

# Long-term geothermal study

BRANZ research into materials performance in geothermal environments has provided many insights. A new study continues this work, examining the long-term durability of a range of building materials and coatings.

**GEOTHERMAL EMISSIONS** have negative impacts on the condition and safety of buildings and infrastructural assets. Four years ago, BRANZ started looking at how typical building materials perform in New Zealand's geothermal environment.

Technical outputs from short-term environmental monitoring and exposure testing gave an insight into the science behind material degradation and also challenged industrial and standard practices.

## Materials perform differently

An accelerating and oscillating kinetic behaviour combined with extremely high corrosion rates has been observed with mild steel and zinc in some geothermal environments (Figure 1). This has not been commonly observed in other natural environments.

Aluminium-zinc alloy coatings, a prime choice for durability, demonstrated a service life of approximately 2 years in some geothermal environments. This fell short of expectations and was related to its unique microstructure with aluminium-rich

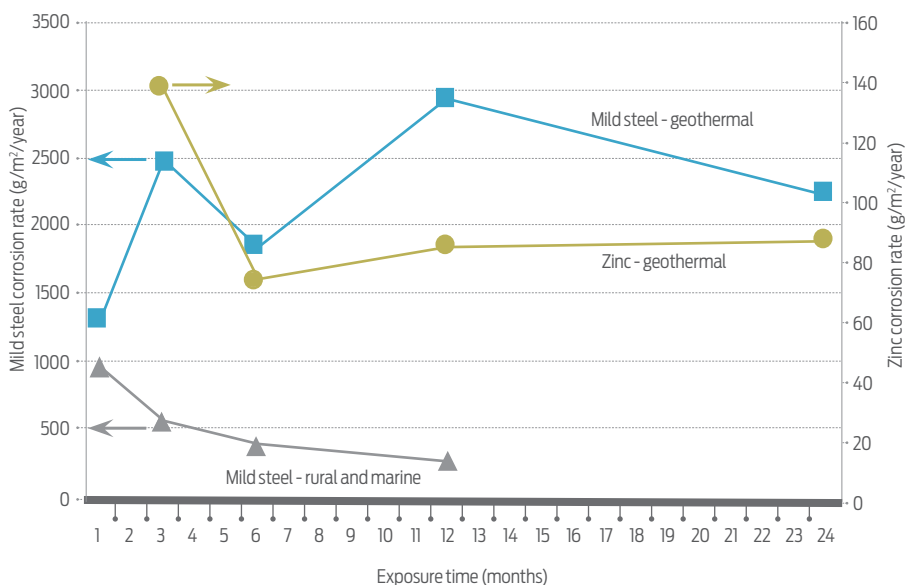


Figure 1: Atmospheric corrosion of mild steel and zinc in New Zealand environments.

dendritic and zinc-rich interdendritic phases.

Preferential attack on the zinc-rich phases produced numerous surface defects through which sulphur-containing species could readily enter deeply into the coating and attack the steel substrate directly. Coating

integrity was quickly compromised with the formation of a large number of cracks and rust spots (Figure 2).

These unusual degradation behaviours could lead to a high risk of premature failure of materials, components or structures.

### Boundary being increased

To minimise this risk, a 50 m boundary from a geothermal source or spot is recommended by NZS 3604:2011 *Timber-framed buildings* because corrosion rates could be decreased at this distance.

Meanwhile, atmospheric corrosivity in areas approximately 500 m from a geothermal source were found to be influenced by many factors. Corrosivity was found to range up to ISO 9223:2012 CX (extreme) and also demonstrate considerable variation.

The current 50 m boundary might not always be sufficient. SNZ TS 3404:2018 *Durability requirements for steel structures and components* has increased its boundary to 500 m based on a BRANZ study.

### Corrosivity classification challenging

Mild steel, zinc and copper are commonly used by ISO 9223:2012 for atmospheric corrosivity classification and are expected to give reasonably consistent outcomes. These metals were found to respond to geothermal attack differently.

Copper showed the highest sensitivity and always gave a corrosivity category higher than mild steel and zinc. This provides some serious challenges for atmospheric corrosivity classification:

- If the metals were used together, very different corrosivity categories could be derived for one specific geothermal environment, making material specification difficult.
- If only one metal was used, atmospheric corrosivity could be either overestimated or underestimated, potentially leading to a higher material cost due to overprotection or a higher risk of premature failure.

### Long-term performance monitoring needed

Due to the unusual degradation behaviours observed (for example, as seen in Figure 1), short-term monitoring is not suited

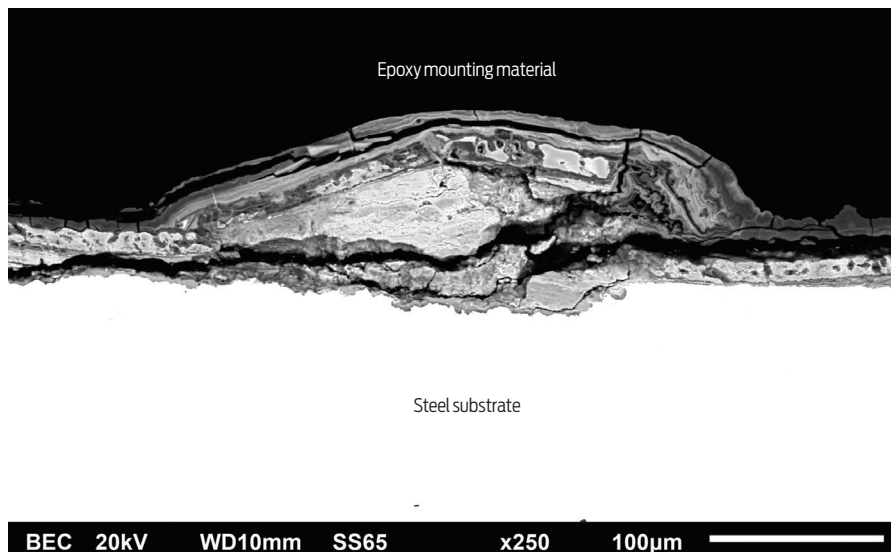


Figure 2: Cross-sectional view of a rust spot on Al-Zn alloy-coated steel. The epoxy mounting material was used to prepare this sample.

to understanding the unique characteristics and impacts of geothermal environments.

To estimate the service life of building materials, a longer-term study is needed to deliver solutions in a planned and systematic way. The new research components may include the following:

- Developing methodologies to characterise geothermal environments and to classify their corrosivity using state-of-the-art technology, such as continuous or passive gas analysers and sensors.
- Evaluating long-term durability and performance of representative metals, alloys, ➤

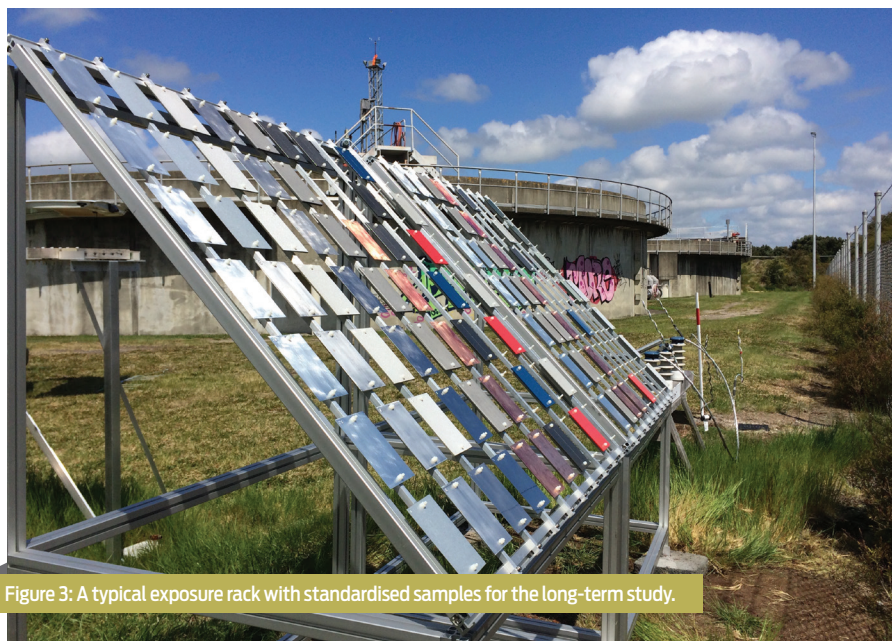


Figure 3: A typical exposure rack with standardised samples for the long-term study.

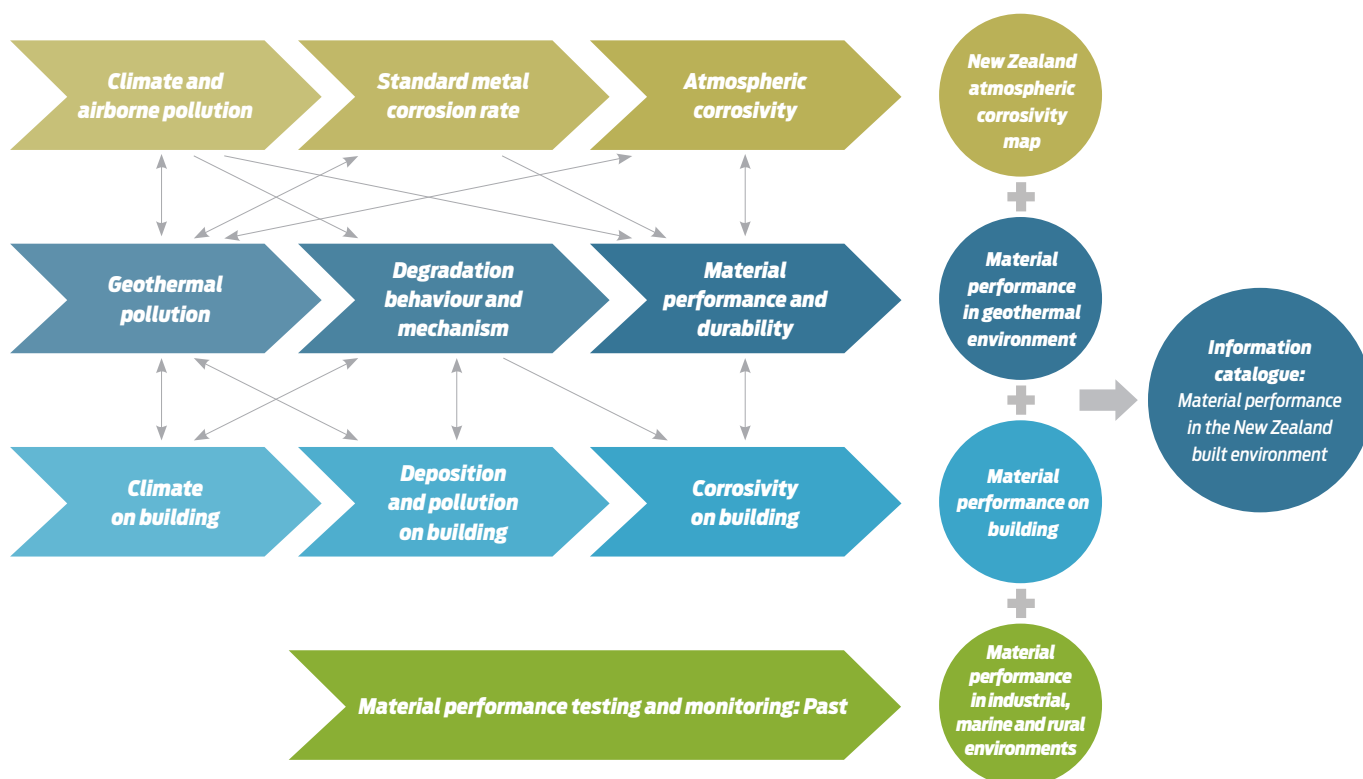


Figure 4: An integral approach for an information catalogue of the New Zealand built environment and material performance.

timbers and coating and painting systems using internationally accepted methods.

- Exploring mechanisms behind unusual degradation behaviours using advanced materials characterisation techniques, such as electron microscopy and X-ray diffraction and spectroscopy.
- Establishing a comprehensive comparative database to meet industry's needs for new information of materials durability and performance in New Zealand's built environment. This would support designing, constructing and maintaining resilient buildings and supporting infrastructure.

#### **New BRANZ study under way**

Long-term durability and performance testing (Figure 3) has started with hundreds of standardised coupons (samples) prepared from a variety of materials, including:

- aluminium
- copper
- mild steel
- stainless steel - austenitic and ferritic

- zinc
  - 55 wt.% Al-Zn alloy coating
  - thermal-sprayed aluminium coating
  - painting systems
  - timbers
  - fasteners in H3.2 CCA-treated timber.
- This list is expanding according to emerging scientific and engineering requests.

#### **Research delivers improved knowledge**

This study is building further on long-standing BRANZ corrosion research in industrial, marine and rural environments and is closely related to current research on building micro-environments and atmospheric corrosivity mapping.

This integral approach helps deliver a more complete profile of the New Zealand built environment and its influences on material performance (Figure 4). For example, it has been found that interactions between climatic factors, airborne pollution and construction features produce unique positional material degradation patterns on

buildings. These findings challenge common understanding in this area.

#### **More information available from BRANZ**

More information is freely available in these publications through [www.branzfind.co.nz](http://www.branzfind.co.nz):

- Study Report SR393 *Materials within geothermal environments*
- Bulletin 627 *The impact of geothermal environments on metals and wood*
- Build articles:
  - *Building materials in geothermal areas* (Build 149, p63-64)
  - *Materials in geothermal areas* (Build 159, p76-77)
- BRANZ Research Now:
  - *Which metals are more sensitive to geothermal corrosion?*
  - *Distance effects of corrosion in geothermal environments*
  - *Discolouration and deterioration of wood in geothermal environments*
  - *The performance of aluminium-zinc alloy coating in geothermal environments.* ◀