HYDRAMAX® 1609 Technical Note

Understanding Calcium Chloride Based Admixtures

In some territories calcium chloride is not allowed to be used within concrete containing steel reinforcement. For example, EN 206-1 section 5.2.7 states "Calcium chloride and chloride-based admixtures shall not be added to concrete containing steel reinforcement, prestressing steel reinforcement or other embedded metal." BS 8500-2 states "Calcium chloride or admixtures based on chlorides shall not be used in designated concretes."

These are simplistic statements to what is fundamentally a complex topic. They do not explore what the issues are, and why this rule has been put in place.

So why are the EN 206-1 and BS 8500 statements too simplistic? The basis of these statements is that by removing calcium chlorides from the additive, the risk of these chlorides coming into contact with water and becoming soluble, and then being able to reach the steel, is eliminated.

Unlike sulphates, chlorides do not damage the concrete mass on their own. Chlorides only become a problem for steel when they are combined with water and oxygen. All these elements need to be present to allow the degradation and expansion of steel reinforcement, which in turn can result in spalling of concrete.

The corrosion of steel reinforcement is an electrochemical process in which both chemical processes and the flow of electricity are involved. Reinforcement normally exists in a protective environment (alkaline). Chloride intrusion tends to lower the pH (usually around 13.5) to values near 10. This in turn lowers the electrical resistivity of the concrete. There are threshold limits of soluble chloride ion concentration, which must be reached, before corrosion commences.

Hydramax 1609, although a calcium chloride-based admixture, fundamentally reduces the likelihood of soluble chloride, oxygen, steel and water reacting. There are two reasons for this: the chemical binding and physical binding process that occur by using the product. Unlike standard concrete, concrete containing Hydramax 1609 utilises some of the chloride ions. These ions become chemically bound, and no longer soluble. In addition to this, because Hydramax 1609 utilises up to 95%[(1)] of the Portland cement present in a concrete mix, the density of the concrete matrix increases, thus physically limiting the chance of soluble chlorides coming into contact with the steel reinforcement.

As a worked example of the effects of Hydramax 1609, a mix design with 350 OPC, and a 0.5 w/c ratio, has 175 litres of water within it. Of those 175 litres of water, a maximum of 84 litres will typically be used to hydrate the cement. The remaining 91 litres of free water will aid with placement but also help create pores and bleed tracts within the mass. The 65% (approx.) of cement particles that are hydrated by the 84 litres of water mean that there is an actual 'active' water cement ratio of 0.369.

Hydramax 1609 changes this. Assuming that 95% of the 350 OPC is hydrated, then 332.5kgs of cement is "activated". The water content is reduced by 30% to accommodate Hydramax 1609 (therefore only 122.5 litres is within the mix), the "active" water cement ratio is 0.368.

When comparing the above two 'active' water cement ratios, it becomes apparent that with the mix containing Hydramax 1609, there is in essence no free water left, which is often the cause of troublesome pores and bleed tracts.

As calcium chloride is the carrier of the active ingredients in Hydramax 1609, the initial soluble chloride ion concentration of a concrete mix containing Hydramax will likely be between 0.40 and 0.45%. However, after 7 days this will reduce to under 0.075%, taking the amounts of soluble chloride below the threshold limits recognised and allowable to instigate corrosion of reinforcement. (ACI 318 Table 19.3.2.1 shows a range of between 0.15 - 1.00% of water-soluble chloride to weight of cement, and the Concrete Society state "A fairly traditional view is that below 0.4% chloride by mass of cement represents a low corrosion risk, 0.4 to 1% a medium risk and above 1% a high risk.[(2)]").

(1) Based on a Hydramax 1609 dosage rate of 2.5% of OPC by weight, added to a comparable mix containing no admixtures.

(2) For a 30 MPa concrete: Estimate for tensile/flexural strengths: 30 x 0.15 = 4.5 MPa. With Hydramax 1609 added to the same 30 MPa design, compressive strength increases by 30% (30 x 1.3 = 39 MPa). The corresponding tensile/flexural strengths increase by 100% (4.5 + 4.5 = 9 MPa). The comparative compressive strength to tensile/flexural strength ratio is 23% for the mix containing Hydramax 1609, compared to 15% for the mix not containing Hydramax 1609 (9 MPa/39 MPa = 23% v's 4.5 MPa/30 MPa = 15%).

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