



Sydney Environmental & Soil Laboratory

Specialists in Soil Chemistry, Agronomy
and Contamination Assessments

Assessing Corrosion Risks

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ISO 9001
Lic QEC21650
SAI Global



Assessing Corrosion Risks in Acid Sulphate Soils

The consequences to the natural environment of acid sulphate soil and leachates are most frequently emphasised but it is well understood that acid sulphate conditions impact on the built environment at significant financial cost. The various factors contributing to corrosion of steel and concrete are ionic strength and ratios, temperature, oxygen concentrations and pH.

Acidity is the most commonly understood corrosive agent toward concrete and the reaction of protons with carbonates and the complex calcium and aluminium silicates in concrete hardly need explanation here. Most of these compounds are simply more soluble in acid conditions. Ion exchange reactions are more complex. Sodium sulphate in solution will cause a series of ion exchange reactions. Put simply sodium sulphate will react with calcium hydroxide to form sodium hydroxide (soluble) and gypsum (also quite soluble) the result being partial disruption of the concrete matrix. Sulphate will also react with calcium aluminates to form calcium sulfoaluminate with twice the molecular volume of the original aluminate placing severe internal mechanical stresses in the concrete matrix. Magnesium can exchange for calcium in the aluminates causing similar stresses.

These ionic reactions occur faster with increased temperature and the presence of acidity. Because they are diffusion dependant increased water flow rates (water volume and soil permeability dependant) hasten the reactions. High ion mobility, such as with chloride and oxygen, can result in deep penetration of porous concrete to attack the steel reinforcing forming ferric chloride, thence releasing the chloride ion for another round of attack in an almost catalytic manner and resulting in “concrete cancer”. On the other hand ammonium and carbon dioxide associated with anoxic conditions is highly aggressive toward concrete resulting in void formation through complex ion exchange and ammonia volatilisation. Wetting and drying cycles can synergise these reactions and result in physical ablation of concrete surfaces through salt deposition.

Sydney Environmental and Soil Laboratory have traditionally used a simple electrical resistivity (inverse of electrical conductivity) and a chloride and sulphate measurement in waters and soil to try to assess the degree of corrosion hazard. This is not the full story and recently we have put together a “concrete aggressiveness index” package that combines information from a wide literature search including existing corrosion assessment standards from overseas. The packages use-

Soils	Waters
pH and EC	pH and EC
Texture	Sodium ion
Permeability Class	Magnesium ion
Sulphate ion	Calcium ion
Chloride ion	Ammonium ion
Resistivity*	Sulphate ion
	Chloride ion
	CO_3^{2-} and HCO_3^-
	Calculated CaCO_3 saturation index

* Resistivity- saturated paste resistivity (actually better assessed in the field at field soil moisture and structure conditions). Resistivity is actually “bulk resistivity” of the soil mass as influenced by porosity, permeability, particle charge and moisture content as well as ionic activity.

These results are used in a semi-quantitative interpretation to provide an assessment of the Corrosion Risk Index class. This ranges from Non to mildly aggressive up to very highly aggressive.

This semi-quantitative assessment can then be used by engineers to recommend strategies to improve longevity. While we are not engineers and will not make such recommendations the techniques used include modification of the surrounding soil (drainways, membranes, densification, capillary breaks and layers, liming), use of different classes of concrete (eg pozzolanic cement, sulphate resistant portlands), densification and carbonation of concrete, use of lower water to cement ratios, inorganic and polymeric coatings, manipulation of aggregate types (eg use of basic blast furnace slag). Reinforcing can be protected by greater coverage, densified concrete and in extreme cases the use of galvanised or even stainless steel reinforcing.

While assessment of corrosiveness potential remains complex and subject to a range of incompletely understood and complex interactions the test packages we have produced use the most modern understanding and provide sufficient pre-warning for engineers to avoid the most severe consequences of inadequate design.

For a good introduction to these issues see-

Building Research Establishment (1982) Digest 363 Sulphate and acid resistance of concrete in the ground. Building Research Establishment, Garston, Watford UK.

Basson J.J. (1989) Deterioration of concrete in aggressive waters – measuring aggressiveness and taking countermeasures. Concrete Durability Bureau of the Portland Cement Institute. Midrand South Africa.

For further information on Sydney Environmental and Soil Laboratory corrosion assessment tests call us on 02 9980 6554.

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