Admixture Technical Sheet – ATS 4

Accelerating admixtures

1 Function

Accelerating admixtures can be used either to increase the rate of stiffening / setting of the concrete or to increase the rate of hardening and early strength gain to allow earlier demoulding and handling. Most accelerators primarily achieve one rather than both of these functions.

Accelerators are most effective at low temperature. In the UK the principle use of set accelerators is in the control of the setting time of concrete floor slabs in cold weather when any extension of set can delay finishing and power trowelling operations. Set accelerators are a very effective way of controlling the setting time of such concretes, even those containing cement replacements.

Accelerators are also used to reduce the risk of damage by freezing when concreting in cold weather and to allow the earlier removal of formwork but it should be noted that they are not an anti-freeze. The exposed faces of struck concrete must still be protected and properly cured.

At normal temperatures, a technically better way of enhancing early strength is to use a high range water reducer/superplasticiser. Significant reductions (greater than 15%) in the water cement ratio can more than double compressive strength at ages less than 24 hours. Accelerators can be used in conjunction with superplasticisers (< 0.35 w/c ratio) where very early age strength is required, especially at lower temperatures. If required, the use of accelerators can be combined with high range water reducers to further enhance early strength development in both low & normal temperatures.

Other applications for accelerating admixtures include urgent concrete repairs and in sea defence work to ensure early stiffening of concrete in the tidal zone.

Very fast set accelerating admixtures, used for sprayed concrete applications are covered on a separate ATS sheet.

2. Standards

These classes of admixture are covered by the requirements of BS EN 934 Part 2: Concrete admixtures – Definitions requirements, conformity, marking and labelling. The specific requirements for each categories are stipulated in Tables 6, 7 and 12.

Three categories of accelerating admixture are covered: -

1) Set accelerating admixtures.
2) Hardening accelerating admixtures.
3) Set accelerating/water reducing/plasticizing admixtures.

The latter produce the effect of a water reducing/plasticizing admixture as their primary function combined with that of a set accelerator as their secondary function.

All CAA manufacturers CE mark their products to show they conform to this standard.

3 Materials

The most cost-effective accelerator for all Portland cement concrete is calcium chloride, which provides both set and hardening acceleration. However, its use is restricted to unreinforced concrete in the UK and in most other countries, due to its potential influence on the corrosion of embedded metal.

Calcium nitrate and calcium nitrite are both effective set accelerators, and are widely used commercially. Nitrite will also give some strength acceleration. The equivalent sodium salts, are also effective, but not always acceptable due to the contribution of sodium ions to the overall alkali content of the concrete.

Thiocyanate salts are effective strength accelerators, particularly at low temperatures. Sodium thiocyanate is widely used commercially.

Calcium formate is another material which finds use, mainly as a set accelerator.

Other technologies such as nucleation aids are also available depending on the specific requirements of the job, contact your supplier for more information.

4. Mechanism

Accelerating admixtures increase the rate of hydration of tricalcium silicate (C_3S) and tricalcium aluminate (C_3A) phases of cement, thereby providing earlier heat evolution and strength development.

It should be noted that accelerators do not depress the freezing point of water significantly and should not be referred to as anti-freeze admixtures.

The accelerating effect of both set and strength accelerating admixtures is most pronounced at temperatures below 10^oC.

5 Use

5.1 Admixture Selection

Accelerating admixtures are usually termed ‘chloride based’ or ‘chloride free’ and may be principally set or hardening accelerators. Care is needed to ensure that the correct one is selected for the required application.

Most Concrete specifications restrict the use of calcium chloride or admixtures containing calcium chloride to plain unreinforced concrete and ban it for structural concrete that contains embedded metal.

5.2 Dosage

Typically the range is from 0.5 to 2.5% by weight of cement but they may be used at higher dosages with advice from the manufacturer.

5.3 Cement Type

Accelerating admixtures can be used with all types of Portland cement including those covered by EN 197-1 and with addition blended with CEM 1 cement at the mixer. They should not be used with aluminate cements without consulting the manufacturer.

5.4 Overdosing

High dosage rates or, occasionally, normal dosage rates with high cement content mixes may cause rapid stiffening and considerable heat evolution with consequent risk of thermal and shrinkage cracking. Calcium chloride in particular should be used with care in hot weather.

High dosage rates of sodium salt accelerators will result in raised alkali levels and consideration should be given to their input towards the total alkali calculation for the concrete. High doses of some accelerators may also adversely affect strength at later ages.

6 Effects on properties of concrete

6.1 Strength

Hardening accelerators can produce a significant increase in the early strength of concrete, especially at lower temperatures. For example at 5 - 10°C, 200% of the strength of a control mix without admixture can be achieved. However, the increase in long term strength is generally small. At temperatures above 10°C it may be technically preferable to use a non retarding high range water reducer, as illustrated in the following table but note that these are only typical and other technologies may produce enhanced results.

	5^0C	20^0C	
	Accelerator	**Accelerator**	**High Range Water Reducer**
Final Set -	5.5	2.25	4.75
hours			
Strength N/mm^2 -	0.0	7.0	2.5
6 hours			
-	1.8	12.5	8.5
8 hours			
-	3.5	20.0	23.5
12 hours			
-	12.5	27.5	35.0
24 hours			
Strength N/mm^2 -	48.5	50.5	63.0
28 days			

BS EN 934-2 specifies that for hardening accelerators a concrete mix containing the admixture should have at 20°C, a1 day strength at least 20% greater than a mix without the accelerator. At 5°C a 2 day strength at least 30% greater than that of the control mix.

6.2 Workability

Unless combined with a water reducer, accelerating admixtures give no significant change in workability.

6.3 Slump loss

The rate of slump loss of concrete containing a set accelerating admixture will be significantly faster than that of the equivalent plain concrete mix of the same initial workability and even for hardening accelerators it will generally be quicker.

Where long delivery times are expected, it may be appropriate to add the accelerator at the point of delivery. This technique should be used with caution in the case of power floated floors where there could be finishing problems resulting from load to load variation in stiffening time.

6.4 Setting time

The setting time of concrete containing an accelerator will be shorter than that of the equivalent plain concrete containing no accelerator. The acceleration is typically 1 to 2 hours for a set accelerator but less than one hour for hardening accelerators. This will be affected by accelerator type, dose and ambient temperature.

BS EN 934-2 stipulates that for set accelerators, a mix containing the admixture must have an initial setting time at 5°C of 60% or less than that of a mix without the accelerator.

A 2% dose of calcium nitrate accelerating admixture can typically give 90 minutes acceleration of initial set.

Calcium chloride is a set and hardening accelerator and is the most effective admixture type for both categories.

6.5 Air entrainment
Most accelerators do not entrain air and have little or no effect on the performance of air entraining admixtures.

6.6 Bleeding
Accelerating admixtures do not normally have any adverse effect on bleeding.

The bleeding capacity of most concretes is related to setting time. Cold weather will prolong setting of concretes and so exacerbate the potential for concretes to bleed. Hence, accelerators may reduce bleeding purely as a result of reduced concrete setting time.

6.7 Heat of hydration
Accelerators increase the rate of heat release and may, therefore, give a greater temperature rise than the equivalent plain concrete mix. The total heat of hydration is unaffected.

6.8 Volume deformation
Calcium chloride increases both drying shrinkage and creep.

Other accelerating admixtures generally cause a slight increase in drying shrinkage. There is little published data available relating to their effect on creep.

6.9 Durability
Calcium chloride has the ability to break down the natural passivity of steel provided by the alkalinity of concrete and thereby encourages the corrosion of reinforcement or other embedded steel. The corrosive influence of calcium chloride and its ability to increase shrinkage make it a potential hazard to long-term durability in reinforced concrete and its use should be avoided for this application.

Nitrites do not cause corrosion, and indeed there is much evidence to support the view that they may inhibit corrosion.
There is some evidence that nitrates and thiocyanates could cause stress corrosion and their use is restricted where they may contact prestressing tendons.

There is less published data on the influence of calcium formate on durability but electro-potential tests of a blended calcium formate/sodium nitrite based accelerator and on thiocyanate based hardening accelerators have shown no corrosive influence on normal reinforcing steel.

Calcium formate based accelerators have been in use in the UK without reported harmful effects since the mid 1960s and thiocyanates since the 1970s.

7 Health and Safety of Admixtures
Most admixtures are non hazardous and pose no abnormal health and safety risk but as with all forms of chemical it is essential that the material safety data sheets are read and understood before use. Risk assessments should be conducted to ensure all users are provided with a safe means of use and relevant PPE.

8 Other information
Other CAA information sheets are available including Environmental Product Declarations, use of admixtures in drinking water applications, sustainability, storage and dispensing. These are available at www.admixtures.org.uk under the ‘Publications’ tab.