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A Discussion of the Paper "CHEMICAL EFFECTS OF CEMENT MORTAR OF CALCIUM MAGNESIUM ACETATE AS A DEICING SALT" by O. Peterson*

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Dr Peterson has produced some interesting results in his study of the chemical effects of calcium magnesium acetate (CMA) of molar ratios Ca/Mg of 1.26 and 0.91 upon two Portland cement mortars of water/cement ratios 0.44 and 0.60 respectively (1). The concentrated solutions of CMA employed were found to dissolve the hardened cement paste in the mortars rapidly at 20°C, but very slowly at 5°C. Reduction of the CMA concentrations from *ca.* 38 to 6.5g.per 100g. water lowered the observed dissolution effect, but the compressive and flexural strengths of the mortar prisms tested were reduced.

Little was said of the implications of the results for CMA as a deicing salt. The temperature dependence of CMA dissolution of hardened cement paste in mortar, which gave low dissolution at 5°C was interpreted technically as suggesting that it is possible to use CMA as a deicing agent in spite of the fact that the substance may dissolve hardened cement paste (1).

The author (1) assumes that CMA is a double salt that contains Ca^{2+}, $CH_3CO_2^-$ and OH^- ions plus some form of water. I am not aware of CMA as used in the U.K. being a double salt but a mixture of calcium and magnesium acetates in given proportions. This point is not very important per se, because, even if CMA were to exist as a double salt, the presence of water, especially in excess, would induce dissolution and hence separation of the Ca^{2+} and Mg^{2+} ions to arise.

CMA is usually supplied in pellets with CA:MA ranging from about 3:7 to 4:6 in practice and costs around 30 times that of the commonest deicer, rock salt (NaCl), but is advantageous in not being known to be corrosive to steel reinforcement. CMA is stored in bags or timber hangers and is spread at 20-30 g/m^2, being effective (like potassium acetate deicer CH_3CO_2K, which also contains a small quantity of a proprietary corrosion inhibitor) down to -15°C. Although skid resistance is adversely affected, there are normally no significant effects of CMA on any building materials apart from some concrete scaling (usually less than for potassium acetate KA), nor are

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there any known adverse environmental effects. However, CMA is thought to be deleterious to concrete in the presence of chloride from rock salt.

The question has frequently arisen as to whether there might be some damage to concrete through Mg^{2+} ion penetration from CMA, which is in fact quite difficult actually to disprove. Poorly compacted and lean concretes with large surface pores are likely to be subjected to frost attack and to take in Mg^{2+} ions from the CMA deicer. However, they will also take in other extraneous ions like SO_4^{2-} or even Mg^{2+} from their environment, which can cause damage to the concrete, like cracking and rebar corrosion, that has nothing to do per se with the applications of CMA. After all, sulphate damage to bridge decks is well known and can arise from wind transmission. For CMA to penetrate concrete, there must be large concentrations (15% w/w or more) or static concentrations in particular areas like pits and pockets. Overall, such situations are unlikely, because of the natural flushing effects through wind, rain, hail, sleet, snow etc.

Some experiments undertaken with mortar blocks partially immersed in CMA solutions have shown the development of long thin crystalline needles above the waterline containing both Ca^{2+} and Mg^{2+} ions that are richer in Ca^{2+} ions relative to Mg^{2+} ions in comparison with their contents in the CMA utilised (2). These look like an efflorescence effect (3), since there have been no obvious signs of cracking. Such a view is supported by observations that the mortar partially immersed in magnesium acetate $(CH_3CO_2)_2Mg$ solutions show the development of cauliflower-like crystals of calcium acetate $(CH_3CO_2)_2CaxH_2O$ and not the more soluble magnesium acetate. Such results demonstrate that there has been ion exchange at the surface, presumably with those Ca^{2+} ions transported within the mortar to the surface. Efflorescence is normally just an unsightly phenomenon and usually does not adversely affect the structural integrity of the mortar or concrete in question (3). At the water line, the mortar blocks can dry out and calcium acetate can readily crystallise out in solid form, which permits some gradual change of calcium-rich cement phases into magnesium-rich ones, especially in the drying zones. There is some evidence that acetate ions can enter the AFt and AFm phases of the hardened cement paste to form salts like $C_3(A,F).CaAc_2.10\text{-}12H_2O$ ($Ac{=}CH_3CO_2$) that can be in solid solution with monosulphate, $C_4(A,F)H_{13}$ etc., but the extent to which this can occur needs to be investigated further.

It is possible that the magnesium-rich phases plus the forces produced in the changes can be the cause of the observed deterioration in the mortar strengths. However, this is merely speculation at this stage, as real definitive evidence is still lacking. CMA is unlikely to give any problem with surface spalling of concrete unless there are repeated wet and dry cycles, which in reality represent a worst case scenario.

CMA is slower than rock salt to enter solution, but is a very effective deicer. On cost grounds alone, alternative deicing agents like CMA will never totally replace rock salt. However, they do have their own particular niches in the market place, such as in environmentally sensitive areas, reinforced structures and their approaches, as well as aircraft runways.

Dr Peterson has produced a series of useful results pertaining to CMA, which usefully add to our knowledge of the material and which should prove valuable for seeking to define the base parameters and limits within which CMA can be optimally utilised without contributing per se to any mortar or concrete problems.

References

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