BRANZ

ISSUE 649 BULLETIN

CORROSION OF METALS IN NEW ZEALAND BUILDINGS

April 2020

- Corrosion requires moisture and oxygen. It can occur much faster where sea salt, geothermal gases and industrial or agricultural chemicals are also present.
- Metal corrosion in New Zealand has an economic cost in the billions of dollars.
- This bulletin gives an overview of the corrosion of metals in New Zealand buildings and how corrosion and its costs can be reduced or managed.

1 INTRODUCTION

1.0.1 Corrosion is a chemical or electrochemical reaction between a material and aggressive substances in its surrounding environment. The interaction normally leads to the material being consumed and a reduction of performance, durability and/or visual attractiveness.

1.0.2 A common example of corrosion is the rusting of steel, which converts the metal into compounds such as oxides, hydroxides or sulphides.

1.0.3 The economic cost of corrosion is enormous. One New Zealand estimate put it at the equivalent of 2.5% of gross domestic product (GDP) or around NZ$7.5 billion, while another put it at NZ$9 billion. International studies have estimated the annual cost of corrosion as the equivalent of 2–6% of GDP.

1.0.4 The costs of corrosion often extend well beyond replacement of the corroded materials. With a rusty roof, while there is the roof replacement cost, there may also be indirect costs such as water damage to building contents and structures and the costs of alternative accommodation while the roof is replaced. Indirect costs can often be much higher than the direct replacement cost of the corroded materials.

1.0.5 Some overseas research on the cost of corrosion has estimated that 10–40% of the loss is avoidable.

1.0.6 There are many steps architects, designers, engineers and specifiers can take to reduce the impact and cost of corrosion. For example, an understanding of the basic science of metal compatibility (see 3.1) can lead to buildings with enhanced durability and integrity and reduced costs.

1.0.7 Good maintenance is crucial (see 8). This may involve regular inspections, cleaning and reapplication of protective coatings.

1.0.8 This bulletin gives an overview of the corrosion of metals in New Zealand buildings and explains how corrosion can be reduced and managed. BRANZ scientists have researched corrosion for over 40 years, and much of the content in this bulletin reflects their findings.

1.0.9 In addition to this bulletin, a series of BRANZ fact sheets about corrosion is available at www.branz.co.nz/researchnow.

2 THE PROCESS OF CORROSION

2.0.1 Atmospheric corrosion requires the presence of moisture. Below a specific relative humidity (RH) threshold, corrosion will not occur because there is not enough moisture to create an electrolyte layer on the metal surface. The threshold varies by the type of metal surface and the type and concentration of pollution in the air.

2.0.2 Atmospheric pollutants can dissolve in the moisture on a metal and significantly increase the rate of corrosion. These pollutants include chlorides such as marine salts and sulphur-containing gases from natural geothermal features or industrial processes. Other industrial or agricultural chemicals in the atmosphere, such as nitrogen oxides and ammonia, can also impact on corrosion rates.

2.0.3 Corrosion of reinforcing steel in concrete can also result from the presence of moisture and chlorides or can occur when the pH level in the concrete falls (loss of alkalinity) due to carbonation. Carbonation occurs when carbon dioxide enters the concrete in the presence of moisture.

2.0.4 Corrosion can occur in different ways. Four forms are encountered most commonly in the building industry:

- **Uniform corrosion** is the form seen most often. It is an attack over the entire surface area, leading to a general thinning of the metal. Copper, mild steel and zinc in most natural environments will most likely suffer from uniform corrosion.
- **Pitting** is a highly localised attack leading to the formation of small pits on the metal surface. These pits can be deep and can eventually result in holes. Pitting can be seen with aluminium alloys and stainless steels, particularly when exposed to corrosive environments with chlorides, such as coastal environments.
- **Crevice corrosion** occurs when moisture and pollutants sit in crevices formed on a shielded metal surface. It can be found under gaskets, washers, fastener heads and lap joints and in similar locations.
- **Galvanic corrosion** occurs where two metals with different electrochemical potentials are in direct contact in the presence of an electrolyte. This is explained in more detail in 3.1.

2.0.5 Chlorides in sea salt are a significant contributor to corrosion in New Zealand. While many New Zealand buildings are within 5 kilometres of the coast, BRANZ studies have found that winds can carry chloride-containing particles more than 20 kilometres inland.

2.0.6 BRANZ research has found that metals exposed to geothermal environments (with sulphur gases such as hydrogen sulphide and sulphur dioxide in the air) corrode very differently to metals in other environments. Atmospheric corrosion of mild steel usually slows down with time in rural, industrial or marine environments, for example. After 1 year of exposure, steel samples usually corrode at a constant low rate. In geothermal environments, corrosion of mild steel was found to increase rapidly in the first 6–9 months, then decrease slowly (Figure 1). However, the corrosion rate measured after 1 year was still higher than that measured after 1 month and much higher even than in a severe marine environment. In some geothermal areas, an oscillating behaviour has also been observed with the corrosion of mild steel.

2.0.7 BRANZ research has also addressed fastener corrosion in treated timber, including field trials of fastener performance in timbers treated with waterborne copper-containing preservatives chromated copper arsenate (CCA), copper azole (CuAz) and alkaline copper quaternary (ACQ). CuAz and ACQ appear to be more corrosive than CCA. Stainless steel nails and

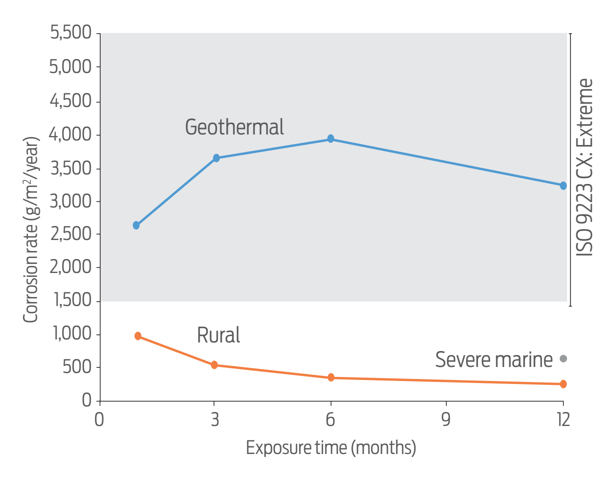

Figure 1. Corrosion of mild steel in different environments (BRANZ trials).

screws performed considerably better than mild steel and zinc-coated (hot-dip galvanized and mechanically plated) steel fixings.

2.0.8 Corrosion does not just affect the metal itself but can have a big impact on construction elements the metal is part of. Rust occupies three times greater space than the steel it forms from, so the increasing volume created as steel rusts can force adjacent materials apart. Steel rusting in concrete can cause the concrete to crack and then spall or flake off. In extreme cases, this can lead to the failure of concrete structural elements. Corrosion of concrete reinforcing steel is a common cause of poor concrete durability in New Zealand. Timber can also be affected. As fixings corrode in timber, the cellulose components of the timber are attacked, causing loss of strength and structural integrity – sometimes referred to as nail sickness.

2.0.9 In practical terms, corrosion in building materials can be the result of or made worse by:

- a structure not being watertight
- close proximity to the sea, to geothermal areas or to industrial or agricultural chemicals and the specification of inappropriate materials for the location
- inadequate corrosion protection as a result of trying to cut the costs of material or protective coating
- poor maintenance – corrosion cannot be completely eliminated but can be slowed with effective cleaning and maintenance.

3 METALS MOST COMMONLY USED IN NEW ZEALAND BUILDINGS

3.0.1 New Zealand buildings make considerable use of various types of metals and alloys.

3.0.2 Steel is the most widely used metal in New Zealand construction and comes in many forms:

- **Mild steel** is an alloy of iron and a small amount of carbon and several other elements such as manganese and silicon. It is the most widely used steel in building and construction. Mild steel is much more vulnerable to corrosion than other types of steel.
- **Galvanized steel** has a zinc coating that provides significantly enhanced corrosion protection to the steel in mildly corrosive environments. In general, hot-dip galvanizing gives better protection than some other types of application of zinc to steel such as electroplating and mechanical plating of similar thickness.
- **Stainless steels** contain a minimum 11% chromium. When exposed to the air, a very thin chromium-rich passive oxide film can form spontaneously on the surface to reduce further corrosion. Grade 304 contains 18–20 % chromium and 8.0–10.5% nickel. Grade 316 includes 2–3% molybdenum and a slightly higher nickel content of 10–14%. Grade 316 stainless steel is more resistant to pitting and crevice corrosion in coastal environments and has a better repassivation ability than grade 304 when the passive layer is damaged. These two stainless steels are typical austenitic stainless steels and find wide applications in the New Zealand built environment. BRANZ testing in Rotorua found that these stainless steels performed well when exposed to atmospheric geothermal attack – grade 304 suffered greater corrosion in a severe marine environment.
- **Weathering steels** have very small quantities of copper, chromium, nickel, phosphorus, silicon and/or manganese added as alloying elements. Carbon content is typically less than 0.2%. Weathering steel has greater corrosion resistance than mild steel in most relatively benign environments due to the formation of a dense and well-adhering corrosion product layer (patina). These steels find applications in claddings and inland steel bridges.
- **55% aluminium-zinc alloy-coated steel** is very widely used as roof and wall claddings. It has better general corrosion resistance than galvanized steel in most environments. This is related to its unique two-phase micro-structure.

3.0.3 Aluminium is a lightweight metal approximately one-third of the weight of steel with a density of approximately 2.7 g/cm^3. The most common aluminium alloys in buildings are from the 5000 and 6000 series, with AA6063 one of the most popular. Corrosion of aluminium typically takes the form of pitting rather than a uniform surface change. Aluminium alloys have much better corrosion resistance in clean environments than carbon steels. BRANZ testing has also found that some aluminium alloys corrode more slowly in a geothermal environment than a severe marine environment.

3.0.4 Copper is a ductile metal that, used externally, typically weathers to a greenish colour (patina). Copper has a long history of use in buildings around the world, mainly due to its high atmospheric corrosion resistance. BRANZ testing has found a very high corrosion rate for copper in geothermal environments, however. This results from the fast interaction of copper and sulphur-containing gases (hydrogen sulphide or sulphur dioxide) and poor protection offered by the corrosion products remaining on its surface. Copper is also affected in ammonia-containing atmospheres such as in toilets.

3.0.5 Zinc is available as two standard products – the pure metal (99.995%) and its alloy with small additions of titanium and copper (typically 0.07% and 0.08%

respectively). These alloys enable the construction of long-run roofs. The largest use of zinc in construction is as a protective coating for steel.

3.0.6 Lead is a soft, heavy metal with good corrosion resistance in most natural environments. It is commonly found on nail heads and flashings in older houses but rarely used in new construction today because lead poisoning can cause serious health problems and even death.

3.1 METAL COMPATABILITY

3.1.1 Different metals can behave in different ways when in close contact in the presence of electrolytes. Galvanic corrosion is one of the major mechanisms behind this.

3.1.2 Galvanic corrosion is a type of deterioration when noble (cathodic) and less noble (anodic) metals are in direct contact in the presence of an electrolyte with corrosive pollutants dissolved in it. These pollutants can include marine salts, geothermal sulphur-containing gases or industrial acid fumes. (Galvanic corrosion is seldom a problem with pure water.) There is aggressive corrosion of the less noble metal at the contact point and partial or complete protection of the other metal. The different electrochemical potential of different metals is the main driving force for galvanic corrosion (Figure 2).

3.1.3 Galvanic corrosion has been seen frequently in building systems with many metal components such as HVAC (heating, ventilation and air conditioning) systems.

3.1.4 The intensity of galvanic corrosion is partly related to the ratio of areas of the metals in electrical contact. When a noble metal with a large area is coupled to a less noble metal with a small area, galvanic action will cause much more severe corrosion of the less noble metal. The reverse situation, where the noble metal has a small area, produces little galvanic current. This explains why stainless steel fasteners in aluminium sheets or window frames are normally considered safe if the contact is free of salt deposits and moisture/rainwater cannot be retained or trapped for long periods of time.

3.1.5 Corrosion can also occur when water that has passed over a more noble metal flows over a less noble metal – for example, aluminium may corrode if water passes over lead then aluminium.

3.1.6 Many rules around the use of metals are based on avoiding or reducing galvanic corrosion. For example, Acceptable Solution E2/AS1 Table 21 *Compatibility of materials in contact* says that copper and brass are not compatible with aluminium, galvanized steel or zinc. The reason is clear when you look at their places in the galvanic series in Table 1.

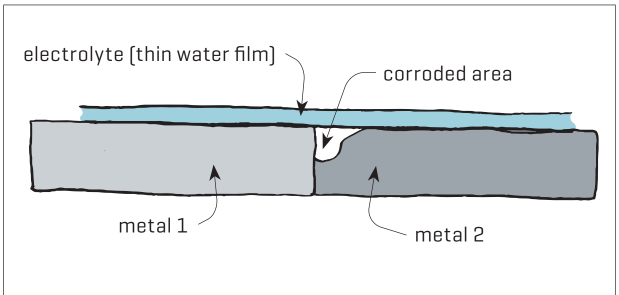

Figure 2. Schematic illustration of galvanic corrosion.

3.1.7 Other practical guidance on material compatibility and galvanic corrosion can be found in:

- E2/AS1 Table 22 *Compatibility of materials subject to run-off*
- BRANZ Bulletin 519 *Fastener selection*
- New Zealand Metal Roof and Wall Cladding Code of Practice (v3.0) Table 4.10.3C *Material compatibility*.

4 HOW THE BUILDING CODE AND STANDARDS DEAL WITH THE RISK OF CORROSION

4.0.1 New Zealand Building Code clause B2 *Durability* requires that materials will remain functional for certain minimum periods:

- 50 years for building elements (including floors, walls and fixings) that provide structural stability or are difficult to access or replace or where failure may go undetected.
- 15 years for elements (including the building envelope, exposed plumbing in the subfloor space and in-built chimneys and flues) that are moderately difficult to access or replace or where failure would go undetected during normal use but would be easily detected during normal maintenance.

Table 1. The galvanic series with common metals and alloys listed according to their corrosion potential in seawater (with saturated calomel electrode, SCE, as a reference electrode).

Graphite	(0.2 → 0.29 V)	Noble (least active)
Platinum (Pt)	(0.22 → 0.25 V)	
AISI 316 (Passive)	(-0.1 → 0 V)	
AISI 304 (Passive)	(-0.1 → -0.05 V)	
Lead (Pb)	(-0.25 → -0.19 V)	
AISI 430 (Passive)	(-0.28 → -0.2 V)	
AISI 410 (Passive)	(-0.35 → -0.26 V)	
Silicon bronze	(-0.29 → -0.26 V)	
Copper	(-0.37 → -0.3 V)	
Brass	(-0.4 → -0.3 V)	
Mild steel	(-0.63 → -0.57 V)	
Aluminium (Al)	(-1.0 → -0.76 V)	
Zinc (Zn)	(-1.03 → -0.98 V)	
Magnesium (Mg)	(-1.63 → -1.6 V)	

- 5 years for elements (including services, linings, renewable protective coatings and fixtures) that are easy to access and replace and where failure would be easily detected during normal use.

4.0.2 Corrosion can threaten these durability requirements. The Building Code, Acceptable Solutions and New Zealand standards take considerable account of the risks of corrosion. Metals and corrosion protection must be specified based on the geographical location of the building and where the material is installed on the building.

5 NEW ZEALAND'S CORROSIVITY MAPS

5.0.1 In 1987, BRANZ launched a study of atmospheric corrosivity in New Zealand, measuring the corrosion rates of various metals at 168 locations. As an example of the results, corrosion rates of mild steel after 1 year of exposure varied from 18–4800 $g/m^2/year$. The highest rates were in geothermal areas. There was also a clear link between corrosion rate and distance from the coast. This data was used to establish the exposure zone (atmospheric corrosivity) map in NZS 3604:1999 *Timber framed buildings* and the current (2011) version of the standard (Figure 4.2 from the 2011 version is reproduced here as Figure 3).

5.0.2 The map in the current version of the standard divides New Zealand into exposure zones B, C and D, depending on exposure to wind-driven sea salt. Zone B is the least exposed and zone D the most. Zone D includes all areas within 500 m of the coast including harbours, 100 m from tidal estuaries and sheltered inlets, all offshore islands and all other areas shown in white in the maps. (The exposure zones are also given in the BRANZ Maps online tool.)

5.0.3 NZS 3604:2011 also addresses very specific atmospheric environments/micro-climates, excluding from its scope and requiring specific engineering design for:
- industrial contamination and corrosive atmospheres
- contamination from agricultural chemicals or fertilisers
- geothermal hot spots (defined as being within 50 m of a bore, mud pool, steam vent or other source).

5.0.4 The map allows designers to understand the atmospheric corrosivity of a particular location. From this, they can select the zone they are working in and specify the appropriate materials.

5.0.5 E2/AS1 also has a zone E (severe marine – breaking surf beach fronts) for material selection in Table 20 of the Acceptable Solution. The corrosion protection requirements for structural fixings in zones D and E are the same, so zone E does not appear in NZS 3604:2011. (Zone E in E2/AS1 is also effectively the same as atmospheric corrosivity category E in AS/NZS 2728:2013 *Prefinished/prepainted sheet metal products for interior/exterior building applications – Performance requirements*.)

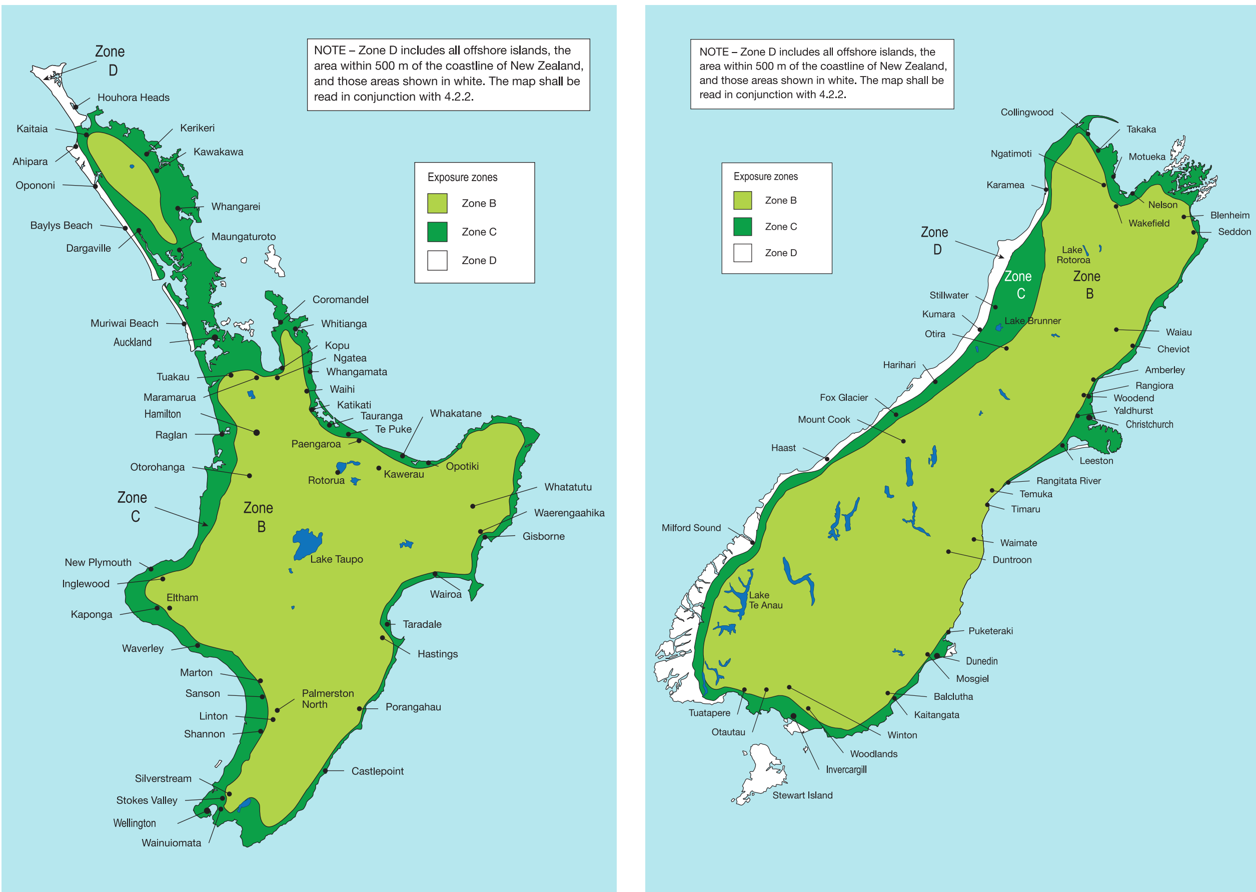

Figure 3. Exposure zone maps from NZS 3604:2011 Timber-framed buildings.

5.0.6 Approximately 25 years after its original research, BRANZ conducted another study to assess whether the map is still reliable, testing at 61 exposure sites. With a few exceptions (such as Auckland Airport, Tiwai Point and Greymouth), most new data was comparable with the 1980s data. BRANZ has recommended a few zone boundary adjustments and produced regional atmospheric corrosivity maps for Auckland, Wellington, Christchurch and Dunedin. Details can be found in BRANZ Study Report SR325 *Update of New Zealand's atmospheric corrosivity map (Part 2)*.

5.0.7 Atmospheric corrosivity mapping in New Zealand takes into account the methods used in international standard ISO 9223:2012 *Corrosion of metals and alloys – Corrosivity of atmospheres – Classification, determination and estimation* (Table 1). This standard defines corrosivity categories for atmospheric environments by the first-year corrosion rate of standard metals. BRANZ research has found that the atmospheric corrosivity of some New Zealand geothermal environments falls into the highest (most corrosive) category in ISO 9223:2012, CX extreme.

5.0.8 AS/NZS 2312:2014 *Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings – Part 1: Paint coatings* and *Part 2: Hot dip galvanizing* and *SNZ TS 3404:2018 Durability requirements for steel structures and components* give atmospheric corrosivity categories based on the corrosion rates of mild steel in ISO 9223:2012.

5.0.9 There are other corrosivity classifications for specific building materials or elements. For example, there are environmental exposure classifications in NZS 3101.1 & 2:2006 *Concrete structures standard*. These allow designers and engineers to ensure durability of concrete by accounting for wet or salty conditions, aggressive soil or groundwater or contact with potentially aggressive chemicals.

6 CORROSION, MICRO-CLIMATES AND MICRO-ENVIRONMENTS

6.0.1 Knowing a building's geographical location is not enough to specify the fixings and other metallic materials required in its construction. BRANZ research has found that the orientation and location of metal materials on a building have a large impact on corrosion rates:

- Steel samples that sit horizontally typically have the highest corrosion rates, followed by samples inclined at 45° and then vertically.

Table 2. Corrosion rates, r_{corr}, for the first year of exposure for the different corrosivity categories.

ISO 9223:2012 corrosivity category	Corrosion rates of metals[2] r_{corr}					NZS 3604:2011 exposure zone
	Unit	Carbon steel	Zinc	Copper	Aluminium[4]	
C1 very low	$g/(m^2 \cdot a)$ μm/a	$r_{corr} \leq 10$ $r_{corr} \leq 1.3$	$r_{corr} \leq 0.7$ $r_{corr} \leq 0.1$	$r_{corr} \leq 0.9$ $r_{corr} \leq 0.1$	negligible —	
C2 low	$g/(m^2 \cdot a)$ μm/a	$10 < r_{corr} \leq 200$ $1.3 < r_{corr} \leq 25$	$0.7 < r_{corr} \leq 5$ $0.1 < r_{corr} \leq 0.7$	$0.9 < r_{corr} \leq 5$ $0.1 < r_{corr} \leq 0.6$	$r_{corr} \leq 0.6$ —	B
C3 medium	$g/(m^2 \cdot a)$ μm/a	$200 < r_{corr} \leq 400$ $25 < r_{corr} \leq 50$	$5 < r_{corr} \leq 15$ $0.7 < r_{corr} \leq 2.1$	$5 < r_{corr} \leq 12$ $0.6 < r_{corr} \leq 1.3$	$0.6 < r_{corr} \leq 2$ —	C
C4 high	$g(m^2 \cdot a)$ μm/a	$400 < r_{corr} \leq 650$ $50 < r_{corr} \leq 80$	$15 < r_{corr} \leq 30$ $2.1 < r_{corr} \leq 4.2$	$12 < r_{corr} \leq 25$ $1.3 < r_{corr} \leq 2.8$	$2 < r_{corr} \leq 5$ —	D
C5 very high	$g/(m^2 \cdot a)$ μm/a	$650 < r_{corr} \leq 1{,}500$ $80 < r_{corr} \leq 200$	$30 < r_{corr} \leq 60$ $4.2 < r_{corr} \leq 8.4$	$25 < r_{corr} \leq 50$ $2.8 < r_{corr} \leq 5.6$	$5 < r_{corr} \leq 10$ —	E[6]
CX extreme[5]	$g/(m^2 \cdot a)$ μm/a	$1{,}500 < r_{corr} \leq 5{,}500$ $200 < r_{corr} \leq 700$	$60 < r_{corr} \leq 180$ $8.4 < r_{corr} \leq 25$	$50 < r_{corr} \leq 90$ $5.6 < r_{corr} \leq 10$	$r_{corr} > 10$ —	

Notes:

1. The classification criterion is based on the methods of determination of corrosion rates of standard specimens for the evaluation of corrosivity (see ISO 9226:2012 *Corrosion of metals and alloys – Corrosivity of atmospheres – Determination of corrosion rate of standard specimens for the evaluation of corrosivity*).
2. The corrosion rates, expressed in grams per square metre per year [$g/(m^2 \cdot a)$], are recalculated in micrometres per year (μm/a) and rounded.
3. The standard metallic materials are characterised in ISO 9226:2012.
4. Aluminium experiences uniform and localised corrosion. The corrosion rates shown in this table are calculated as uniform corrosion. Maximum pit depth or number of pits in aluminium can be a better indicator of potential damage, depending on the final application. Uniform corrosion and localised corrosion cannot be evaluated after the first year of exposure due to passivation effects and decreasing corrosion rates.
5. Corrosion rates exceeding the upper limits in category C5 are considered extreme. Corrosivity category CX refers to specific marine and marine/industrial environments.
6. See 5.0.5 in this bulletin for an explanation of exposure zone E.

- Sheltered areas on a building that collect more salt because they are less likely to be washed by rain do not necessarily have higher corrosion. Significantly lower levels of time of wetness can contribute to a remarkable reduction of material degradation despite more salt deposits being collected.
- The moisture content of timber has a key role on the level of corrosion risk to fastenings and fixings in timber. A moisture content of approximately 18% is generally accepted as the threshold below which corrosion in timber would be limited. When the timber moisture content is higher than 20% due to exposure to rain or moist air, the metal corrosion risk significantly increases. For corrosion of steel fasteners in timber, the greatest corrosion is typically seen in exposed positions.

6.0.2 NZS 3604:2011 acknowledges the different levels of atmospheric corrosion risk around the building envelope. Section 4 *Durability* defines three main micro-environments:

- Closed – a dry internal location, not subject to airborne salts or rain wetting.
- Sheltered – open to airborne salts but not rain washed. These are generally the areas above a 45° line from the lower edge of a projecting weathertight structure such as a floor, roof or deck (Figure 4).
- Exposed – open to airborne salts and rain wetting. These are generally areas below a 45° line from the lower edge of a projecting weathertight structure.

6.0.3 There are often different requirements around fastenings and fixings in different locations. For example, hot-dip galvanized steel may be acceptable for a sheltered location while an exposed location requires grade 304 stainless steel.

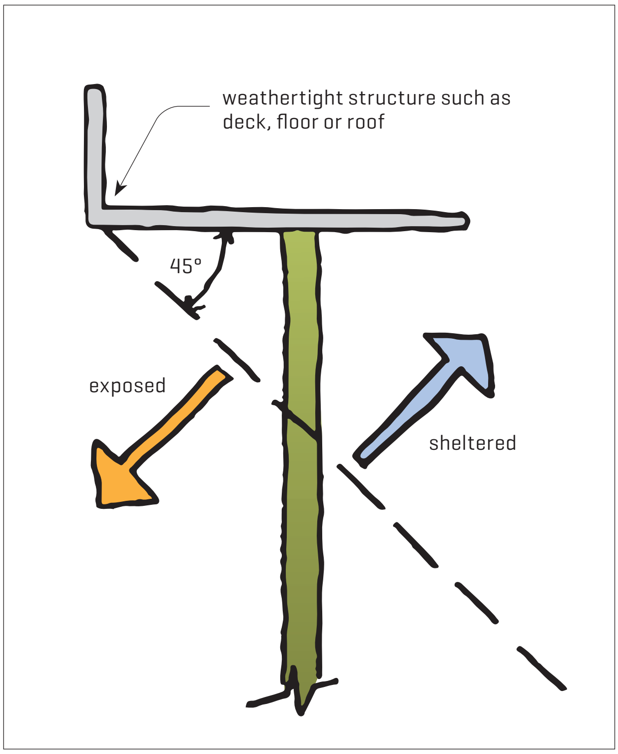

Figure 4. The definitions of sheltered and exposed as given in NZS 3604:2011 *Timber-framed buildings*.

7 REDUCING THE RISK OF CORROSION

7.0.1 Corrosion control begins early in the design of a building project and continues to handover. The entire design and construction team, including subcontractors, must understand the requirements. At the point of completion, maintenance requirements must be given to the building owners and users (see 8).

7.0.2 Knowing that corrosion requires moisture, a key design decision is reducing the time that moisture sits on a surface. The most obvious example of this is roof pitch – if moisture or rainwater remains for longer on a low-pitched roof, the risk of corrosion is increased. Large, flat areas of horizontal surfaces should be avoided, particularly in geothermal areas. Crevices that can retain water (and/or corrosive chemicals dissolved in the water) should be designed out where possible.

7.0.3 Selection and specification of metals must take account of their position in the galvanic series. If there is contact between dissimilar metals, it is important to avoid large area ratios of noble metal to less noble metal, particularly in corrosive environments.

7.0.4 Dissimilar metals can be isolated with durable, non-absorbent, non-conductive plastic or rubber gaskets and nylon or Teflon washers and bushes and polymeric coatings at the joint area. These are widely used for isolation between fasteners and roofing steel sheets.

7.0.5 Another option is painting the galvanic couple with a barrier coating to exclude water. Always paint both the less noble and noble metals. (If only one member of the couple can be painted, the noble metal should receive this treatment.) Check the paint condition regularly. Damaged paint cover may not provide the protection required and may even retain moisture for longer periods, leading to higher galvanic corrosion risk.

7.0.6 Take particular care specifying fastenings and/or fixings where ACQ and/or CuAz-treated timbers will get wet during service, such as outside or in contact with the ground or concrete. Galvanized nails and screws in these timbers may not meet the 50-year durability requirement for structural connections. BRANZ recommends grade 304 or 316 stainless steel or silicon bronze fasteners in these situations (see *Selecting nails and screws for 50-year durability* in *Build* 137).

7.0.7 Designers and engineers specifying exterior concrete structures, especially those close to the coast, must choose a combination of concrete strength and concrete cover that ensures that carbonation or chloride entry does not reach the reinforcing steel over the service life of the structure (see BRANZ Bulletin 574 *Preventing corrosion of reinforcing steel in concrete* and NZS 3604:2011 section 4.5 for more details). Using high-grade cement concrete may also reduce the corrosion risk.

7.0.8 Designers and engineers specifying steel structures and components should reference AS/NZS 2312.1&2:2014, AS/NZS 5131:2016 and/or SNZ TS 3404:2018.

8 THE IMPORTANCE OF MAINTENANCE

8.0.1 At the end of residential construction work, certain information must be given to the client. This includes details about maintenance required, especially where this is necessary to meet Building Code requirements or for a guarantee or warranty to remain valid.

8.0.2 It is particularly important for property owners to get detailed information about the maintenance required to prevent or slow the development of corrosion. This may involve regular checking, cleaning, repairing and reapplication of protective coatings and painting. With cleaning, the property owner should remove debris build-up that may retain water.

8.0.3 Maintaining a building well can save money:

- Regular inspection helps to identify deteriorating elements and fix them before costly repairs are needed.
- Proactive maintenance can prevent a building from deteriorating quickly, enhancing durability and providing better value to the owner in the long run.
- Maintaining a building well helps to reduce the need for new materials, lowering energy consumption and a building's carbon footprint and increasing its sustainability.

9 MORE INFORMATION

BRANZ PUBLICATIONS

BRANZ Bulletin 631 *How micro-environments affect material performance*

BRANZ Bulletin 627 *The impact of geothermal environments on metals and wood*

BRANZ Bulletin 574 *Preventing corrosion of reinforcing steel in concrete*

BRANZ Bulletin 519 *Fastener selection*

BRANZ Research Now: Positional corrosion 1: *The impacts of natural elements on different parts of the building envelope*

BRANZ Research Now: Positional corrosion 2: *How different micro-environments around a building envelope affect material corrosion*

BRANZ Research Now: Geothermal corrosion 1: *Which metals are more sensitive to geothermal corrosion?*

BRANZ Research Now: Geothermal corrosion 2: *Distance effects of corrosion in geothermal environments*

BRANZ Research Now: Geothermal corrosion 4: *The performance of aluminium-zinc alloy coating in geothermal environments*

BRANZ Research Now: Metal corrosion 1: *Corrosion in coastal buildings*

BRANZ Research Now: Metal corrosion 2: *How metals interact in the built environment*

BRANZ Research Now: Metal corrosion 3: *Corrosion over the building envelope*

BRANZ Research Now: Metal corrosion 4: *Corrosion of metal in timber and concrete*

BRANZ Research Now: Metal corrosion 5: *Atmospheric corrosivity classification*

BRANZ Research Now: Metal corrosion 6: *How metals are protected against corrosion*

BRANZ Study Report SR288 *Update of New Zealand's atmospheric corrosivity map*

BRANZ Study Report SR325 *Update of New Zealand's atmospheric corrosivity map (Part 2)*

BRANZ Study Report SR393 *Materials within geothermal environments*

STANDARDS AND TECHNICAL SPECIFICATIONS

AS 1397-2011 *Continuous hot-dip metallic coated steel sheet and strip – Coatings of zinc and zinc alloyed with aluminium and magnesium*

AS/NZS 2312.1:2014 *Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings – Part 1: Paint coatings*

AS/NZS 2312.2:2014 *Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings – Part 2: Hot dip galvanizing*

AS/NZS 2728:2013 *Prefinished/prepainted sheet metal products for interior/exterior building applications – Performance requirements*

AS/NZS 5131:2016 *Structural steelwork – Fabrication and erection*

NZS 3101.1&2:2006 *Concrete structures standard*

NZS 3604:2011 *Timber-framed buildings*

SNZ TS 3404:2018 *Durability requirements for steel structures and components*

ISO 9223:2012 *Corrosion of metals and alloys – Corrosivity of atmospheres – Classification, determination and estimation*

OTHER PUBLICATIONS

Koch, G. et al. (2016). *International measures of prevention, application, and economics of corrosion technologies study*. Houston, TX: NACE International (National Association of Corrosion Engineers).

INSPIRING THE INDUSTRY TO PROVIDE BETTER BUILDINGS FOR NEW ZEALANDERS

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