

## Chloride Resistance

C3-06  
Properties

### Summary

The use of microsilica is very favourable in concrete which is subject to chloride attack (road salt, sea salt). The addition of Elkem Microsilica will strongly reduce the penetration of chlorides into the concrete and therefore delay the onset of corrosion. Furthermore, the use of Elkem Microsilica in concrete will reduce the rate of corrosion after initiation.

### General

Reinforcement in concrete is normally protected against corrosion. A high alkalinity gives the pore water a pH of 12.5–14, and this causes the formation of a protective passive oxide layer on the steel surface. Active corrosion begins if the

passive film is broken, locally or over larger areas. This can happen as a result of chloride ingress or carbonation. This datasheet deals with chloride attack. Chlorides are a common cause of the breakdown of the passive layer. If a sufficiently high concentration of chloride ions is established on the steel surface, the passive layer will be disrupted locally. Because the flaw will be the small anode to the large cathode of passive steel, intense corrosion can then take place (pitting).

### Chloride Sources

The most important sources of chloride contamination are:  
Sea salt:  
Along the coast and in the sea, chlorides from sea water

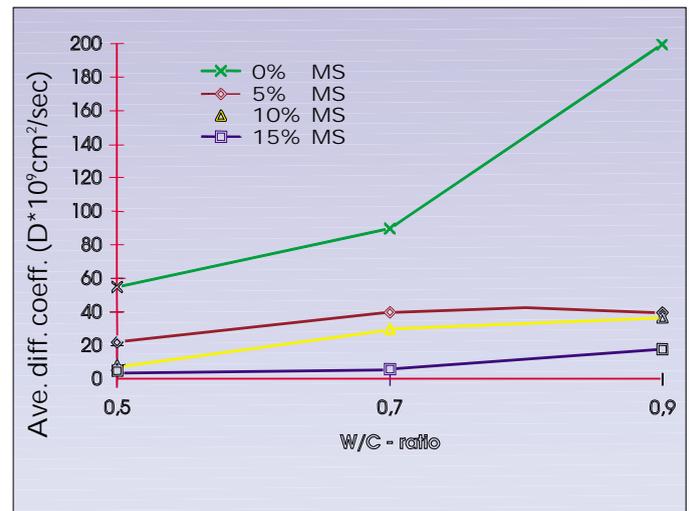


Fig. 1 Chloride diffusion (after Gautefall)

and sea spray can contaminate constructions, sometimes far inland.  
Road salt:  
Salting of roads in winter leads to concrete constructions in and along

the road becoming contaminated. Moreover, cars will carry the contamination into parking garages (which prove to be particularly at risk).

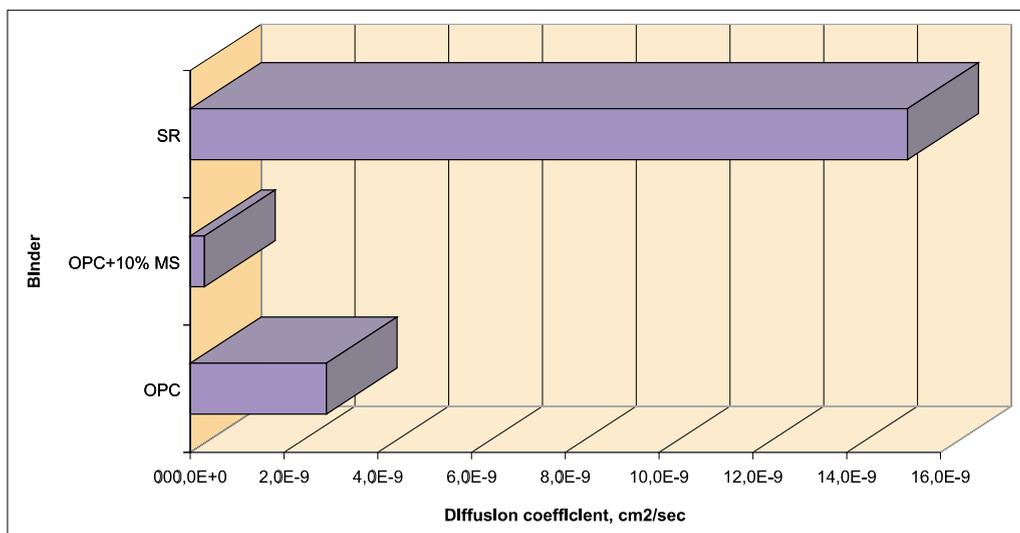


Fig. 2 Effect of ms on chloride diffusion

(Fidjestøl & Frearson)

### Chloride Penetration

Many investigations have been made which document the dramatic reduction in the rate of chloride diffusion which is achieved by using Elkem Microsilica in concrete (Figs. 1, 2, 3). The reduction is mainly due to the refinement of the concrete pore structure. The use of Elkem Microsilica reduces the amount of continuous capillary pores.

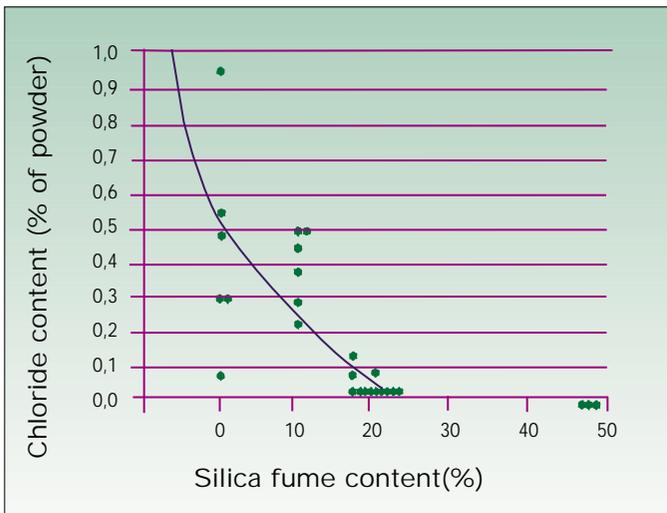


Fig. 3 The chloride content at 16–20 mm depth as a function of the silica-fume content in 15 year old concrete from bridge edge beams (Larsen & al., 1996)

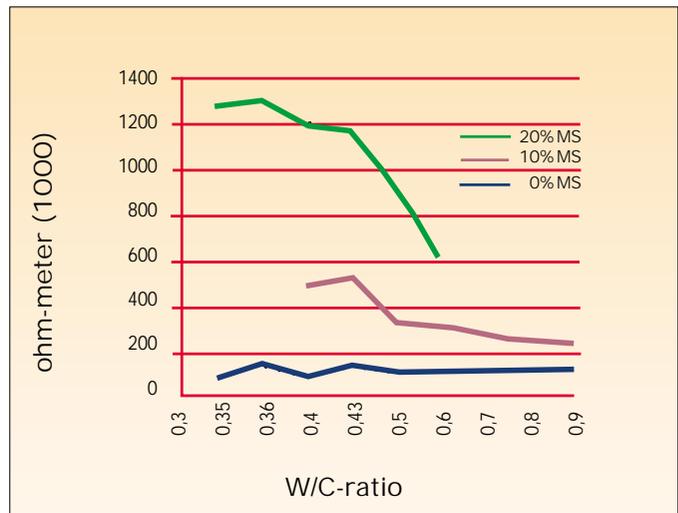


Fig. 4 Specific resistance (after Vennessland)

## Rate of Corrosion

When embedded steel has started to corrode, the rate of corrosion will be determined by the transfer of oxygen through the concrete and by the electrical resistivity of the concrete. The oxygen transfer will not necessarily be affected by the addition of Elkem Microsilica (factors such as moisture state, etc. are dominant), but the electrical resistivity of concrete is strongly affected by the addition of Elkem Microsilica. As Figure 4 shows, the specific resistance increases with an increased Elkem Microsilica content in the concrete.

## References

- Vennesland, Ø.: "Corrosion Properties for Silica Concrete. Condensed Silica Fume in Concrete". NTH 1982.
- Gautefall, O.: "Effect of Condensed Silica Fume on the Diffusion of Chlorides through Hardened Cement Paste", Paper SP 91-46, Second CANMET/ACI International Conference on the Use of Fly Ash, Silica Fume, Slag and Natural Pozzolans in Concrete, Madrid, 1986.
- Detwiler, R. J., Kojundic, T., Fidjestøl, P.: "Evaluation of Staunton, Illinois, Bridge Deck Overlays", ACI Spring Convention, 1996.
- Fidjestøl, P., Frearson, J.: "High-Performance Concrete Using Blended and Triple-Blended Binders", ACI Int. Conference, Singapore, 1994.
- Swamy, R. N., Lai, J. C.: "Effectiveness of Supplementary Cementing Materials in Controlling Chloride Penetration into Concrete", ACI Conf., Paper No. SP 153-34, 1995.
- Stoklund Larsen, E., Eriksen, K., Fidjestøl, P., Leth-Jensen, P.: "Experience on Long-Term Performance of Silica-Fume Concrete", ACI Spring Convention, 1996.

The information given on this datasheet is based on many years of research and field experience and is accurate to the best knowledge of Elkem Materials.

However, due to the numerous factors that can affect the performance of a concrete, with or without microsilica,

Elkem Materials offers this information without guarantee and accepts no liability for any direct or indirect damage from its use.

If further information or assistance is required, please contact your local representative or the office number given on this datasheet.