Salt Frost Deterioration in Concrete Pavement --Causes and Mitigation

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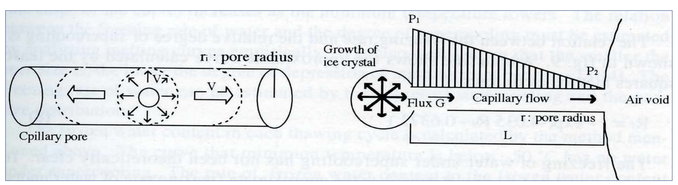
Abstract

•Freezing of water can be explained by the thermodynamic properties of the water due to the influence of temperature, pressure and special effects such as surface tension and osmotic effect (salt solution).

•Below the nucleation temperature, a vacuum with low partial pressure of the water develops around the ice which starts a cryogenic suction pump. For a closed system (i.e., no external liquid at freezing), partial pore-drying develops leading to specimen shrinkage. In air-entrained concrete the ice growth may be accommodated within the pore system without structural damage. In the case when external liquid is present, such as when the surface contains a salt solution, pore suction attracts surface liquid and additional ice growth may not be accommodated within the pore system. Thus, a net expansion occurs.

Frost Deterioration Model

Salt frost deterioration is essentially a hydraulic pressure-induced mechanism. Growth of ice front pushes liquid or vapor and hydraulic pressure will be generated if the travelling distance to the nearest pressure-relief site (air voids) is too far.



Katsura, O. and Kamada, E. (*"A mechanism of frost damage of concrete under supercooling", RILEM Proceedings, Vol.34, "Frost Resistance of Concrete", 1997*)

Joint Deterioration

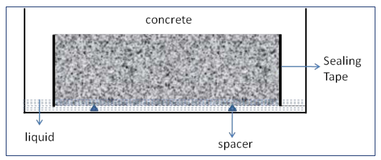
Salt frost deterioration at a joint starts at the bottom of joint reservoir with paste disintegration and concrete erosion. The erosion promotes vertical cracks under truck axle loading. This results in joint spalling.

Joint spalling (M-14)

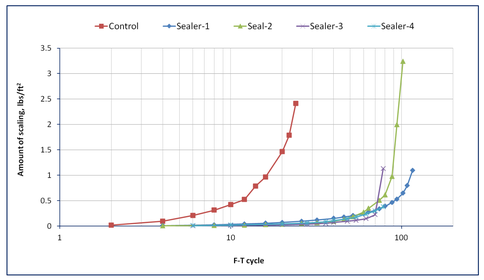
Joint concrete replacement (I-275)

Mitigation

Several types of penetrating sealers is applied on poorly-performing field concrete. Preliminary results from laboratory freeze-thaw test show that salt scaling is substantially reduced after surface treatment.



Rilem F-T machine



Scaling amount with F-T cycles

Untreated specimen **Silane treated specimen**

Surface profile after 20 F-T cycles

Conclusions

•The cryogenic suction pump is a major factor in salt frost damage as it provides additional pore liquid for continued ice-growth within the surface region.

•A silane surface treatment is effective in improving deicer salt resistance in the laboratory on field concrete with insufficient air