Module – 4 – Corrosion Control

- Corrosion protection - cathodic protection – sacrificial anodic and impressed current protection methods; Advanced protective coatings: electroplating and electroless plating, PVD and CVD.
- Alloying for corrosion protection – Basic concepts of Eutectic composition and Eutectic mixtures - Selected examples – Ferrous and non-ferrous alloys.

Reference – Corrosion Engineering by Mars G. Fontana

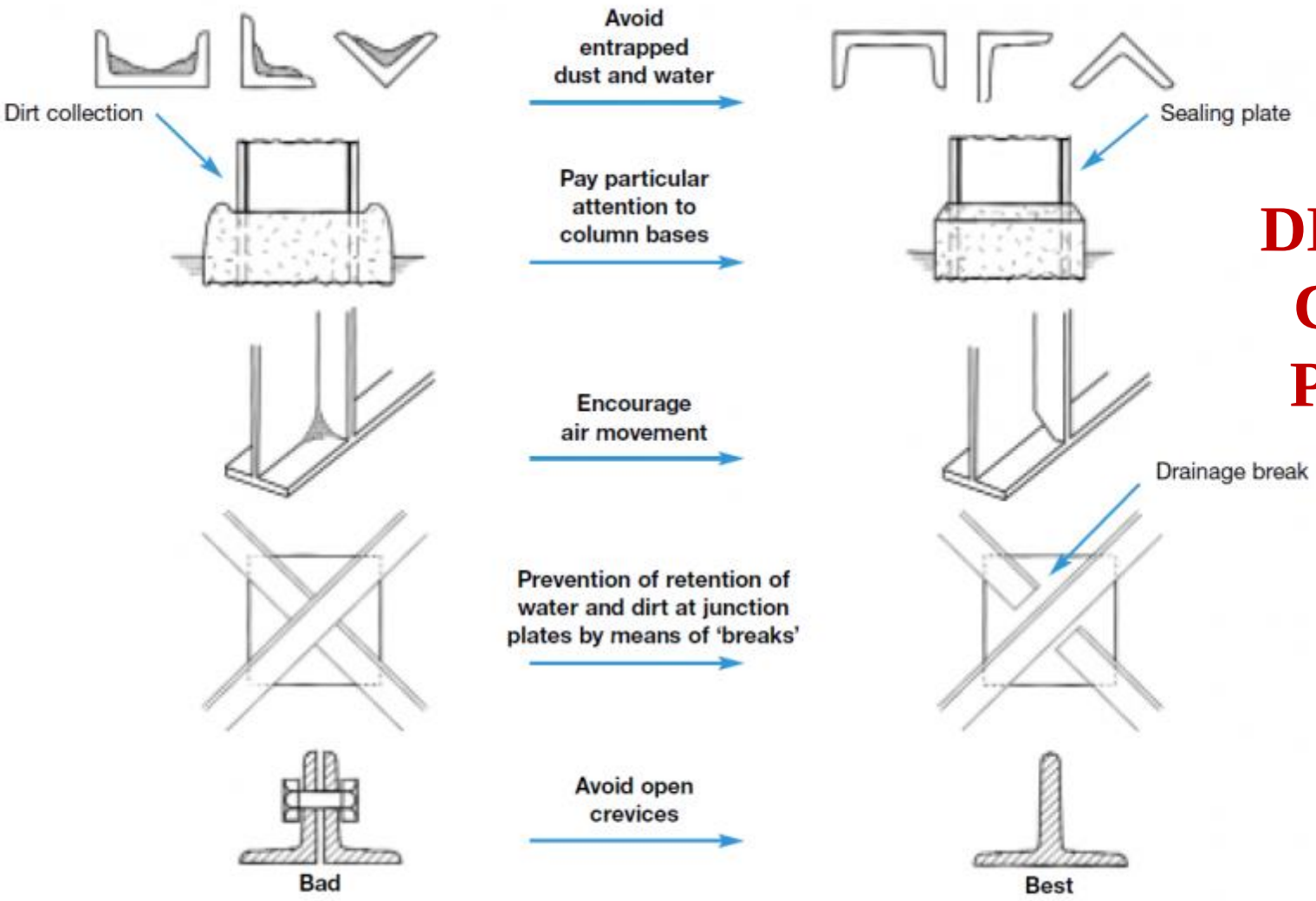
Corrosion Protection/Control

1. **Proper Designing**
2. **Using pure metal**
3. **Using metal alloys**
4. **Cathodic protection**
    a. Sacrificial anodic protection
    b. Impressed current cathodic protection
5. **Modifying the environment**
6. **Corrosion inhibitors**
    a. Anodic inhibitors
    b. Cathodic inhibitors
7. **Protective coatings**
    a. Anodic coatings
    b. Cathodic coatings

Corrosion Protection/Control

1. **Proper Designing**
   - Avoid contact of dissimilar metals
   - Dissimilar metals should be as close as possible in Galvanic series
   - Anodic material should be large
   - Insulating fitting between dissimilar metals
   - Prevent inhomogeneities
   - No sharp edges or corners & crevices in joints
   - Free circulation of air
   - Uniform flow of liquids
   - Prevent some areas of structure to stress

1. Proper Designing



DESIGN for Corrosion Protection

Corrosion Protection/Control

2. Using pure metal (impurity causes corrosion)

- 100% pure metal does not undergo corrosion

3. Using metal alloys (should be homogeneous)

- Alloys may change the metal structure to stable form
- Alloys may act as a protective coating

4. Cathodic Protection

Cathodic protection:

Principle is to make the base metal to be protected as cathode by connecting to a highly anodic metallic plate.

Two methods of cathodic protection are known:

i) Sacrificial anodic protection

ii) Impressed current cathodic protection

i) Sacrificial anodic protection:

- The metallic structure to be protected is connected through a metal wire to a more anodic metal.
- This will induce corrosion at the anodic metal.
- Thus the more anodic metal sacrifices itself and gets corroded protecting the metallic structure.
- Sacrificial anodes known are Zn, Mg, Al and their alloys.
- Applications are: protection of underground pipelines, ship hulls and other marine devices, water tanks.

Table 17.2 The Galvanic Series

	Platinum
	Gold
	Graphite
	Titanium
	Silver
	316 Stainless steel (passive)
	304 Stainless steel (passive)
	Inconel (80Ni–13Cr–7Fe) (passive)
	Nickel (passive)
	Monel (70Ni–30Cu)
Increasingly inert (cathodic)	Copper–nickel alloys
	Bronzes (Cu–Sn alloys)
	Copper
	Brasses (Cu–Zn alloys)
	Inconel (active)
	Nickel (active)
	Tin
	Lead
Increasingly active (anodic)	316 Stainless steel (active)
	304 Stainless steel (active)
	Cast iron
	Iron and steel
	Aluminum alloys
	Cadmium
	Commercially pure aluminum
	Zinc
	Magnesium and magnesium alloys

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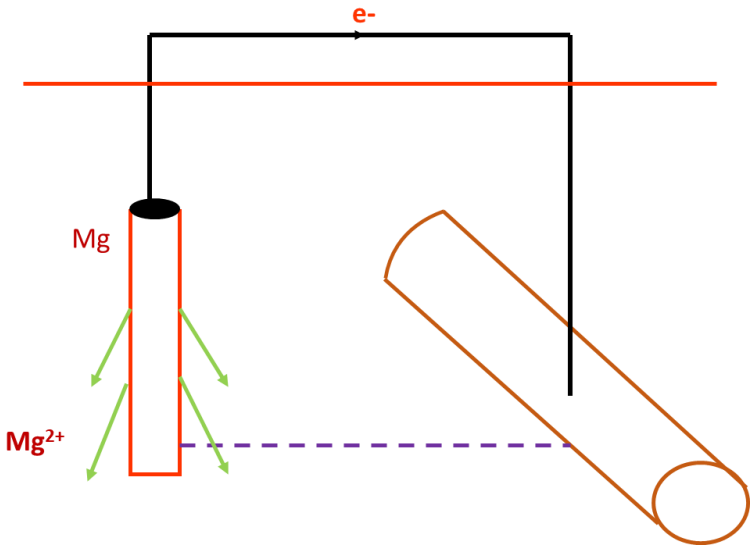
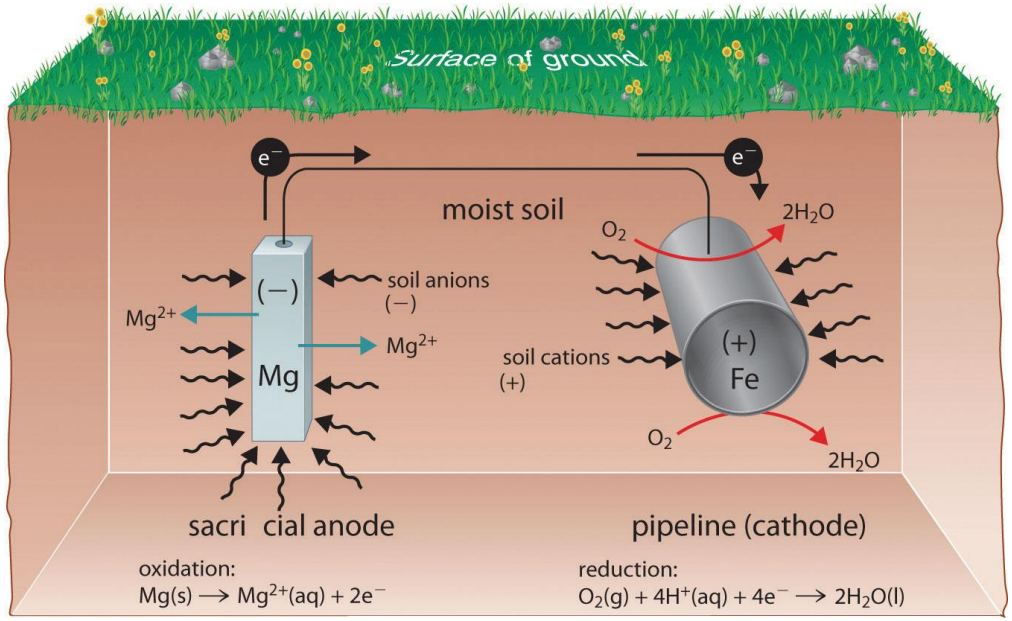
Sacrificial anodic protection

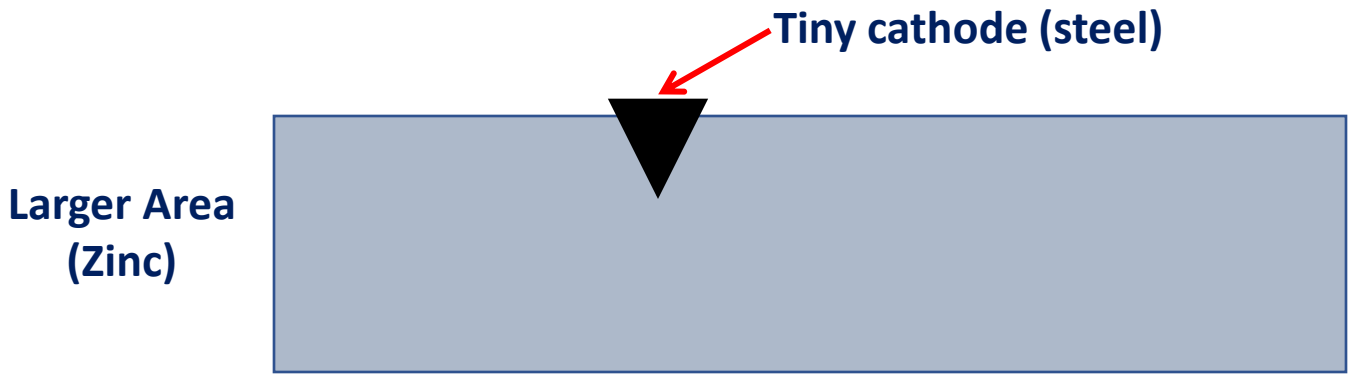
Sacrificial anodic protection - concept





Sacrificial Anodes

- Galvanization of Steel
- Dip steel sheet in molten zinc. Get a pretty thin coating.
- Zinc will be anode. Steel exposed by crack is the cathode. Since we have a huge anode having to be served by a small cathode, corrosion rate will be slow.



An example of a unfavorable area ratio. Bad deal: huge cathode, tiny anode

Another Example

Zinc is attached to the steel hull of the vessel

Corrosion control

ii) Impressed current cathodic protection:

- Impressed direct current is applied in the opposite direction to the corrosion current to nullify it.
- Usually, one terminal of a battery is connected with an insoluble anode e.g. graphite electrode is immersed in black fill containing coke, gypsum, bentonite and sodium sulphate for good electrical conductivity.
- The other terminal is connected to the metallic structure to be protected.
- Since the current is impressed on the metallic structure, it acts as cathode and thus gets protected.
- This method is usually used to protect underground water pipe lines, oil pipe lines, transmission lines, ships etc.

Impressed current cathodic protection

Impressed current cathodic protection - concept

Corrosion current of equal magnitude but opposite in direction applied to nullify corrosion current