CEMENT ADMIXTURES ASSOCIATION

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the Sign of Quality

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Admixture 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 a prime use of set accelerators is in the control of the setting time of concrete floor slabs in cold weather when any extension of set delays 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. 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. A large reduction (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 where very early age strength is required, especially at lower temperatures.

Other applications where accelerating admixtures are used are in 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 AS sheet.

2. Conformance Standards

Three categories of accelerating admixture are covered by BS EN 934 Part 2: 2001 'Concrete admixtures – Definitions, requirements, conformity, marking and labelling' : -

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.

The specific requirements for these 3 categories are stipulated in Tables 6, 7 and 12 of BS EN 934-2, respectively.

3 Materials

The most cost-effective accelerator for all Portland cement systems, 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.

Low concentrations of alkanolamines may also be combined with these compounds. The most commonly used is triethanolamine, but since its effectiveness is very sensitive to dosage level and to the composition of cement its principal usage is to counter the retarding effect of some water reducing materials, notably lignosulphonates.

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

4. Mechanism

Accelerating admixtures increase the rate of hydration of tricalcium silicate (C_3S) and tricalcium aluminate (C_3A) phases of the 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 lower temperatures of the order to 5-10^{o}C.

5 Use

5.1 Admixture Selection

Accelerating admixtures are 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.

5.2 Dosage

Accelerating admixtures usually have an effect that is proportional to their dosage, at least at lower dosages. 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.

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.

Calcium chloride can be obtained as a solution or in flake form. In the case of flake it is essential that the flake is completely dissolved in water before addition to the concrete mix.

Calcium formate may also be supplied in powder form and in such cases should be added to the dry batch before mixing.

Liquid admixtures are generally considered easier to dispense accurately and are more readily dispersible evenly through the mix.
Some settlement may occur in calcium chloride solutions after only a relatively short period of storage and facilities for agitation may be necessary.

5.3 Cement Type

Accelerating admixtures can be used with all types of Portland cement including those covered by EN 197-1 and with other binders 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 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 approximately 10°C a technically better way of enhancing early strength is to use a non retarding high range water reducer, as illustrated in the following table:

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

Many accelerators can achieve 1-day strength gains of up to 100% higher than the equivalent plain concrete mix. However, the cost of achieving this with a chloride free accelerator such as a sodium thiocyanate or calcium nitrite based accelerator is likely to be several times that of using calcium chloride.

BS EN 934-2 specifies that for hardening accelerators a concrete mix containing the admixture should have a compressive strength, at 20°C and 1 day's age, of 20% or more greater than a mix without the accelerator. At 5°C and 2 days' age, it should be 30% or more greater than that of the control mix.

6.2 Workability

Unless combined with a water reducer, accelerating admixtures give only a small increase 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.

Calcium nitrite and calcium nitrate have a significant beneficial effect upon setting time, but are not very effective at enhancing strength development. The acceleration of set is generally greater than that of hardening accelerators such as sodium thiocyanate.
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 to any significant degree.
They have little or no effect on the performance of air entraining admixtures, although calcium chloride has been reported to reduce the frost resistance of air entrained concrete in the longer term.

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