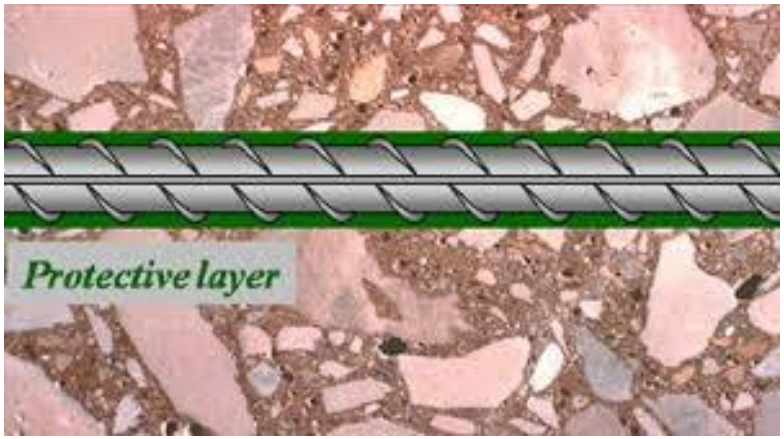
Corrosion of steel reinforcement

- Chloride attack is distinct in that the primary action is the corrosion of steel reinforcement.
- Consequence of this corrosion ,the surrounding concrete is damaged.
- Corrosion of reinforcement is one of the major causes of deterioration of reinforced concrete structures.

Mechanism of reinforcement corrosion

- There is a protective passivity layer on the surface of embedded steel.
- This layer, which is self-generated soon after the hydration of cement has started, consists of γ-Fe2O3 tightly adhering to the steel.
- As long as the oxide film is present, the steel remains intact. However, chloride ions destroy the film and, in the presence of water and oxygen, corrosion occurs.



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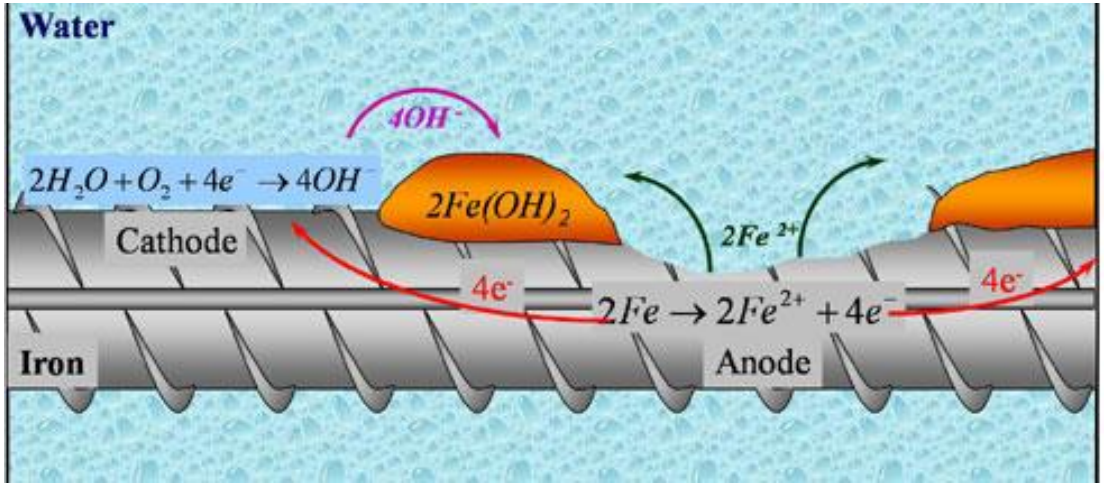
- When there is a difference in electrical potential along the steel in concrete, an electrochemical cell is set up.
- Anodic and catholic regions, connected by an electrolyte solution i.e. the pore water in the hardened cement paste.
- The positively charged ferrous ions Fe++ at the anode pass into solution while the negatively charged free electrons e– pass through the steel into the cathode where they are absorbed by the constituents of the electrolyte and combine with water and oxygen to form hydroxyl ions (OH)–.



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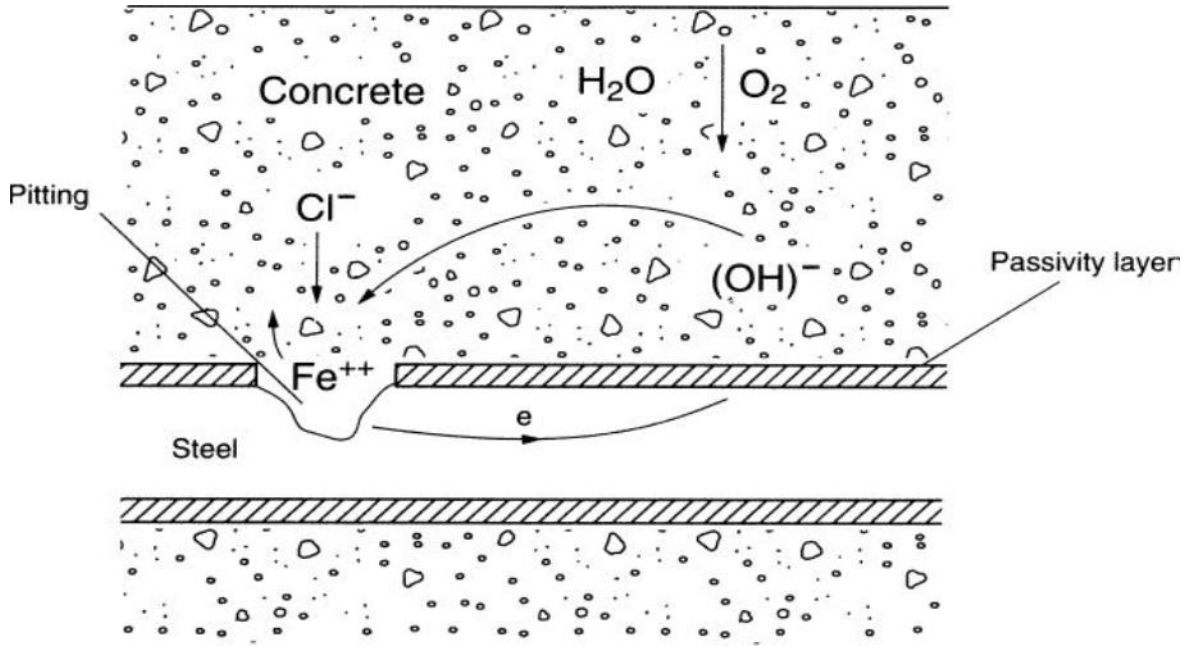
- These travel through the electrolyte and combine with the ferrous ions to form ferric hydroxide which is converted by further oxidation to rust as can be showing in Figure below. The reactions involved are as follows:

Anodic reactions:

$$Fe \rightarrow Fe^{++} + 2e^{-}$$
$$Fe^{++} + 2(OH)^{-} \rightarrow Fe(OH)_2 \quad \text{(ferrous hydroxide)}$$
$$4Fe(OH)_2 + 2H_2O + O_2 \rightarrow 4Fe(OH)_3 \quad \text{(ferric hydroxide)}$$

Cathodic reaction:

4e- + O2 + 2H2O → 4(OH)-



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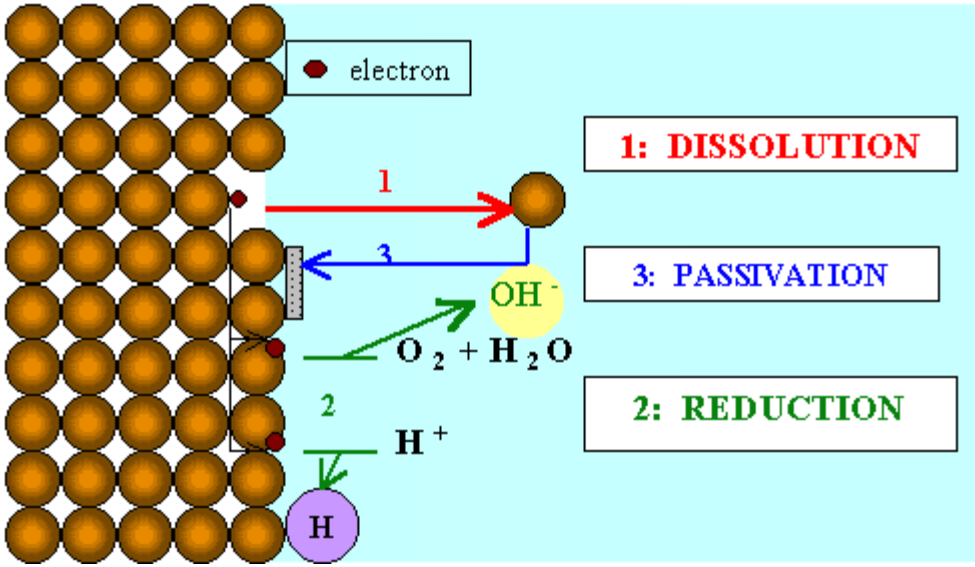
- It can be seen that oxygen is consumed and water is regenerated but it is needed for the process to continue.
- Thus, there is no corrosion in, dry concrete, probably below a relative humidity of 60 per cent; nor in fully-water-saturated concrete , except when water can entrain air.
- For corrosion to be initiated, the passivity layer must be penetrated.
- Chloride ions activate the surface of the steel to form an anode, the passivated surface being the cathode. The reactions involved are as follows:

$$Fe^{++} + 2Cl^{-} \rightarrow FeCl_2$$

$$FeCl_2 + 2H_2O \rightarrow Fe(OH)_2 + 2HCl$$



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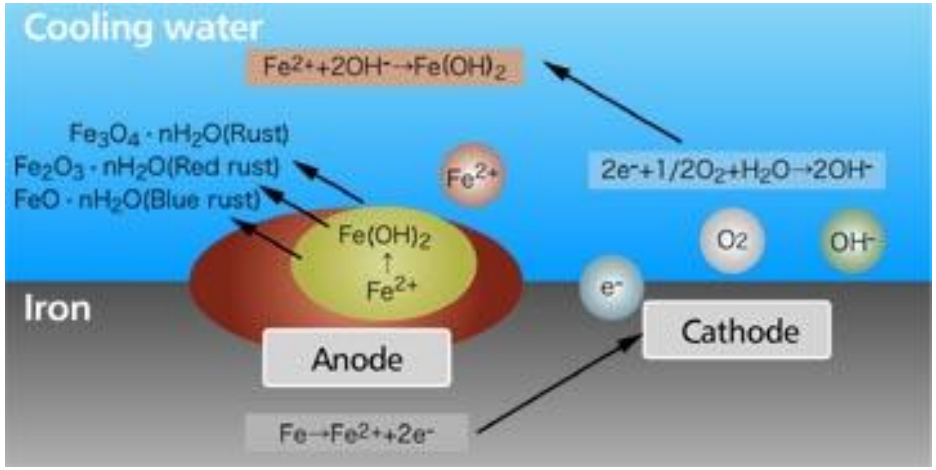
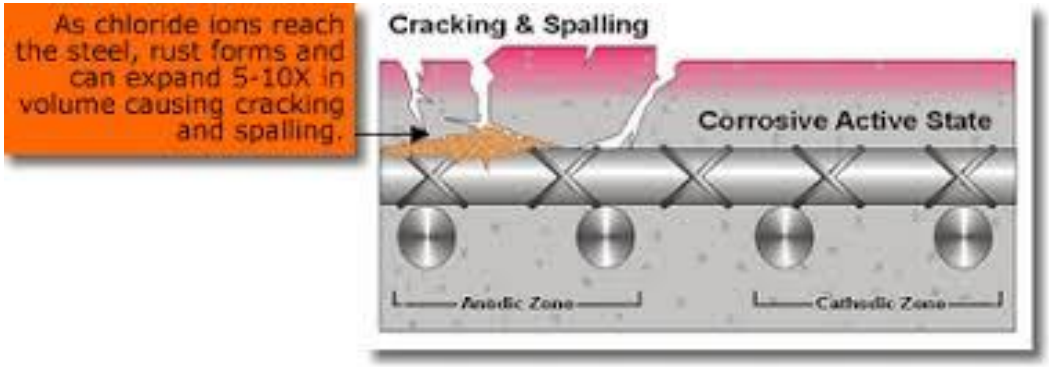
There are two consequences of corrosion of steel:

- the products of corrosion occupy a volume several times larger than the original steel so that their formation results in cracking (characteristically parallel to the reinforcement), spalling or in delamination of concrete .
- the progress of corrosion at the anode reduces the cross-sectional area of the steel, thus reducing its load carrying capacity





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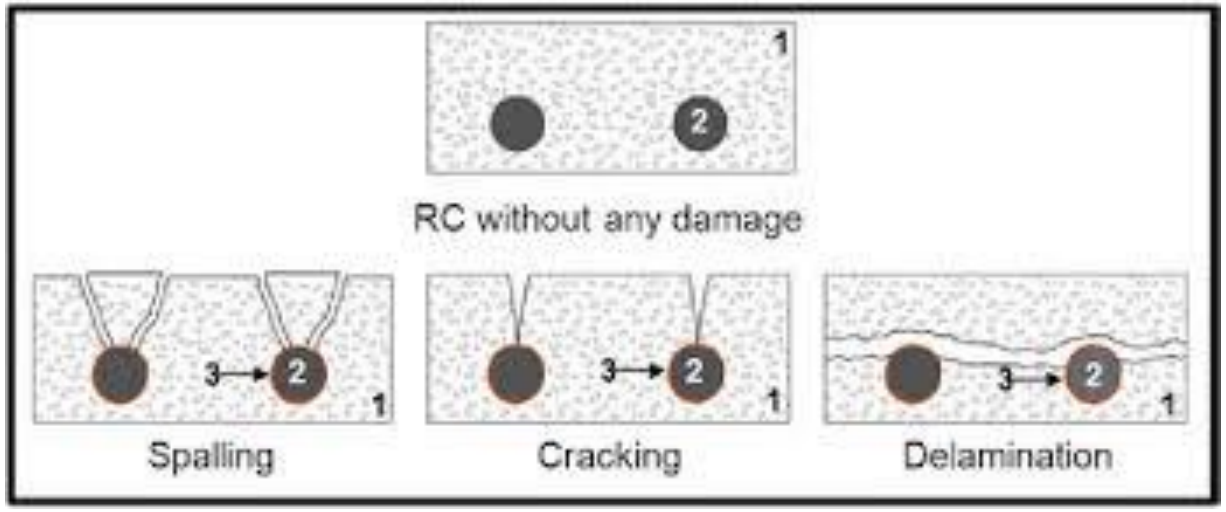
The thickness of reinforcement cover is an important factor controlling the transport of chloride ions: the greater cover means longer time interval before the chloride ion concentration at the surface of the steel reaches the threshold value. Thus, the quality of the concrete (in terms of its low penetrability) and the thickness of cover work together. The cover thickness should at least 50 to 75 mm.



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