

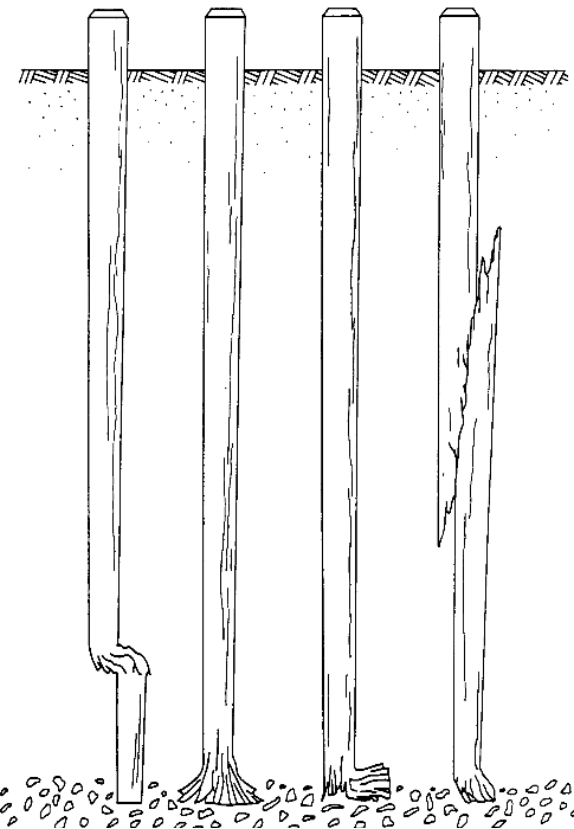
Soil Construction Materials

Text: Das, 2010. Chapter 17.

As well as understanding soil as a construction material, geotechnical engineers need an understanding of common structural materials such as steel, concrete and timber. Geotextiles and geoplastics are other types of material specific to geotechnical construction.

This section covers the following materials, particularly in regard to durability::

- a) Steel
- b) Reinforced, pre- or poststressed concrete
- c) Treated timber
- d) Geotextiles



Steel in Soil

The corrosion of bare steel in soils varies significantly based on the type and location of the soil. The corrosion rate of steel in soil can range from less than 20 microns per year in favourable conditions, to 200 microns per year or more in very aggressive soils.

Factors effecting the corrosion process are:

1. Aeration : more air = less corrosion
2. Moisture retention : moist environment promotes galvanic reactions
3. Dissolved salt content : salt solution increases conductivity hence rate of reaction
4. Soil resistivity : resistance to electrical current reduces reaction
5. Soil acidity or alkalinity : both indicate ionic species in solution increasing reaction rate
6. Bacteria : organic byproducts tend to be acidic or saline. Some bacteria consume corrosion products

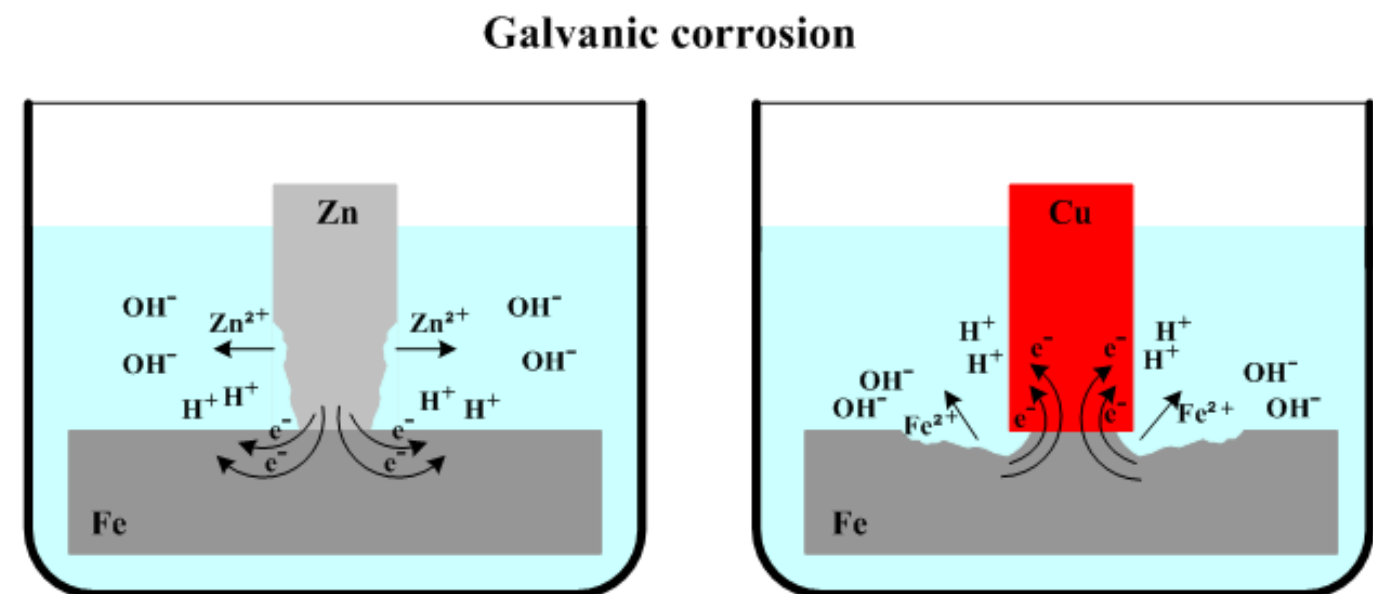


Mechanism of Steel Corrosion

Galvanic reactions involve a conductive pathway between materials of different electrical potential.

This includes different alloys of a structure or the same structural element in even slightly different soil types.

1. For example copper valves and fittings on steel pipe work
2. Steel structures embedded in soils with a vertical conductivity gradient.



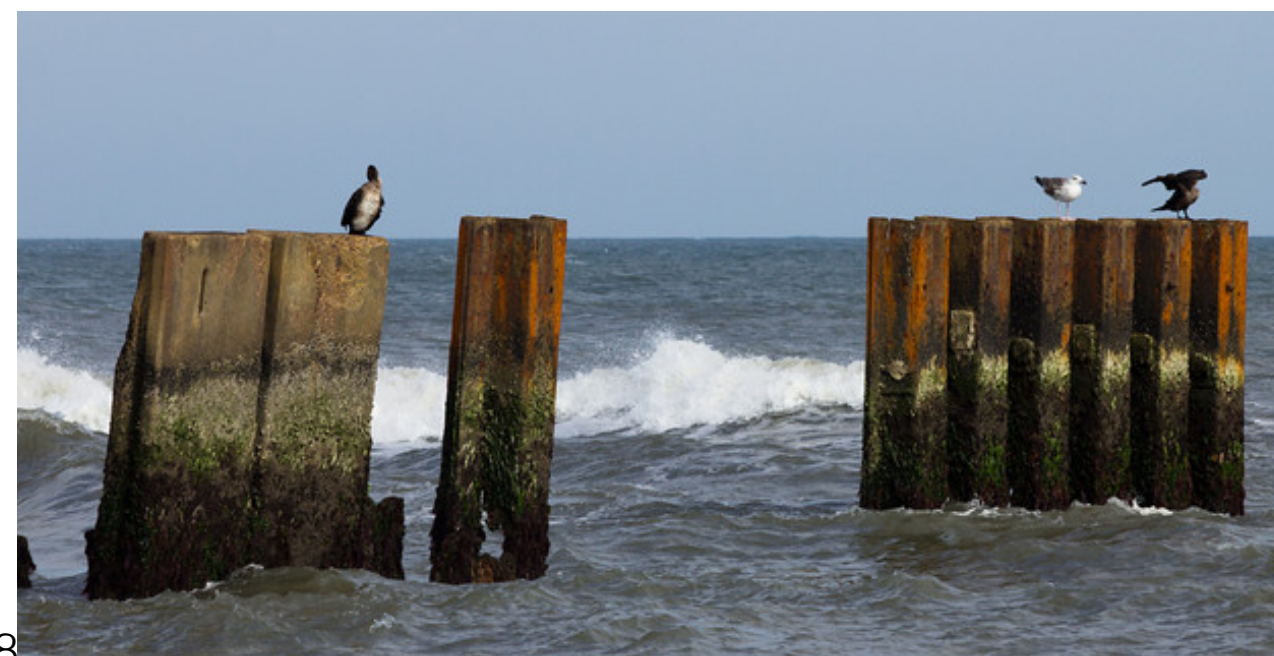
Particle Size Effect on Corrosion

Particle size plays a very large role in determining the longevity of steel in a particular soil. Particle size will dictate the amount of aeration as well as the duration of excess moisture.

In sandy soils, the larger particle size allows for air to enter between the particles and promote aeration of the soil.

At the same time, aerated soils allow moisture that remains in the soil from rainfall or other sources to evaporate at a much faster rate than non-aerated soils of smaller particle size.

This resulting aeration and shorter time of wetness correlates to a lower corrosion rate.



Resistivity and Corrosion

Soil resistivity can be measured and related to corrosion risk:

Resistivity ohm-cm	Corrosion
0-500	Very corrosive
500-1000	Corrosive
1000-2000	Moderately corrosive
2000-10000	Mildly corrosive
> 10000	Negligible corrosion

Steel Protection

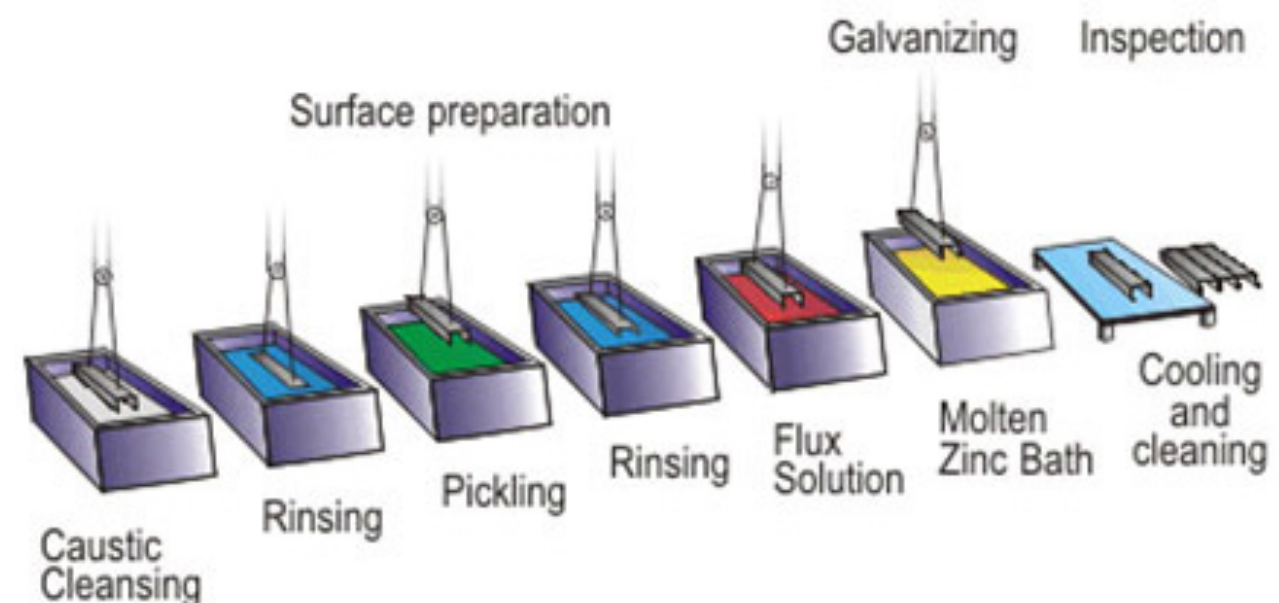
A number of corrosion-inhibiting techniques are available. The most common are galvanising, sacrificial anodes and impressed current or cathodic protection.

Galvanising is the process of electrolytically coating a steel structure with a high potential metallic coating such as zinc.

Sacrificial anodes are replaceable fittings of a zinc or other high-potential material, that corrode in preference to steel

Impressed current requires a constant earthed power supply to the structure, making the structure into the cathode of an electrical circuit.

Modern practice is to use some combination of these, in particular cathodic protection and galvanising.



Steel Piles

Steel piles come in a number of cross-sections: H-sections (in common use in other structural applications) X-sections (less common) and sheet piles.

Their relatively small cross-sectional area combined with high strength makes penetration easier in firm soil.

Steel piles can be easily cut off or joined by welding, bolting or mechanical joints.

It is common to allow for an amount of corrosion in design by simply over-dimensioning the cross-sectional area of the steel pile. Normally the speed of corrosion is 0.2-0.5 mm/year.



Pros and Cons of Steel Piles

- + Easy to handle and cut, splice or bolt to required length
- + Can be driven through dense layers.
- + Lateral displacement of the soil is low.
- + Can be driven heavily and in very long lengths.
- + Can carry heavy loads.
- The piles will corrode,
- Will deviate relatively easily during driving.
- Are relatively expensive.

Concrete in Soil

Concrete structures can be constructed in-situ, or as prefabricated units. Prefabrication can involve pre- or post-tensioning or ordinary steel reinforcement.

Concrete geostructures range from small components such as crib units to very large elements such as cast in-situ caissons, with or without a steel casing.

Concrete piles can be installed by boring or driving. Driven piles are stronger, but the impact must be carefully set to reduce stress in the concrete.

Soil water corrosion of concrete is a significant design issue both for the reinforcing steel cover and mix of concrete. Aggressive soils will corrode concrete by a range of mechanisms. Anodic protection is possible but less common than increased cover to reinforcing.

For concrete, the risk of corrosion also is expressed as low, moderate, or high. It is based on soil texture, acidity, and the presence of sulfates. As before, granular soils are less corrosive than silt or clay soils



Pluses and Minuses of Concrete Piles

- + Length can be readily varied to suit varying ground conditions.
- + Can be installed in very large diameters.
- + Easy to splice. Relatively inexpensive.
- + Can be driven in long lengths.
- + Can increase the relative density of a granular founding stratum.
- Can be damaged during driving. Replacement piles may be required.
- Cannot be driven with very large diameters or in condition of limited headroom.
- Concrete is not placed under ideal conditions and cannot be subsequently inspected.
- Water under artesian pressure may pipe up pile shaft washing out cement.

Timber in Soil

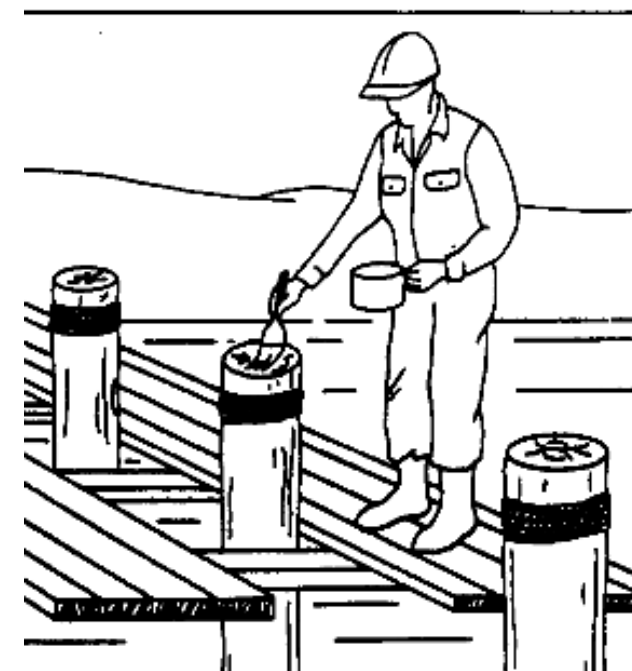
Timber is not common in geotechnical construction except as temporary formwork or framing. The exception is in pile foundations, where treated timber is frequently used.

Timber piles have been in use since ancient times and are still common practice even in small domestic construction.

Timber is most useful for long friction-bearing piles and where more lightweight materials are required.

For timber piles of length less than 14 meters, the diameter of the tip should be greater than 150 mm. If the length is greater than 19 meters a tip with a diameter of 125 mm is acceptable. To protect and strengthen the tip of the pile, timber piles can be provided with a toe cover.

Timber should not be driven into firm ground as this can easily damage the pile. Pressure treating is a common method of protecting timber piles. Cut ends may be treated by several coats of tar, creosote or other preservative.



Advantages (etc) of Timber Piles

- + The piles are easy to handle
- + Relatively inexpensive where timber is plentiful.
- + Pile ends are an ideal platform and material for further construction.
- The piles will rot near the ground water level.
- Have a limited bearing capacity.
- Can easily be damaged during driving by stones and boulders.
- The piles are difficult to splice and are attacked by marine borers in salt water.

Material Selection

The choice of which of these three construction materials to use is seldom difficult. Requirements are driven by the scale, context and economics of a job.

Where considerable strength and flexibility is required, as is usually the case, steel is the basic material of choice. Road infrastructure invariably tends to concrete with steel fittings and services.

Low budget jobs will often turn to concrete or timber. In marine construction treated timber and steel are suitable. Freshwater infrastructure is more likely to be in concrete and steel.

Usually, combinations of materials are essential for more reasons than just the geotechnical. Creative choice can be exercised and innovative materials explored, so long as strength and serviceability requirements are met.



Wood Rots



Steel Rusts



Concrete Crumbles



Fiberglass Lasts

Geotextiles

Geotextiles are one of a class of fabric-like materials known as geosynthetics. This includes materials such as:

- Geomembranes
- Geogrids
- Geonets
- Geocomposites
- Geoplastics

Each type performs one or more of the following major functions:

1. Separation (eg of imported fill layers)
2. Reinforcement ("knitting" layers together)
3. Filtration (allowing water to pass while retaining soil)
4. Drainage (often relying on a "wick" or capillary action to draw water out of soil)
5. Moisture Barrier (impermeable layers eg geoplastics)

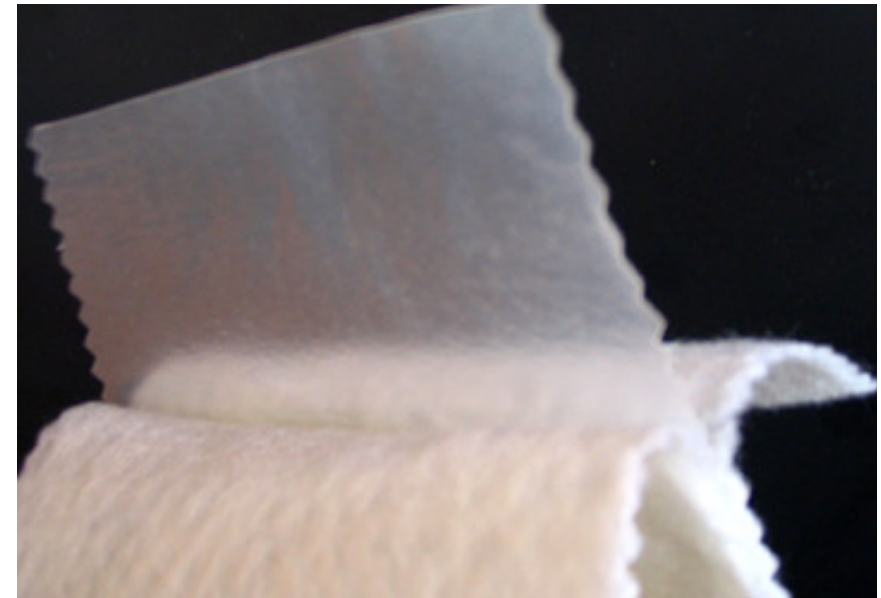
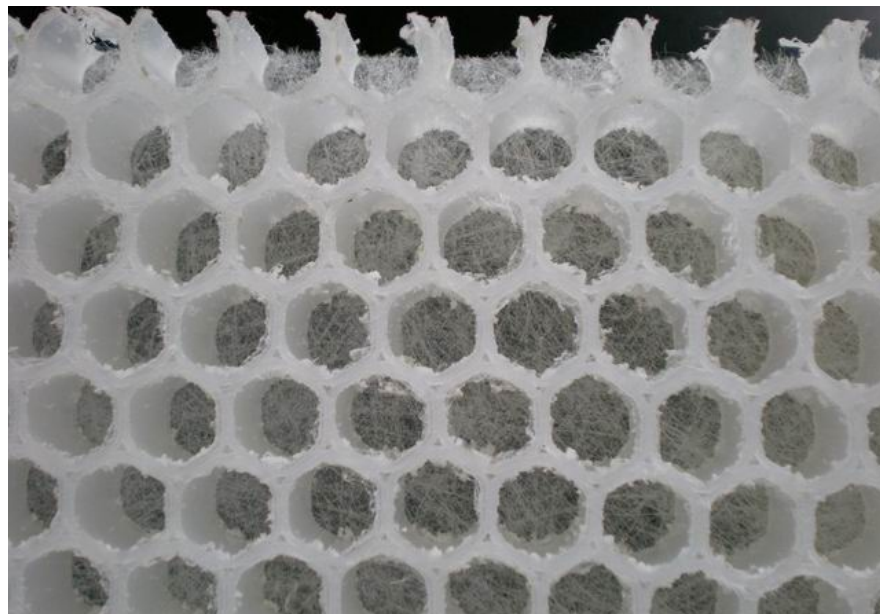


Geotextiles

Geotextiles are fabrics in the traditional sense: however they are usually manufactured from petroleum-based organic chemicals rather than natural plant fibres, which tend to decay. Mineral fibres are carcinogenic and no longer in use.

Geotextiles are manufactured as per domestic fabrics, ie by woven, knitted or non woven (eg fibre-mat or felt) processes. Unlike most domestic fabrics, geotextile manufacture often includes a bonding stage to create very strong composite fabric:

- Chemical bonding (glue, rubberising, etc)
- Thermal (layers bonded by partial melting, or cured by "cooking")
- Mechanical (needle punching, eyelets)



Geotextile Handling and Installation

Geotextiles are generally transported and installed as rolls of fabric or large units similar to mattresses or pillows. Installation typically includes in-situ bonding or splicing of parallel and sequential layouts.

Geotextiles range in thickness from about 0.25 mm to around 1 cm.

Mass per unit area varies from 100-1000 g/m² for non-woven, up to 100-2000 g/m² for woven geotextiles. Heavier fabrics create significant installation handling issues. Manual teamwork is a common solution.

Spool adapters for heavy-lifting machinery are also in common use.

Geotextile installation is a precision technique! Planning for equipment and manpower to the required tolerance is essential



1618



Geotextile Selection and Testing

When a geotextile is being considered for use, certain properties must be measured by a range of in-factory tests:

1. Mass per unit area
2. Percentage of open area
3. Equivalent opening size
4. Thickness

The tests required will depend on the intended application. This is a fairly specialised area and cannot be covered in detail here.

5. Ultraviolet resistance
6. Permittivity
7. Transmissivity
8. Puncture resistance

9. Abrasion resistance

10. Compressibility

11. Tensile strength and elastic properties

12. Chemical resistance



at. No. NS 0039

Clamping Rings,
Guide Block and
S/S Drop Cone

Determination of Puncture Resistance of Geotextiles
using modified CBR Mould AS 3706.5—2000



Readings

Chapter 17 Das

Smith, D.W. 1992. Geotextiles (Reading 14)

Keyword search: Engineering use of geotextiles

