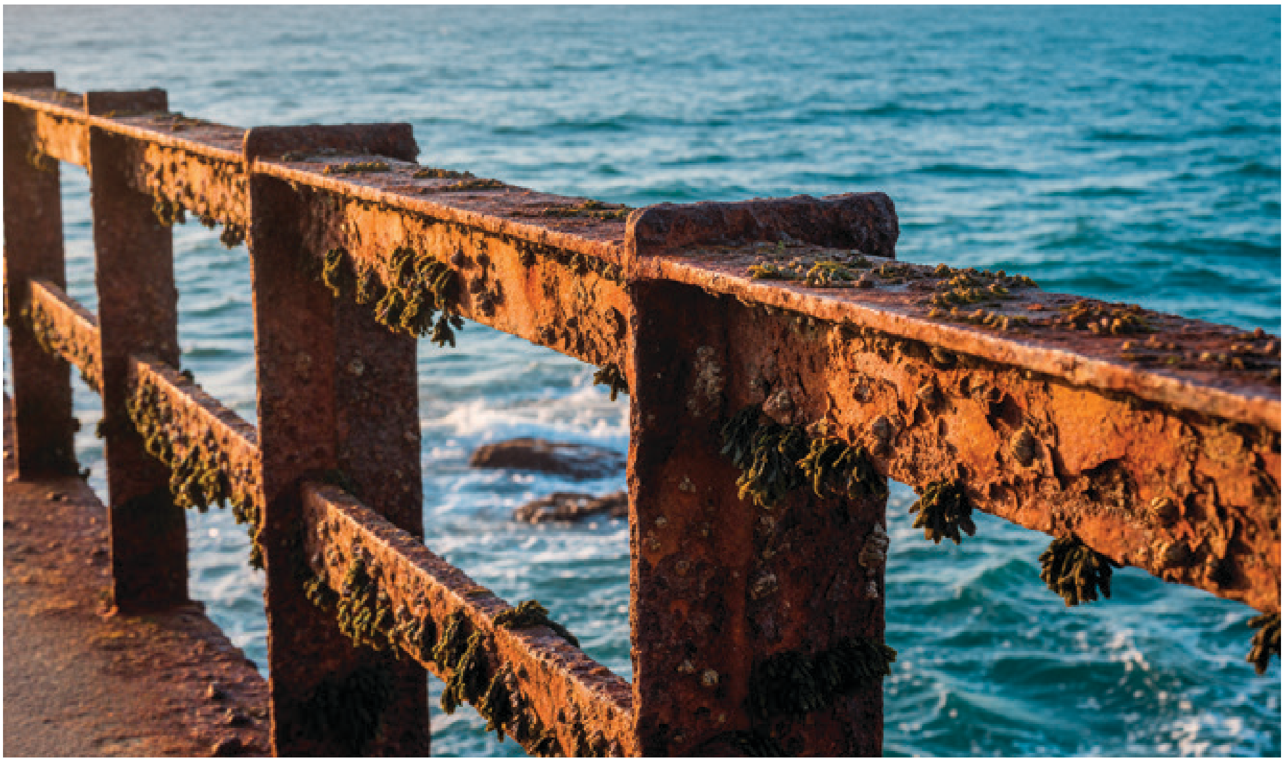
EDITORIAL COMMENT:

It is said that the way into the future is with good roads and up-to-date maps. The future inevitably rings in change, and it is necessary to have the way and the means to adopt the changes to the benefit of our society. In this issue, we focus on:

- The need for extending service life in infrastructure.
- How SANRAL has applied the concept of hot dip galvanized rebar to ensure effective, long-lasting road infrastructure on the N2 and N3 projects.
- Corrosion is an insidious condition, and planning has always been necessary to deal with the invisible adversary. We introduce the most up-to-date corrosion map of South Africa and an in-depth reprint of the article related to the 2019 updated corrosion map of South Africa.
- The need to reuse steel by refinishing, refurbishing, and reusing previously galvanized steel by re-galvanizing for effective life extension and corrosion control.
- Engaging with SAISC in a digital technical presentation allowed the HDGASA to emphasize the importance of designing for hot dip galvanizing and using the SANS/ISO 14713 standard to achieve quality hot dip galvanized articles and structures.
- Training remains as strategic today as it was 60 years ago, keeping all stakeholders on point with the technology and standards that drive our industry.
- The HDGASA has supported the industry and its customers for 60 years and looks forward to being of service well into the future, locally and globally, relevant and effective.



GALVANIZED FOR GOOD:
Extending the service life of reinforced concrete

Concrete spalling, which refers to the cracking, flaking, and delamination of concrete surfaces, is a global concern for engineers and asset owners alike. Whether the issue arises in a bridge deck or a coastal structure exposed to harsh marine environmental conditions, the underlying cause is often the same: corrosion of embedded steel reinforcement. As the steel corrodes, it expands, fractures the surrounding concrete, and compromises the structure's tensile strength and long-term durability.

At the core of any corrosion-resistant design is one fundamental truth: concrete quality is paramount. Harmful agents such as chlorides and carbon dioxide do not attack steel directly. Instead, they penetrate through the concrete cover. This is why low permeability is essential. Four key factors, commonly referred to as the "Four Cs," govern this permeability: the concrete mix (especially the water-to-cement ratio), compaction, curing, and cover depth. Despite adherence to best practices, cover depth can still be compromised during rebar placement, often without visible signs, leaving the reinforcement exposed to risk.

Hot dip galvanizing (HDG) provides a strategic solution. It does not replace good concrete practice but serves as a valuable complement. Galvanized steel reinforcement delivers dual protection. First, it forms a robust barrier composed of zinc-iron alloy layers and pure zinc. Second, it offers cathodic protection, where zinc sacrifices itself to protect the underlying steel. This makes HDG particularly effective in aggressive environments such as marine zones, industrial sites, and regions subject to freeze-thaw cycles, where uncoated reinforced concrete may fall short.

The galvanizing process is both straightforward and effective. Steel is immersed in molten zinc at approximately

450°C, resulting in a metallurgically bonded coating. The coating thickness is carefully controlled, typically kept below 200μm, to prevent brittleness caused by excessive alloy growth. A final chromate passivation step is applied to prevent white rust during storage and to shield the zinc from alkaline attack when embedded in fresh concrete.

Zinc's behaviour in concrete is well documented. In the high-pH environment of fresh concrete, zinc initially reacts to form a stable compound known as calcium hydroxyzincate, which passivates the surface. This early reaction consumes only 5 to 10μm of the outer zinc layer, preserving the integrity and functionality of the underlying alloy layers. Once the concrete has cured, zinc corrosion slows significantly, with annual loss rates averaging just 2μm under normal conditions.

Concerns regarding bond strength, particularly the impact of hydrogen gas evolution, have been thoroughly addressed through extensive research. Studies confirm that galvanized rebar performs as well as, or better than, uncoated steel. The textured surface and the formation of dense interfacial layers enhance mechanical interlock, and no modifications to anchorage lengths or design parameters are necessary.

The long-term advantages are substantial. HDG rebar extends service life, reduces maintenance requirements, and maintains structural integrity even under severe exposure conditions. It represents a cost-effective investment for critical infrastructure, including bridges, tunnels, industrial chimneys, cooling towers, and inland facilities.

In summary, hot dip galvanizing is not a substitute for sound concrete practices. It is a powerful enhancement. By increasing corrosion resistance, improving bond performance, and supporting long-term durability, HDG rebar plays a crucial role in modern concrete design and infrastructure resilience. For engineers aiming to future-proof their structures, it offers a solution that ensures strength, stability, and peace of mind.

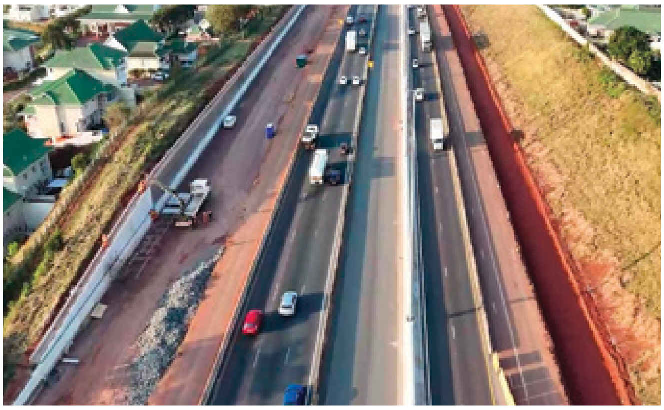
GALVANIZED REINFORCEMENT BAR:
N2/N3 SANRAL upgrade project

Reinforcement bar (rebar) is a tension device added to concrete to form reinforced concrete and reinforced masonry structures to strengthen and aid the concrete under tension.

The Hot Dip Galvanizers Association Southern Africa (HDGASA) has urged the industry to make use of galvanized rebar, which is steel that is coated in zinc to provide enhanced corrosion resistance. The galvanized protective coating protects the steel substrate from corrosion due to moisture, saturated environmental conditions, or ambient humidity.

Durban Galvanizing a member of the HDGASA, highlighted the ongoing N2 and N3 Freeway upgrades in KwaZulu-Natal, noting with excitement, that significant quantities of the rebar used for these upgrades has been galvanized. After years of persistence, the industry has increasingly recognised the necessity to use galvanized rebar, especially in the Coastal Regions.

The Association went to KwaZulu-Natal, accompanied by Durban Galvanizing to attend a meeting with SANRAL regarding the Freeway upgrades and the use of galvanized rebar. We met with Mr. Ronny (Design & Construction Manager) and Mr. Nephembani (Project Manager), who provided insight into the projects currently in progress.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Mr. Ronny affirmed that the galvanized rebar being used on the N2 and N3 road works is to improve the durability and longevity of concrete structures like bridges and barriers. Specifically, it's being implemented as part of the SANRAL N2/N3 EB Cloete upgrade at the Mbokodweni River Bridge repairs. It is estimated that approximately 8 000 tons of galvanized rebar will be utilised during these upgrades from 2025 to 2031.

Moreover, Mr Ronny mentioned that, SANRAL's primary sphere of influence is engineering; as such the N2 and N3 were designed with the needs of all road users in mind. The safety of motorists, workers and pedestrians alike was a central consideration in every decision made about construction.

Quieter pavements

By using noise-reducing asphalt mixes and specialised concrete grinding techniques, motorists travelling along the N2 and N3 will experience reduced tyre noise, ensuring a quieter and more comfortable journey.

Robust pavements

Heavy vehicles cause the most damage to roads. To accommodate the growing volumes of freight traffic on the N2 and N3, robust pavement design methods and materials have been utilized on sections most prone to deterioration.

Aesthetically pleasing

The bridge structures are built to last for decades and often serve as a gateway to a community. Good bridge design not only considers structural integrity, but also aesthetics. Therefore, SANRAL places importance on the new bridge structures along the N2 and N3 to be both durable as well as enhancing landmarks in the surrounding environments. The redesigned EB Cloete Interchange (Spaghetti Junction) will feature a cable suspended bridge from an iconic arch inspired by the design of the Moses Mabhida Stadium.

Figures 1 and 2: N2 KwaMashu Interchange.

Figures 3 and 4: Westville Viaduct.

Figures 5, 6 and 7: EB Cloete Interchange.

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MAPPING THE invisible adversary

HOW SOUTH AFRICA'S UPDATED CORROSION ZONES ARE RESHAPING INFRASTRUCTURE STRATEGY

Steel is the backbone of modern infrastructure, but its durability is constantly challenged by an invisible adversary: *atmospheric corrosion*. Driven by moisture, pollutants, and salt-laden air, corrosion silently undermines structural integrity, shortens service life, and inflates maintenance costs. For decades, engineers and asset managers have relied on broad assumptions about environmental severity.

Hot dip galvanizing provides excellent corrosion control for the service life of steel in terms of a metallic coating, simple to implement and easy to inspect. Hot dip galvanizing can be used across the full range of corrosivity categories either as a standalone technology or in synergy with a suitably specified paint system for extreme corrosion conditions.

The HDGASA is often approached to assist in the determination of rates of corrosion probabilities for a newly designed hot dip galvanized steel structure. The quantum of these queries centres around the atmospheric environments in South Africa on a macro and micro basis. Using the macro/micro corrosion category to estimate the service life of the corrosion protection.

In 2019, researchers Janse van Rensburg DT, Cornish LA, and the late Van der Merwe J, published a comprehensive update to South Africa's national corrosion map in the *South African Journal of Science*[1]. Their work offers a data-rich, statistically grounded view of how steel corrodes across the country's diverse climates, and it is already influencing design and corrosion control strategies for protecting, maintaining, and refurbishing infrastructure.

Improved measure of the level of detail in the data structure

The original corrosion map, developed in 1991, was heavily weighted toward coastal data and lacked inland resolution. The 2019 update corrected this by analysing over 100 exposure sites nationwide, measuring first-year corrosion rates of mild steel, a reliable proxy for atmospheric aggressiveness. Together with the rate of corrosion of zinc in SANS ISO 9223, clarity of inland microclimates can now be better used to ensure effective specification of hot dip galvanizing for optimised service life of the HDG coating.

The findings revealed striking variability:

- **Inland corrosion rates** ranged from as low as **1.3μm/year** in the arid Droërivier region to **over 50μm/year** in industrial hubs like Germiston and Sasolburg.
- **Coastal zones** showed steep gradients in corrosion severity, with rates dropping by up to **80%** within the first kilometre from the shoreline.
- **Altitude, humidity, and SO_2 levels** emerged as key modifiers, especially in high-traffic or industrial zones.

This level of data granularity allows engineers to align protection strategies, such as galvanizing, regalvanizing, or duplex coatings, with actual environmental exposure, rather than relying on generalised assumptions. This emphasises the HDGASA's long-held position that both the macro and micro conditions must be understood when implementing a corrosion control solution for steel.

Implications for asset protection

The updated map supports more accurate classification of corrosivity zones using the SANS ISO 9223 standards, enabling tailored decisions for coating selection, inspection intervals, and refurbishment planning.

For example:

- In **low-corrosivity inland zones (C2 - C3)**, standard hot dip galvanized coatings (≥85µm[>6mm Thk Steel]) may deliver over **30 years** of corrosion control with minimal maintenance.
- In **high-corrosivity coastal or industrial zones (C4 - C5)**, thicker coatings or duplex systems may be required to achieve comparable durability.
- **Inspection intervals** can be optimised based on zone severity, ranging from 5 to 20 years depending on exposure and coating type.

These insights are especially valuable for engineers managing ageing infrastructure, where decisions about refurbishment, replacement, or protective upgrades must be grounded in environmental reality.

Engineering meets strategy

By integrating SANS ISO 9223 corrosivity categories with localised data, the corrosion map enables:

- More accurate lifecycle costing and service life prediction
- Strategic planning for coating systems and maintenance schedules
- Risk-based asset management across diverse geographic zones

It also supports the development of corrosion exposure matrices and degradation models, helping quantify the trade-offs between protection cost and expected performance.

For instance, a galvanized steel structure (>6mm thick, steel) in a C3 inland zone may well retain over 70µm of zinc coating after 25 years, while the same structure in a C5 coastal zone may require recoating or replacement within 15 years.

Toward smarter infrastructure management

The updated corrosion map is more than a technical reference; it's a strategic enabler. It allows South Africa's engineers, fabricators, and asset managers to move from reactive maintenance to proactive planning, aligning protection strategies with environmental realities.

In a country where infrastructure spans deserts, coastlines, industrial belts, and high-altitude plateaus, this level of insight is not just useful, it is essential.

Downloading the original article at: *https://doi. org/10.17159/sajs.2019/4901* will maintain feedback important to Darelle Janse van Rensburg's research and consulting in dealing with corrosion control in a practical and scientifically valid manner, enabling effective engineering in the 21st century.

[1]**Citation**

Janse van Rensburg DT, Cornish LA, Van der Merwé J. Corrosion map of South Africa's macro atmosphere. S Afr J Sci. 2019;115(7/8), Art. #4901, 8 pages. https://doi. org/10.17159/sajs.2019/4901

CORROSION MAP OF South Africa's macro atmosphere

Figure 1: Atmospheric corrosion map of southern Africa – adapted from the Callaghan 1991 map[1] and taken from Janse van Rensburg (2010)[7].

The first atmospheric corrosion map of South Africa, produced by Callaghan in 1991, has become outdated, because it primarily focuses on the corrosivity of coastal environments, with little differentiation given concerning South Africa's inland locations. To address this problem, a study was undertaken to develop a new corrosion map of the country, with the emphasis placed on providing greater detail concerning South Africa's inland regions. Here we present this new corrosion map of South Africa's macro atmosphere, based on 12-month corrosion rates of mild steel at more than 100 sites throughout the country. Assimilations and statistical analyses of the data (published, unpublished and new) show that the variability in the corrosion rate of mild steel decreases significantly moving inland. Accordingly, the average first-year corrosion rate of mild steel at the inland sites (at all corrosion monitoring spots located more than 30km away from the ocean) measured 21±12μm/a [95% CI: 18 - 23μm/a]. The minimum inland figure was about 1.3μm/a (recorded at Droërivier in the Central Karoo) and the maxima were approximately 51μm/a and 50μm/a in the industrial hearts of Germiston (Gauteng) and Sasolburg (Free State), respectively. The variability in the corrosion rate of mild steel also decreased by as much as 80% between 150m and 1 000m from the coastline. Moreover, the impact of changing altitude on the corrosivity of the environment was confirmed, particularly along the coastal regions.

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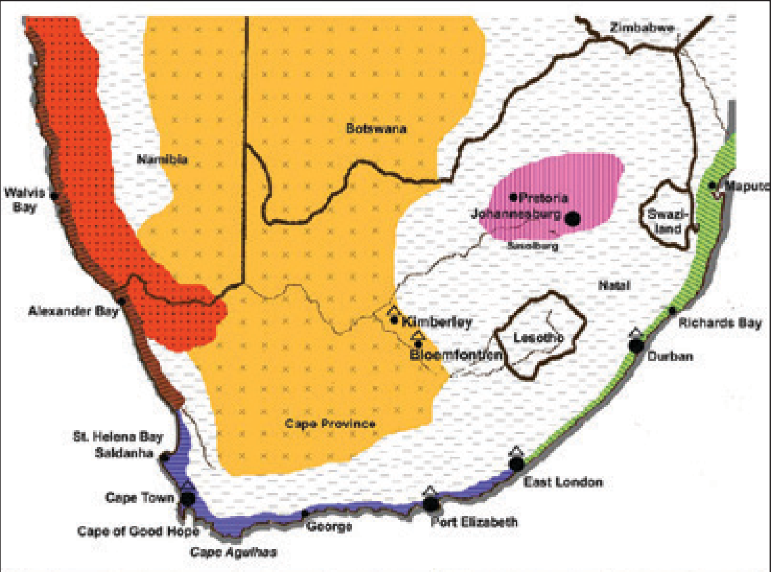


Key	Description	Type of corrosion	Mild steel corrosion rate μm/year	Galvanised steel sheet life in years
	Inland arid	Semi desert	5 – 10	> 30
	Inland	Rural	10 – 20	> 20
	Inland dry	Desert	< 5	> 30
	Inland urban	Inland industrial	15 – 40	5 – 15
	Inland	Industrial	10 – 30	5 – 15
	Sub-tropical marine	Medium to severe marine	50 – 80	3 – 5
	Desert marine (mists)	Severe marine corrosion	80 – 100	0.5 – 2
	Temperate marine	Marine	30 – 50	3 – 7
	Intertidal to 5 km inland	Severe marine corrosion	100 – 300	Up to 3

Significance

- A new corrosion map of South Africa's inland and coastal regions is presented.
- The map facilitates the identification of South Africa's least to most corrosive environments; enabling the selection of more appropriate corrosion protection solutions for general, business, mining and industrial installations.
- In identifying South Africa's least corrosive areas, the use of more environmentally friendly corrosion protection procedures is potentially encouraged.

Introduction

The first atmospheric corrosion map of South Africa was published 28 years ago.[1] This map (*Figure 1*), referred to as the Callaghan map, was developed based on the atmospheric corrosion monitoring results of studies conducted during the

1970s to 1990s, at 11 sites, of which 60% were situated along the South African and Namibian coastlines.

Since its publication in 1991, the Callaghan map has undergone only minor adaptations.[2-7] However, due to the lack of differentiation of inland locations, overstatement of the corrosivity of environments, changes in international standards regarding the measurement of corrosive atmospheres, increased industrialisation of South Africa's large metropolitan areas, global climate change effects, and improved mapping techniques,[8] this chart has become outdated.

Background

Corrosion maps are useful tools in many scientific and engineering fields, e.g. in research, design, construction, maintenance, and operations, as well as from a public perspective. Corrosion maps are also advantageous in the sense that they provide potential means to assess the effects of pollution[9] and climate change[10,11] on communities, materials and the environment.

According to The Worldwide Corrosion Authority (NACE)[12], the cost of corrosion in 2016 was estimated to be USD2.5 trillion (about 3.4% of the global GDP). This average is based on the results of corrosion cost studies conducted by the USA, India, Japan, Kuwait and United Kingdom. It is reported that about 15 - 35% of this cost can be saved by using effective preventative measures. A similar study was also conducted in South Africa in 1986.[13] During the South African study – which covered the mining, power generation, shipping and transportation sectors – corrosion protection preventative measures, metal losses and replacement costs were estimated at ZAR1 250 million/annum or USD625 million/annum.[13] This number was based on an exchange rate of approximately USD1:ZAR2 at the time[14], which amounted to about 5% of South Africa's GDP.

In line with The World Bank's[15] 2017 numbers, South Africa's GDP was given as USD348.9 billion (approximately ZAR4 885 billion). By applying NACE's 2016 figure of 3.4% of the global GDP as the cost of corrosion per annum, this means that, currently, about ZAR166 billion is spent annually in South Africa in trying to combat or prevent corrosion problems. Of this amount, atmospheric corrosion of coated and uncoated metal surfaces is viewed as a significant contributor – more than 50% or ZAR83 billion.[11,16,17] Undoubtedly, the usefulness of corrosion maps to prevent or manage corrosion problems is immense.

Historical overview of South Africa's atmospheric corrosion data

Pre-1970, several small atmospheric corrosion monitoring studies were carried out in South Africa. The Council for Scientific and Industrial Research (CSIR)[18] and Callaghan[1] provided comprehensive overviews of these very early exposure programmes. Post-1970 to the early 1990s, the first national exposure programme was conducted.[1] The initial work involved two 4-year exposure programmes, of which one included the exposure of a range of metals and alloys[18], while the other involved metallic coatings on steel substrates at several sites throughout South Africa.[1] However, because of shortcomings identified with these very early exposure studies, a 20-year exposure programme was initiated. This work was conducted at sites in Cape Town, Port Elizabeth, Strandfontein, Pretoria, Sasolburg, False Bay, Durban, Simonstown and East London in South Africa, and in Gobabeb and Walvis Bay in Namibia, which culminated in the publication of the first corrosion map of southern Africa *(Figure 1)*.[1]

From 1990 to 1993, Eskom Holdings SOC Limited, the leading electricity producer in South Africa, henceforth referred to as 'Eskom', conducted atmospheric corrosion research work along the eastern, southern and western Cape coastlines.[19] Their study involved exposure to the corrosive marine atmosphere of wire-on-bolt (CLIMAT) units, currently manufactured according to ASTM G116:1999[20] procedures.

Simultaneously, Eskom launched a 5-year corrosion study relating to the atmospheric corrosivity of sites in other areas along the South African coastline, as well as in the southern and eastern Highveld regions. This work, done by Nixon and Janse van Rensburg[21-23], Colloby[24] and Northcott[25], entailed the exposure of mild steel, copper, aluminium, zinc, galvanised mild steel, stainless steel and 3CR12 panels to different corrosive atmospheres. Changes in the electrical resistance of iron, zinc, copper and aluminium were also investigated.[24] The studies were performed at locations near Melkbosstrand, Klienzee, Richards Bay, Kriel, Sasolburg, Elandsfontein, Bethal (Palmer), Volksrust and Vanderbijlpark.

During 1991 to 1994, a 3-year project was launched by the CSIR in the Eastern parts of the Gauteng Highveld region. This study was performed in conjunction with Eskom at sites located at Pretoria, Grootpan (close to Ogies), Elandsfontein and Verkykkop (in Volksrust).[21-23,26] The purpose of the CSIR research work, done by Gnoinski and Ramothlola, was mainly to determine the effectiveness of a rapid method for the assessment of atmospheric corrosion.[26]

Numerous atmospheric corrosion tests were also carried out by John E. Leitch, over a period of more than 20 years.[4] His work was done mainly on behalf of Hulett Aluminium (Pty) Ltd, the CSIR, Eskom, and other interested parties. During earlier years, Leitch's studies primarily involved the exposure of wire-on-bolt units to different corrosive atmospheres – to classify the atmospheres of sites using the CLIMAT (CLassify Industrial and Marine ATmospheres) method.[27] However, with the inception of a new technique for the corrosion monitoring of atmospheric environments in 1992, for which the methodology is described in detail in ISO 9223:1992[28] and ISO 9226:1992[29], most of Leitch's work in his later years was effected in accordance with the open wire helix (zinc and aluminium) method[3,5]. Leitch's studies culminated in the publication of an updated corrosion map of South Africa in 1999[3], and again in 2003[4], with the latter chart subsequently incorporated into SANS 1796:2013[30].

The new maps were hailed in the sense that they represented the first attempts by a South African researcher to classify the corrosivity of atmospheric environments based on the ISO 9223 and ISO 9226 procedures.[27,28] Leitch employed the ISO 9226:1992 open zinc and aluminium wire helix technique at places such as Cape Town, Mossel Bay, Port Elizabeth, Durban, Umhlanga Rocks and Richards Bay.[4]

In 2005, the Hot Dip Galvanizers Association of Southern Africa (HDGASA)[6] also published an updated atmospheric corrosion map for zinc (after the Callaghan map) based on the ISO 9223:1992 classification system. Additional work worth mentioning is that of Vosloo of Eskom, in partnership with Pietersen and Holtzhausen of the Stellenbosch University.[31] Their studies involved the development of an insulator pollution severity application map for South Africa, which added to the knowledge base relating to atmospheric pollution in South Africa. Calitz and Potgieter[32] also conducted atmospheric corrosion studies of overhead power transmission conductors at a marine site near Koeberg Nuclear Power Station, situated along the Western Cape coastline.

The SAIAE (South African Institute of Agricultural Engineers) likewise launched an 11-year atmospheric exposure programme on five diverse agricultural wire types at seven sites in South Africa.[33] Findings of this work, dating back to December 1990, are currently still used to provide recommendations regarding suitable fencing materials for different corrosive environments. Materials tested included light galvanised, heavy galvanised, aluminium coated, Galfan and 3CR12 wires, which were exposed at Bathurst and Riviersonderend. Work in this field was also conducted by R.J. Bronkhorst and K.L. Rodseth.[33]

Between 2005 and 2010, Janse van Rensburg[34] initiated one of the most extensive atmospheric corrosion programmes in South Africa. This study, performed on behalf of Eskom, involved the atmospheric corrosion monitoring of 50 sites throughout South Africa – covering both inland and coastal regions. Janse van Rensburg also conducted smaller studies at other locations in the country.

Moreover, during 2013 to 2017, a further study was undertaken that focused on the development of a new corrosion map for South Africa,[8] also providing greater detail concerning the atmospheric corrosivity of South Africa's inland industrial areas. This new South Africa atmospheric corrosion map, based on assimilations and statistical analyses of the historical published, unpublished and new 12-month corrosion rates of mild (carbon) steel, as measured at different sites throughout South Africa, is presented in this paper.

General methodology of historical and new corrosion monitoring studies

In general, corrosion monitoring sites were established throughout South Africa, covering industrial, marine, desert, urban and rural environments. The methodology followed mainly involved the exposure of mild steel (low carbon steel) coupons to the different environments over a period of 12 months, after which weight-loss measurements of the metal coupons were conducted. This was after chemical cleaning of the metallic test coupons by conventional procedures, like ISO 9226,[29,35] followed by drying and reweighing of the test specimens. Subsequently, the 12-month corrosion rate of each mild steel coupon was calculated as per *Equation 1*.[29,35]

$$\text{Corrosion rate of metal} = \frac{\Delta m}{Atp} \qquad \text{Equation 1}$$

where: Δm is the mass loss in grams (g); A is the exposed surface area in m^2; t is the exposure time per annum; and p is the density of the metal (g/cm^3). The corrosion rate (r_{corr}) is in µm/a, and the density of the steel was taken as $7.86 g/cm^3$.[29,35]

The corrosivity of the atmosphere was classified successively based on the 12-month corrosion rate of mild steel as per the ISO 9223:2012 rating scheme: C1 – *very low* (≤1.3µm/a), C2 – *low* (≤25µm/a), C3 – *moderate* (≤50µm/a), C4 – *high* (≤80µm/a), C5 – *very high* (≤200µm/a) and CX – *extreme* (≤700µm/a) corrosive.[36] The corrosion data were then processed into an atmospheric corrosion map of South Africa using Esri ArcGIS 10.2, which is a geographical information system (GIS) developing

Figure 2: Atmospheric corrosion map of South Africa[8] (base maps provided by Esri – ArcGIS and the South African Weather Service).

Caveat: This map is issued for general information purposes only and does not consider any plant design, operational mode or site-specific pollution that can influence the corrosivity of local atmospheres. The authors accept no responsibility for the use of this map.

software programme. It is noteworthy that because of the sensitive nature of some of the sites, not all the site names or detailed corrosion data are given. Consequently, the results are presented as an interpolated corrosivity map, for which legends are provided.

Regarding the latest corrosivity map, the interpolated vector data are projected over physical and annual rainfall maps for South Africa, as supplied by Esri ArcGIS and the South African Weather Service. Furthermore, select conventional map symbols are included to facilitate ease of interpretation and widespread use of this map.

Results and discussion

The new atmospheric corrosion map for South Africa is presented in *Figure 2*,[8] while the linked meteorological and corrosion data for some of the sites are given in *Table 1*.

2

Site name	Approximate average rainfall per annum (mm/a)	Approximate average midday temperatures (°C)	Approximate average first-year corrosion rate of mild steel (µm/a)	References
Bedford	390	17.8–27.8	12	7,37
Belfast	674	14.7–22.5	18	22,37
Cape Town – Ysterplaat	788	15.5–25.9	28	1,37
De Aar	196	16.0–30.3	2	7,37
Dealesville	357	17.0–30.0	7	7,37
Droërivier	160	16.8–30.9	1.3	7,37
Durban – Bayhead	759	22.2–27.4	66	1,37
Durban – Congella	759	22.2–27.4	122	1,37
Durban – Salisbury Island	759	22.2–27.4	134	1,37
Empangeni	948	23.0–29.0	58	7,37
Gariep	273	15.8–31.3	4	7,37
Germiston	601	16.5-26.1	51	7,37
Grabouw	990	15.0–24.8	20	7,37
Melkbosstrand	318	16.0–27.0	460	7,37
Mossel Bay	333	18.4–26.0	57	7,37
Oyster Bay	591	18.2–24.2	40	37
Sasolburg	550	17.0–27.9	50	7,37
Secunda	560	16.4–25.8	38	7,37
Vredendal	105	19.2–31.5	16	7,37

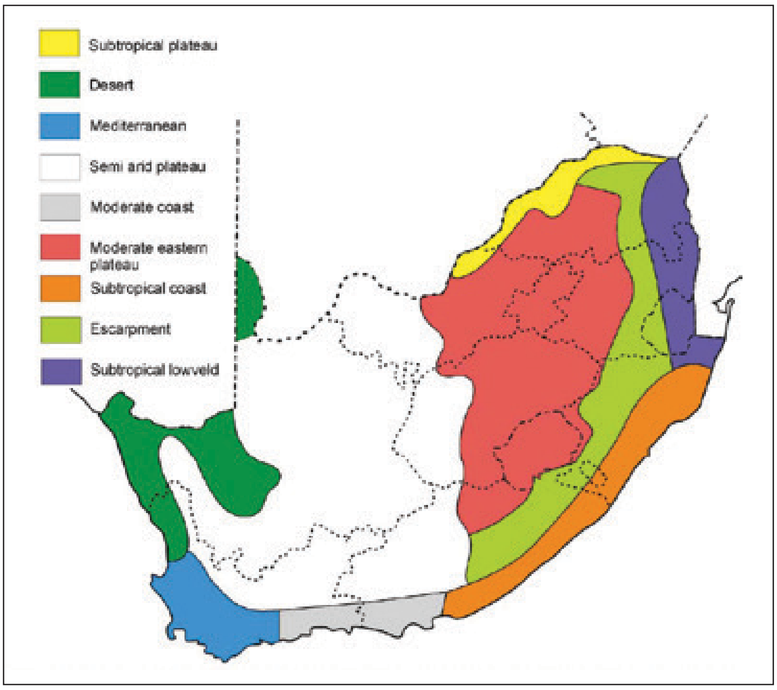
Table 1: Meteorological data and first-year corrosion rates of mild steel for select historical and new corrosion monitoring sites.

Assimilations, statistical analyses and interpolations of the 12-month corrosion rates of mild steel for South Africa and the Highveld region, based on the historical published, unpublished and new data, revealed that the average first-year corrosion rate of mild steel at the inland sites (at all corrosion monitoring spots located more than 30km away from the ocean) was about 21±12μm/a [95% CI: 18 - 23μm/a]. The minimum inland measurement was about 1.3μm/a and was recorded at Droërivier in the Central Karoo, a hot semi-arid environment *(Table 1 and Figure 3)*. The maxima, of approximately 51μm/a and 50μm/a were recorded in Germiston (Gauteng) and Sasolburg (Free State), respectively,[7] both located in South Africa's heavy industrialised Highveld and Vaal Triangle areas, with average rainfall of approximately 550 - 600mm/a.[37] It is significant that these corrosion rates are outside the 5 - 40μm/a range given in the Callaghan map for inland (arid, rural, urban and industrial combined) environments.[1]

Based on the assimilated results, the inland sites vary from low to potentially highly corrosive, corresponding with the lowest limits given in the ISO 9223 standard for C2 and C4 corrosive environments, namely 1.3μm/a and 50μm/a, respectively.[36] This finding suggests that in the desert and semi-arid (non-industrial) inland areas, with average low rainfall (≤400mm/a),[37] the corrosivity of the environment is better rated *very low* (C1) to *low* (C2) corrosive. Conversely, in inland areas with an average rainfall of more than 400mm/a,[37] the atmosphere is best ranked *low* (C2) to *moderate* (C3) corrosive, with a potential for *high* (C4) corrosive 'hotspots', in and around heavy-industrial locations.

Figure 3: Climatic regions of South Africa[48]; note the climatic variations along the coastlines.

3



Concerning the coastal regions of South Africa, the average first-year corrosion rate of mild steel exposed within the first 150m from the highwater mark, was 319±112μm/a [95% CI: 215 - 422μm/a]. The minimum value was about 134μm/a (recorded at Salisbury Island in Durban)[1] and the maximum near 460μm/a (measured close to Melkbosstrand in the Western Cape)[7]. This finding was despite the fact that the former site exhibits higher rainfall than the latter locale *(Table 1)*, and was attributed to the increased surf action near Melkbosstrand compared to the calmer sea and landscaped terrain of the Salisbury Island area.[7] These findings concur with ISO 9223:2012 relating to the factors affecting the deposition rate of chlorides along coastlines.[36] The data further suggest that the atmosphere within the first 150m from the shoreline can be rated as *extremely* (CX) corrosive, as per ISO 9223.[36] However, as shown by the high standard deviation, the variation in the corrosivity of the atmosphere along the coastline is substantial and depends on the surf action of the ocean, the altitude, topography, temperature and onshore wind flow (i.e. speed and direction).[1,7]

Regarding those sites which are located within 150 - 1 000m from the shoreline, the average first-year (12-month) corrosion rate of mild steel was 60±22μm/a [95% CI: 45 - 75μm/a]. The lowest value was about 40μm/a (at Oyster Bay in the Eastern Cape) and the highest was approximately 122μm/a (at Congella in Durban)[1], which is expected as Oyster Bay exhibits lower rainfall and midday temperatures than Durban *(Table 1)*[37]. The above range is significantly lower than the 100 - 300μm/a span given in the Callaghan map for the intertidal to 5-km zone along South Africa's coastline. It is also far less than the C5 (200 - 300µm/a) classification given in the HDGASA map.[6] Evidently, the 150 - 1 000m zone along South Africa's coastline is best classified mid-C4 *(high)* to mid-C5 *(very high)* corrosive.

Of note is the near 80% reduction in variability in the corrosion rate of mild steel for the 150 - 1 000m zone along the coastline, compared to that of the first 150m from the ocean, with a change in the standard deviation from 112µm/a to 22µm/a *(Figure 2)*. This decrease suggests that the effects of airborne salts, altitude, topography and onshore wind flow on the atmospheric corrosivity of the environment lessen when moving inland. Janse van Rensburg[8] made a comprehensive study in this regard. Doyle and Godard[18,27] also reported an 80 - 85% decrease in the corrosivity of the environment within the first 800m from the ocean in Durban and Port Elizabeth. Similarly, O'Donnell et al.[33] found a 'rapid' change in the corrosivity of marine atmospheres, mainly from 1km onwards.

The sharp decrease in the corrosivity of the environment within the 150 - 1 000m zone is likely attributable to the gravitational settling, turbulence diffusion and momentum-dominated impact of the airborne salts[38] within the first 150m from the sea, causing lower levels of salts (chlorides) to be deposited onto surfaces in the following 150 - 1 000m span. Denser and more abundant vegetation next to the coast, as encountered along the eastern coastline[39], further encourages the deposition of aerosols within a shorter distance from the ocean[40]. This dramatic change in the deposition rate of salts in marine environments, particularly within 1km from the ocean, has also been demonstrated during other corrosion studies.[41]

At 1 - 3km from the ocean, the average first-year corrosion rate of mild steel decreases further to about 43±14µm/a [95% CI: 28 - 58µm/a], suggesting significant stabilisation of the corrosivity of the environment with increasing distance from the ocean. The minimum recorded value was approximately 28µm/a (at Ysterplaat in Cape Town)[1] and the maximum about 66µm/a (at the Durban Bayhead)[1]. Of significance is that the former locale is situated to the west of Cape Town, and is separated from the ocean by numerous houses, industrial plants and office buildings. Conversely, the Durban Bayhead site is not only located in a high rainfall, sub-tropical region *(Table 1 and Figure 3)*, but is also nearly encircled by the Durban Harbour, causing a further spike in the local relative humidity levels, while the open sea is positioned close by to the eastern side, resulting in an increase in airborne salt concentrations.

Regarding mild steel corrosion, the 1 - 3km zone along the South African coastline is best classified as *moderate* (C3) corrosive, which is significantly overstated in the older maps. Concerning Callaghan's map[1] *(Figure 1)*, the corrosion rate of mild steel in the 'Intertidal to 5km inland mark', is given as 100 - 300µm/a, whereas in the case of the HDGASA map[6], the 'Exterior: industrial with high humidity or high salinity coastal' region is given as varying between 80µm/a and 200µm/a.

The average first-year corrosion rate of mild steel at all sites located within 3 - 10km from the coastline, measured 37±13µm/a [95% CI: 27 - 47µm/a]. The lowest was about 20µm/a at Grabouw in the Western Cape (above Sir Lowry's Pass near Gordons Bay)[7] and the highest was approximately 57µm/a at Petro SA's Mossgas plant near Mossel Bay[7]. This finding is irrespective of the fact that Grabouw is located in a higher rainfall region than Mossel Bay *(Table 1)* – the lower corrosivity of the former site being attrbuted to its elevation of approximately 265m above sea level,[42] whereas the latter exposure site is located at a much lower altitude, thus being more exposed to the salt-laden winds from the ocean. Hernandez et al.[43] and Del Angel et al.[44] similarly found that altitude plays a significant role in marine corrosion. The overall results also suggest a decrease in the average corrosivity of the atmosphere by approximately 6µm/a (from about 43µm/a to 37µm/a), between the 3km and 10km marks, with an additional ~1% stabilisation of the corrosivity of the atmosphere. Typically, this zone may be classified as *moderate* (C3) corrosive.

Regarding the 10 - 30km region, the average first-year corrosion rate of mild steel measured 35±14µm/a [95% CI: 22 - 48µm/a], suggesting a further ~1% decrease in the average corrosivity of the atmosphere. Correspondingly, this zone along South Africa's coastline is best classified as *moderate* (C3) corrosive. The minimum recorded value was approximately 16µm/a at Vredendal in the Western Cape[7] and the highest was about 58µm/a at a site in Empangeni (KwaZulu-Natal)[7]. Noteworthy is the significant difference in the corrosivity of these two sites, which can be ascribed to their unique meteorological conditions *(Table 1 and Figure 3)*, with Vredendal in a hot semi-desert environment and Empangeni in a high-rainfall, sub-tropical region.

The apparent slowdown of further stabilisation of the corrosivity of the environment is of note, and implies that, from approximately 30km onwards, windborne marine salts are no longer the dominant force driving the atmospheric corrosion process. This demarcation line was also identified by Callaghan in 1991.[1] However, the coefficient of variation of the average corrosion rate of mild steel remained high at nearly 40%. Congruently, studies in other countries showed that sea salts may still affect atmospheric corrosion more than 50km[45] to 1 400km[46] from the ocean.

Of further importance is the emerging trend that test sites located along the eastern coast (particularly along the KwaZulu-Natal seashore) are inclined to higher corrosivity, at the same distance range from the ocean, compared to sites located next to the Western and Eastern Cape ocean fronts. This tendency appears to be valid for the 150 - 1 000m, 1 - 3km, 3 - 10km, and 10 - 30km ranges from the sea. It is just below the 150-m mark that the corrosivity of the atmosphere along the Western Cape coast appears higher in comparison with the Eastern Cape and KwaZulu-Natal shorelines.

The above alteration in the corrosivity of the environment next to the South African coastline is mainly attributable to the varying meteorological *(Table 1 and Figure 3)*, physical *(Figure 2)* and biome conditions. Concurring with Winter et al.'s[47] climatic regions, the Northern Cape coastline, i.e. from the mouth of the Orange River to Lamberts Bay, is classified as Desert, the Western Cape coast from Lamberts Bay to the mouth of the Breë River as Mediterranean, from the Breë River to Port Elizabeth as Moderate Marine, and the northern parts of the Eastern Cape coastline, i.e. from Port Elizabeth to northern KwaZulu-Natal, as Sub-tropical *(Figure 3)*.[48] Cole et al.[49] state that marine aerosol transport is likely to be favoured in dry environments that exhibit

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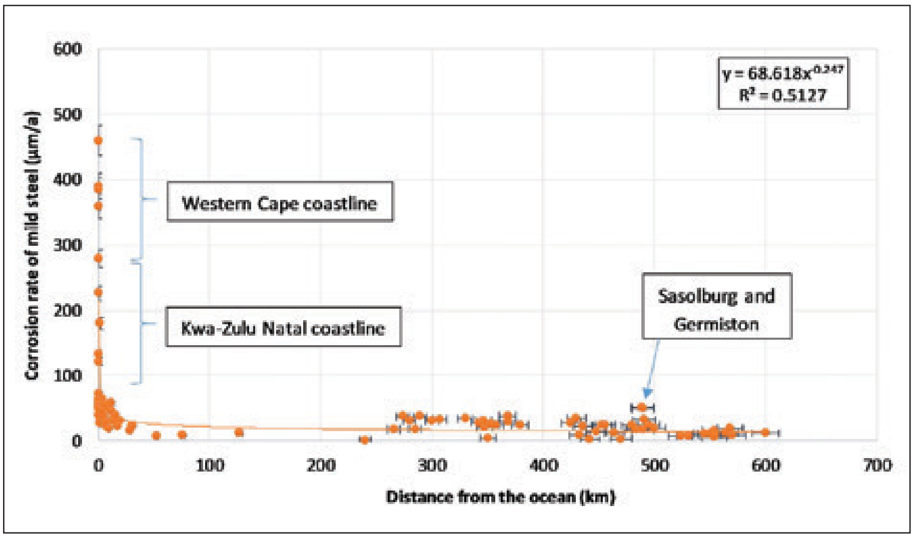


Figure 4: First-year (12-month) corrosion rates of mild steel, measured at numerous sites in South Africa, versus the approximate distances of the sites from the ocean.

reduced rainfall and low ground coverage, like in the Northern and Western Cape, than in more humid and higher rainfall climates with forest cover. The change in the corrosivity of the atmosphere, as a result of increasing temperatures, rainfall and relative humidity (moving from the western to eastern parts of South Africa), is partly reflected in the Callaghan[1] and Leitch[5] maps but is absent in the HDGASA[6] chart.

The higher corrosion rate of mild steel below the 150-m mark (along the Western Cape shoreline) may in all likelihood be ascribed to the presence of smaller dunes and shrubbery, called fynbos.[50] Fynbos offers less shielding against sea sand and spray, which is whipped up by the high winds from the ocean and dunes, and deposited onto surfaces. Conversely, along the Eastern and KwaZulu-Natal coastlines, the larger and broader leafy sub-tropical plants[50] provide better protection against windborne salts. The presence of lingering mist banks (due to the cold Benguela current), reduced rainfall (no washing effect) and prevailing strong onshore winds (southeaster primarily along the Western Cape, as well as parts of the Eastern Cape coastlines), also play important roles in the corrosivity of this region.[1,18,51] Nixon and Janse van Rensburg[21] reported that along the Northern and Western Cape coastlines, the highest atmospheric corrosivity is typically measured during winter, from about March to September, which corresponds with this region's rainy season. Conversely, next to the eastern coastline, the highest atmospheric corrosion rates are primarily measured during summer.[7]

Just below the Great South African Escarpment, the average corrosivity of the environment in the Western and Eastern Cape measured 7±6µm/a [95% CI: 0 - 20µm/a], with a minimum of about 1.3µm/a at Droërivier and a maximum of near 12µm/a at Bedford,[7] corresponding with the difference in the rainfall figures for these locations *(Table 1)*. Moving further inland from the low-lying zones of the Northern, Eastern and Western Cape coastlines, above the Great South African Escarpment (onto the Central Plateau), the conditions change to a desert/semi-desert plateau (the Kalahari Desert and the Karoo). In this region, the corrosion rate of mild steel measured close to 2µm/a (at De Aar) and near 4µm/a at Gariep,[7] averaging 3±1µm/a. This region is best classified as *low* (C2) corrosive, due to the hot arid conditions. From thereon, the corrosivity of the environment increases slightly towards the Free State, measuring approximately 7µm/a at Dealesville,[7] close to Bloemfontein, with an approximate average precipitation of 390mm/a *(Table 1)*.

Of significance is that the Kalahari, Karoo and the Free State Province are also known for their salt pans and dry riverbeds. As a result, salt-laden soil that is swept up by the wind and deposited onto metal surfaces may encourage corrosion to take place at lower relative humidity. It can also increase the time of wetness, which is of relevance when considering that the Kalahari Desert and the Karoo experience the highest percentage changes in average rainfall in South Africa, i.e. 26 - 50%.[47] These regions also display the hottest summers and highest solar irradiation levels in the country.[52,53] Consequently, the variability in the corrosivity of the environment is high. Moreover, studies conducted by Sun et al.[54] demonstrated that soluble salt in surface desert soil might sufficiently lower the relative humidity at which corrosion current density suddenly increases.

From the KwaZulu-Natal coastline towards Gauteng, the change in corrosivity of the atmosphere below and above the Great Escarpment is apparently less extreme compared to that of the Northern, Eastern and Western Cape Provinces *(Figure 2)*. This reduction is likely as the environment changes from a sub-tropical coastal to a moderate, subtropical rising rocky (escarpment) terrain that exhibits cold, snowy winters, with hot, rainy summers.[47,55] The change is also observed in *Figure 3*,[48] which presents the different climatic regions in South Africa.

Proceeding through the lower parts of Mpumalanga, the landscape changes to a temperate Highveld region,[55] classified as *moderately* (C3) corrosive. In this section of Mpumalanga, the average first-year corrosion rate of mild steel measured 29±6µm/a [95% CI: 25 - 32µm/a], suggesting an approximate 26% reduction in the corrosivity of the environment from Empangeni (located in the lowland between the Great Escarpment and the KwaZulu-Natal coastline) towards Ogies, positioned on the Eastern Highveld, likely because of changes in annual precipitation levels *(Table 1*). The maximum recorded value was near 38µm/a (at Secunda) and the minimum about 18µm/a (approximately 20km north of Belfast).[56] The increased corrosivity of Secunda and Emalahleni (Witbank) may be ascribed to the fact that these areas are some of the most polluted regions in South Africa, due to the presence of a large petrochemical plant (Sasol Synfuels), 11 coal-fired power stations and numerous open-cast coal mines.

Shifting towards the North West, Limpopo and Gauteng Provinces, the corrosivity of the environment decreases further. In the case of Gauteng and closely surrounding areas, the average first-year corrosion rate of mild steel measured 25±12µm/a [95% CI: 19 - 32µm/a] (C2), falling to approximately 12±5µm/a [95% CI: 9 - 16µm/a] (C2) towards the Limpopo River (Zimbabwe) and Botswana border, mainly due to a reduction in precipitation levels.

A graphic representation of the first-year corrosion rates of mild steel, measured at all the corrosion monitoring sites, versus their approximate distances from the ocean, is presented in *Figure 4*. Based on the plot, the macro corrosive atmosphere of South Africa stabilises, meaningfully, moving inland, with the corrosive effects of coastal environments being inversely related to their distance from the ocean, with an R^2-value of about 0.5 and Pearson product-moment correlation (PPMC) coefficient *(Equation 2)* of around -0.4, significant at $p \leq 0.05$. Similar graphs have also been reported for sea-salt transport, deposition and corrosion along other coastlines[41,57,58] – all displaying a significant decrease in the corrosivity of the marine environment within 1 - 2km from the ocean.

The formula for the PPMC coefficient, r, is:

$$r = \frac{\Sigma(x-\bar{x})(y-\bar{y})}{\sqrt{\Sigma(x-\bar{x})^2\,\Sigma(y-\bar{y})^2}} \qquad \text{Equation 2}$$

where *x* and *y* present the data points, and *x* and *y* means the averages for array1 and array2, respectively.[59]

In contrast, *Figure 5* gives the first-year corrosion rates of mild steel, measured at all the corrosion monitoring sites versus their relative altitudes in metres. According to the graph, the corrosivity of South Africa's atmosphere is also slight to moderately negative related to elevation, exhibiting a PPMC coefficient of -0.4, which is significant at $p \leq 0.05$. The impact of altitude on the corrosivity of the environment is of particular relevance to the coastal and inland industrial areas of the country.

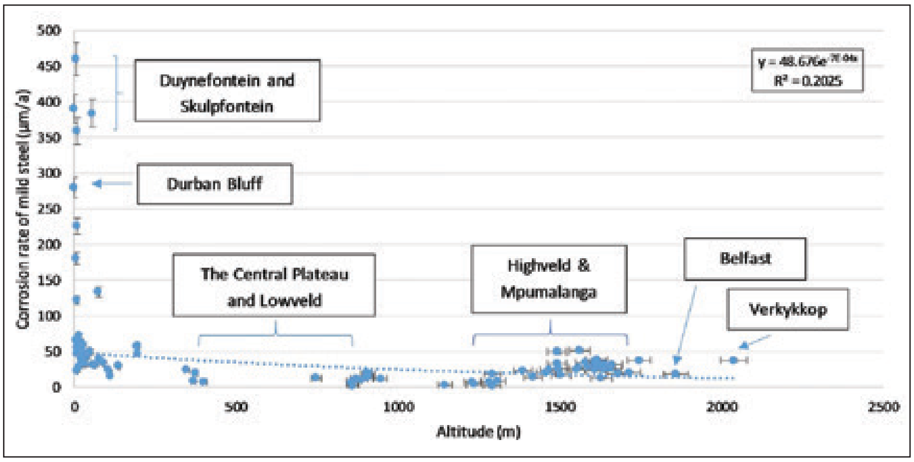
In the sub-tropical Lowveld and semi-desert Karoo regions, with altitude ranges of 500 - 1 000m, atmospheric corrosivity is notably lower. However, this decrease is because of climatic rather than altitude variations. The differences in the 12-month corrosion rates of mild steel at some of the sites, in contrast with altitude, are also presented in *Figure 6*.

At central inland locations *(Figure 6)*, it is indicated that atmospheric corrosion is no longer driven by chlorides in the air, but rather by the time of wetness, temperature, pollution (SO_x and NO_x gases), the wind, and the positioning of the metal substrate above ground level.[8] This observation may also apply to regions in and around the central inland and metropolitan areas of South Africa, e.g. the Greater Johannesburg Metropolitan Area, where it has been shown that localised mining, industrial activity, transport and vegetation play essential roles in the elevation of the corrosivity levels of the atmosphere.[8]

Conclusions

Corrosion maps provide valuable information relating to the degradation of metals and alloys in varying atmospheres. Studies on South Africa's macro atmosphere date back as far as 1947, with the scopes of the more recent studies, i.e. those between the mid-1990s and 2018, being significantly broadened to enable the use of the internationally recognised ISO 9223 corrosivity classification system.

Based on assimilated historical (published and unpublished) and new atmospheric corrosion data for South Africa, the



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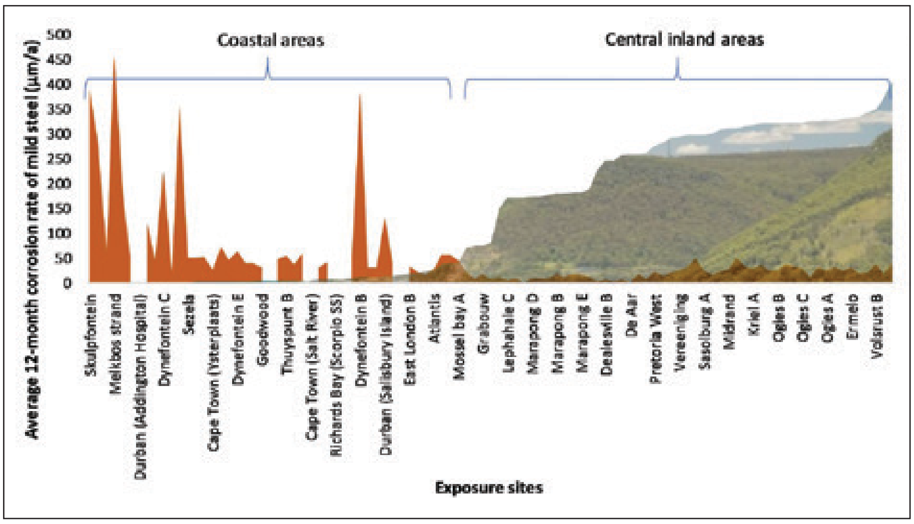

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Figure 5: First-year (12-month) corrosion rates of mild steel, measured at numerous sites in South Africa, versus the relative altitudes (elevations above sea level) of the sites.

Figure 6: Differences in the first-year (12-month) corrosion rates of mild steel at the coastal and central inland sites, versus the relative altitudes (elevations above sea level) of the sites.

atmosphere within the first 150m from the ocean is classified as *extreme* (CX) corrosive. Between the 150m and 1 000m marks, the environment is rated mid-C4 *(high)* to mid-C5 *(very high)* corrosive, from 1km to 30km *moderate* (C3) to *high* (C4) corrosive, and for most inland locations, *low* (C2) to potentially *high* (C4) corrosive. The highest atmospheric corrosivity is typically measured in the Western Cape, within 150m from the ocean, and the lowest in the Karoo and the Kalahari Desert.

The variability in the corrosion rate of mild steel was found to decrease by as much as 80% between 150m and 1 000m from the coastline, which supports the general understanding that the effects of chloride deposition, changing altitude, topography, and onshore wind flow (speed and direction), become less prominent in terms of the atmospheric corrosivity of the environment moving inland.

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Authors' contributions

The study was conceptualised, planned, carried out and written up by D.T.J.v.R., in partial fulfilment of her PhD at the University of the Witwatersrand, under the supervision of L.A.C. and J.v.d.M. Funding was acquired by D.T.J.v.R. from Orytech (Pty) Ltd. and the Hot Dip Galvanizers Association of Southern Africa, and by L.A.C. and J.v.d.M. from the Department of Science and Technology, National Research Foundation and the University of the Witwatersrand.

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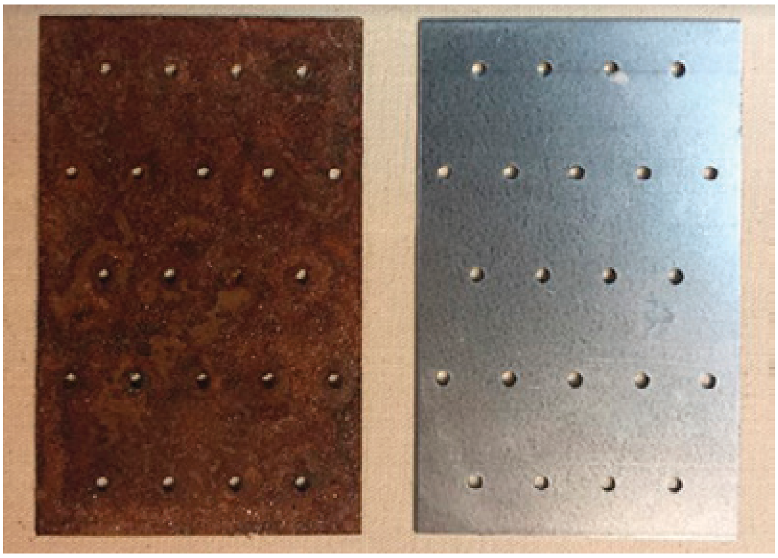
REVIVING STEEL:
Regalvanization as a cornerstone of the circular economy



In an era where sustainability is no longer optional, the regalvanization of steel has emerged as a powerful strategy for extending material lifespans, reducing environmental impact, and aligning infrastructure practices with circular economy principles. Rather than discarding aging steel components, regalvanization offers a second life, preserving embodied energy, minimizing waste, and delivering corrosion protection that rivals new fabrication.

The circular imperative

The circular economy challenges the linear "take-make-dispose" model by promoting reuse, refurbishment, and recycling. Steel, with its inherent recyclability and durability, is a prime candidate for circular strategies. However, recycling often involves melting and reprocessing, which consumes significant energy. Regalvanization, cleaning and recoating existing steel with zinc, avoids this energy-intensive step while restoring corrosion resistance.

The regalvanizing process

Regalvanization begins with a thorough inspection and preparation phase. Components are stripped of old coatings, rust, and contaminants through abrasive blasting and/or chemical cleaning.

In hot dip galvanizing surface condition plays an important role in achieving a quality HDG coated article or structure. Cleanliness of the steel is paramount to HDG coating and the final stage of such is fluxing. By ensuring optimal fluxing the steel will be in the most desirable condition to undergo immersion in molten zinc at 450°C.

The structure undergoes hot dip galvanizing, immersed in molten zinc to form a metallurgically bonded coating. After coating acceptance inspection is conducted in alignment with SANS 121: 2024 (ISO 1461: 2022).

Key considerations include:

- **Steel chemistry:** Low silicon content avoids Sandelin reactivity, ensuring uniform zinc uptake.
- **Dimensional integrity:** Regalvanized components must retain structural tolerances, especially in load-bearing applications.
- **Coating thickness:** Achieving and/or exceeding the stipulated coating minimums in line with SANS 121: 2024 (ISO 1461:2022) ensures coating durability congruent with the environment in which the regalvanized materials will be employed.

Applications in infrastructure renewal

Regalvanization is gaining traction in the refurbishment of utility structures and modular infrastructure undertaken by both SOE's and neighbouring countries. Reusing existing steel elements, such as guardrails, sign gantries, and lattice towers, reduces procurement costs, shortens lead times, and aligns with lifecycle costing models.

Environmental and economic payoffs

Regalvanization reduces greenhouse gas emissions by avoiding new steel production and zinc mining. It also preserves the embodied carbon of existing assets. From an economic standpoint, regalvanizing can cut costs by up to 30% compared to new fabrication, especially when logistics and lead times are factored into the overall costs.

Toward a circular future

As infrastructure owners and engineers embrace circularity, regalvanization stands out as a practical, standards-compliant, and economically sound solution. It bridges the gap between sustainability goals and operational realities, delivering corrosion protection, cost savings, and environmental stewardship in one elegant process.

In short, regalvanization isn't just a technical fix, it's a strategic pivot toward a more resilient and resource-efficient future.

ENGAGEMENT with the SAISC

THE SOUTH AFRICAN INSTITUTE OF STEEL CONSTRUCTION (SAISC) HOSTS REGULAR LUNCHTIME TECHNICAL SESSIONS, OFFERING MEMBERS AND GUESTS THE OPPORTUNITY TO JOIN VIA VIRTUAL PLATFORMS. THESE SESSIONS COVER A RANGE OF TOPICS RELATED TO THE DESIGN, ERECTION, AND MAINTENANCE OF STEEL STRUCTURES, AND TYPICALLY CONCLUDE WITH AN INTERACTIVE QUESTION-AND-ANSWER SEGMENT.

Recently, the Hot Dip Galvanizers Association Southern Africa (HDGASA) was invited to present to a group of 46 delegates on the principles of efficient design and fabrication practices that support optimal galvanizing outcomes. The following summary reflects the key themes shared during that engagement.

HDGASA, now in its 60th year of operation, remains committed to promoting hot dip galvanizing as a preferred corrosion control technology. This is achieved through ongoing technical support and educational outreach to designers, engineers, specifiers, fabricators, and galvanizers. By collaborating internationally on emerging trends and standards, the Association ensures that best practices are disseminated across the entire steel value chain.

We are grateful for the opportunity to engage with SAISC members and guests, and to emphasise the importance of collaboration and communication among engineers, architects, fabricators, and galvanizers in achieving consistent, high-quality galvanizing results.

Design principles and standards

Our point of departure for the session was ISO 14713 Part 1, which outlines general principles for the design and corrosion resistance of iron and steel structures. This standard provides a comprehensive overview of zinc coating types, expected performance across various environments, and essential design considerations.

Among the practical recommendations are the avoidance of pockets and recesses that trap dust and moisture, and the need to account for inaccessible areas that cannot be maintained routinely. These zones must be afforded corrosion protection that matches the intended service life of the structure. Fasteners, too, should be selected to ensure their corrosion resistance is equivalent to that of the surrounding surfaces.

The standard also addresses welding practices, emphasising the importance of weld quality and balance to minimise localised stress. The specification of low-silicon or water-soluble anti-spatter compounds is encouraged to support coating integrity.

Additional guidance is provided on the behaviour of zinc coatings in soil, water, and man-made environments, such as the performance of galvanized rebar in concrete.

Batch hot dip galvanizing: ISO 14713 Part 2

The focus of our presentation then shifted to ISO 14713 Part 2, which offers detailed guidelines for the corrosion protection of iron and steel articles intended for batch hot dip galvanizing. This section is particularly relevant for larger structural members and fabricated components.

A critical paragraph titled *"Effect of article condition on quality of hot dip galvanizing"* warrants close attention. Since the galvanizing process relies on a metallurgical reaction between the steel substrate and molten zinc, the steel's reactivity – primarily influenced by its silicon and phosphorus content, is the key determinant of coating characteristics.

For example:

- Aluminium-killed steels typically produce bright, finely textured zinc layers.
- Reactive steels yield thicker, coarser zinc-iron alloy layers.
- Silicon-controlled steels offer the most predictable and repeatable outcomes.

It is therefore essential that expectations regarding surface finish are clearly understood and communicated.

Steel surface preparation

Part 2 also calls on designers and fabricators to assess the quality of incoming steel. Roll marks, tenacious mill scale, and slag inclusions can be exaggerated during galvanizing and may result in uncoated areas.

From a design perspective, it is vital to avoid pockets or air traps that obstruct the flow of cleaning and fluxing agents during surface preparation. Annex A of the standard provides excellent illustrations for cropping gussets, stiffeners, and welds, and for incorporating lifting lugs.

Safety considerations

Safety must be addressed at the design stage. Properly sized and positioned drainage and vent holes are not only essential for coating internal surfaces, but they are also critical for operator safety.

Given that no weld can be guaranteed to be entirely free of porosity, the risk of liquid ingress into internal cavities poses a serious hazard. When submerged in molten zinc, trapped fluids can cause flashovers or explosions. Accordingly, the correct provision of vents and drains is non-negotiable. The Association offers detailed literature on sizing and placement.

Managing distortion

Solid steel sections are generally resistant to distortion at galvanizing temperatures (450°C). Nonetheless, stresses induced during fabrication, especially from continuous welds or asymmetrical designs, can lead to distortion due to differential heating and cooling rates. Particular attention should be paid to transitions between thick and thin sections.

Coating development

Coating development may be compromised in heat-affected zones, such as those created by laser cutting. These areas should ideally be re-machined or gently ground to achieve a smooth surface finish, thereby supporting uniform coating formation.

Conclusion

HDGASA remains committed to supporting the steel construction industry and welcomes further discussion on any of the points raised. We thank the SAISC for the opportunity to contribute to this valuable technical exchange.

THE STRATEGIC ROLE OF TRAINING AND EDUCATION in hot dip galvanizing

Introduction

Hot dip galvanizing (HDG) is more than a corrosion protection method, it's a precision-driven discipline that underpins the durability of infrastructure across Southern Africa. As the industry evolves to meet higher standards, tighter specifications, and sustainability imperatives, the role of **training and education** becomes central to performance, compliance, and innovation.

In this context, the **Hot Dip Galvanizers Association Southern Africa (HDGASA)** stands out as a technical and educational cornerstone, offering structured learning pathways that elevate competence across the entire value chain.

Why training is non-negotiable

From degreasing and fluxing to bath chemistry and post-treatment, every step in the HDG process demands technical fluency. Without proper training:

- Coating failures due to poor surface prep or venting design become inevitable.
- Misinterpretation of standards like **SANS 121 (ISO 1461)** or **SANS ISO 14713** leads to non-compliance.
- Duplex systems are misapplied, undermining long-term performance.

Training mitigates these risks by embedding best practices, diagnostic skills, and standards literacy into daily operations.

HDGASA: A training powerhouse

HDGASA offers a suite of **industry-specific courses** designed to build technical capacity, drive quality assurance, and support professional development. Key offerings include:

Course Title	Focus Area	Audience
Introduction to Hot Dip Galvanizing (Level I)	Overview at a high level of HDG and relevant aspects to provide an understanding of the technology.	All users, support personnel and stakeholders.
Galvanizing Inspectors Course (Level II)	Coating evaluation, standards compliance, defect identification.	Quality inspectors, engineers, plant managers
Design for Galvanizing	Venting/drainage design, duplex systems, spec alignment.	Structural engineers, architects, fabricators
Technical Plant Training	Process control, bath chemistry, troubleshooting.	Plant operators, maintenance teams
CPD-Accredited Seminars	Corrosion science, lifecycle costing, sustainability.	Specifiers, consultants, project managers

These courses are often **CPD-accredited**, ensuring alignment with professional development frameworks and engineering council requirements.

"Knowledge is the only instrument of production that is not subject to diminishing returns" John Maurice Clark

Level I: Introduction to Hot Dip Galvanizing

The HDGASA one day INTRODUCTION TO HOT DIP GALVANIZING course is designed to provide an initial understanding of the concepts relating to hot dip galvanized coatings applied for corrosion control of steel components. The course comprises six modules. In order for the course to be viable we require six or more candidates to attend. Arrangements can also be made for this course to be held at a venue of your choosing for more than six candidates. In addition to the course, a special visit to a hot dip galvanizing plant may be arranged on a separate date, should six or more candidates be interested and able to attend.

Level II: Certified Galvanizing Inspectors

The HDGASA advanced Level II course provides the necessary skills to assess the quality and conformance of Hot Dip Galvanized coatings and Duplex Systems to the applicable specification. Delegates are introduced to other metallic type coating specifications and their application for corrosion control design.

The course provides an in-depth interpretation of the specifications and accepted best practice procedures for determining coating thickness, visual inspection of surface finishes as well as the evaluation of these coatings for corrosion control of steel components. The course includes a visit to a hot dip galvanizing plant where delegates will have an opportunity to assess finished product against the relevant quality standards on a real time first hand basis.

Three Continuous Professional Development (CPD) points are awarded to delegates attending the entire course. Bookings are limited to a maximum of 10 people, with applications treated on a first-come-first-serve basis. In order for the course to be viable we require 6 or more candidates to attend. Arrangements can also be made for the course to be held at a venue of your choice for more than 6 candidates.

ENROL IN A COURSE TODAY!
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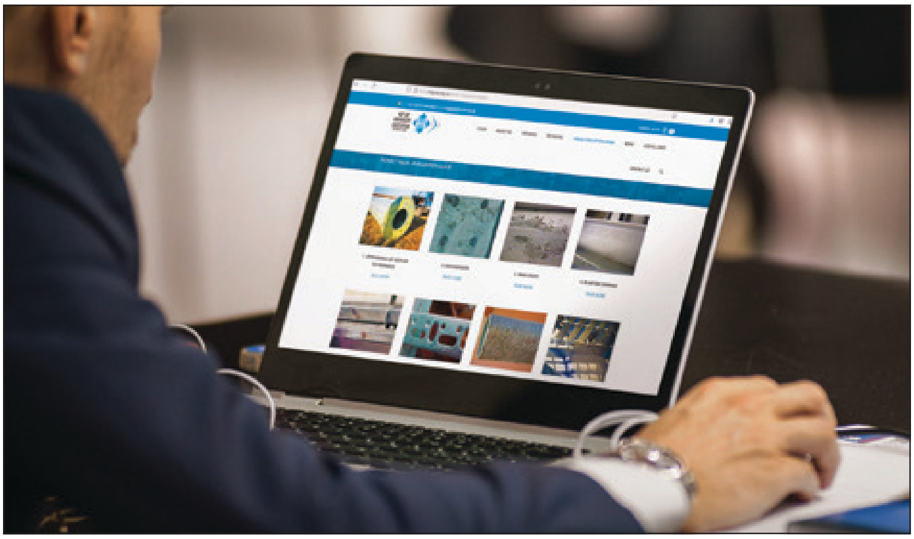
COURSES OFFERED

HOT DIP GALVANIZERS ASSOCIATION SOUTHERN AFRICA



Updated Level I course

The Level I, Introduction to Hot Dip Galvanizing course has been recently updated and offers the delegate a comprehensive overview of hot dip galvanizing. The course allows for clear explanations of key primary aspects affecting hot dip galvanizing its application and process to ensure clarity in working with the technology as a corrosion control system for steel.

Beyond the classroom

HDGASA's training range is not limited to lectures, it includes:

- **Plant tours** for real-world process immersion
- **A free-to-use website** with loads of technical information and evaluation guides
- **Technical papers and case studies** for applied learning
- **Advisory support** during project design and execution
- **Knowledge transfer** through publications like *Hot Dip Galvanizing Today*

This multi-modal approach ensures that learning is not just theoretical, but is embedded in operational excellence.

Strategic impact

Investing in HDGASA training yields tangible benefits:

- **Improved coating quality and reduced rework**
- **Enhanced standards compliance and audit readiness**
- **Greater confidence among specifiers and clients**
- **Innovation through informed experimentation**
- **Alignment with circular economy and sustainability goals**

Final thoughts

In an industry where microns matter and standards define reputations, training is not a luxury, it's a strategic imperative. The Hot Dip Galvanizers Association Southern Africa offers more than education; it delivers **competence, confidence, and continuity.** Whether you're galvanizing bridge components, rail infrastructure or designing duplex systems HDGASA's training provides the bedrock on which to provide foundational support for effective optimised corrosion control of steel structures and articles.

HDGASA'S SIXTY YEARS
of service since 1965

Since its inception in 1965, the Hot Dip Galvanizers Association Southern Africa (HDGASA) has served as a quiet yet unwavering beacon of technical guidance, casting light where needed, navigating complexity with precision, and remaining largely invisible to the broader public eye. Its influence on infrastructure and industrial development has been subtle but far-reaching, shaping outcomes through early-stage design input, advisory support, and rigorous standards alignment. Rarely seeking attribution, HDGASA has preferred to let its impact speak through the success of its members and the integrity of the technology it represents.

HOT DIP GALVANIZERS ASSOCIATION SOUTHERN AFRICA

2025 1965

The Association has long embraced a philosophy of servant leadership, positioning itself not as a public figurehead, but as a technical enabler, a trusted advisor, and a steward of best practice. This low-profile stance is not incidental, it's intrinsic to the Association's character. From the outset, HDGASA has chosen to operate as a service provider, allowing galvanizing members to take the spotlight during pivotal moments in Southern Africa's development. This is not a matter of modesty, but of principle.

Over the decades, HDGASA has consistently directed its energy toward representing galvanizing technology itself, rather than promoting its own institutional identity. Whether offering confidential technical support, investigating coating anomalies with impartial rigour, or guiding engineers and fabricators through the intricacies of international standards, its focus has remained steadfast: to elevate the credibility and capability of its member base. Training programs, plant audits, and advisory services have all been designed to ensure that hot dip galvanizing is not merely used, but applied with precision, efficiency, and strategic foresight.

Even in its public-facing initiatives, HDGASA's ethos remains clear. Its flagship publication, *Hot Dip Galvanizing Today*, does not serve as a platform for self-congratulation. Instead, it highlights the innovations, case studies, and technical excellence of the galvanizing process and the professionals who drive it. Events such as the annual Golf Day are crafted not for institutional promotion, but to foster meaningful connections among members and their clients. And when HDGASA participates in international forums or contributes to global dialogues, it does so with a singular purpose: to bring back insights and advancements that benefit the Southern African community, rather than to elevate its own brand.

Ultimately, HDGASA's conservative public profile is a disciplined and deliberate commitment to ensuring that hot dip galvanizing is understood, respected, and correctly applied. That humility has earned the Association enduring trust among specifiers, engineers, and fabricators across Southern Africa, and increasingly, recognition within the international community.