ANNEX 3

Requirements for using calcium aluminate cement

1 Characteristics of calcium aluminate cement

Whereas Portland cements essentially get their hydraulic properties from the calcium silicates and tricalcium aluminate, calcium aluminate cement gets these properties from the monocalcium aluminate. The Al_2O_3 content of the latter, according to UNE EN 14647, must be between 36 and 55%, although its usual values are between 40 and 42%.

Calcium aluminate cement offers a series of special characteristics. Thus, while its setting time is virtually identical to that of Portland cement, it hardens much more quickly. As a result, mortar and concrete made with calcium aluminate cement reaches strength, after only a few hours, which is about the same as that obtained at 28 days with Portland cement.

This strength reduces over time due to a conversion process in which the hydration of the calcium aluminate cement at ambient temperature (<25°C) produces hexagonal hydrated calcium aluminates which are metastable. These therefore inevitably undergo a transformation (conversion) to the cubic form of hydrated calcium aluminate which is the only thermodynamically stable compound.

This conversion causes the porosity of concrete made with calcium aluminate cement to increase and therefore reduces its strength. This conversion can take just a few minutes or several years as the transformation rate depends on several factors, principally temperature.

The degree of this reduction in strength can vary. If the recommendations for correct use are followed and if a high cement dosage and a low water/cement ratio are used, the concrete can remain strong enough. However, the strength can reduce to excessively low values if the aforementioned recommendations are not followed.

The final strength reached after the conversion can be determined using the test described in UNE EN 14647.

Calcium aluminate cement in particular withstands better than Portland cement the action of pure water, sea water, sulphated water and gypsum-bearing soil and also the action of magnesium salts and diluted acids. However, concrete made with this is less resistant to the action of alkaline hydroxides.

In order to correctly use calcium aluminate cement in its various applications, the general rules which are valid for producing Portland cement mortar and concrete should be borne in mind. The specific instructions indicated below should also be followed.

2 Materials

Calcium aluminate cement shall meet the requirements laid down in the applicable specific regulations in order to be used in those cases indicated in section 8 – Applications of this Annex.

The aggregates shall comply with the general specifications given in this Code.

Aggregates containing releasable free alkalis must not be used and, in particular, the use of granite, shale, micaceous and feldspathic aggregates must be avoided.

Fine aggregates with a sand equivalent higher than 85%, according to UNE-EN 933-8, or those containing less than 5% by weight of particles smaller than 0,125 mm must be used.

The behaviour of admixtures with calcium aluminate cement is significantly different from that observed with Portland cement. Prior tests are therefore compulsory to establish the compatibility and appropriate dosage of each type of admixture.

3 Design

The characteristic strength of concrete made with calcium aluminate cement shall be taken as the minimum residual strength which may be reached after the cement has fully converted, bearing in mind the considerations set out in section 1. Its value shall be determined using the experimental procedure described in section A.7 of Informative Annex A UNE-EN 14647 In any event, the characteristic strength shall never exceed 40 N/mm².

Due to the lower pH and reduced alkaline reserve, reinforcements embedded in concrete made with calcium aluminate cement may be more exposed to corrosion. As a result and for reasons of general durability, the minimum covers which must be used are:

- In the non-aggressive exposure class (I): 20 mm.
- In the normal exposure class (II): 30 or 40 mm depending on the reinforcement diameter and stresses in the element.
- In the marine (III), non-marine chlorides (IV) and aggressive chemical (Q) exposure classes: 40 mm.

The minimum cover shall be increased along the cover edge Δr indicated in Article 37.2.4 of this Code in order to achieve the nominal cover defined in this Article.

4 Batching

The following requirements shall be strictly observed:

- The minimum cement content shall be 400 kg/m^3.
- Water/cement ratios higher than 0,4 shall not be used. When calculating the mixing water, the water provided by the aggregates shall be taken into account.

5 Work equipment and tools

Any possible contact between the calcium aluminate cement and other Portland clinker-based cements or lime or gypsum shall be avoided, as also shall any accidental contamination of the calcium aluminate cement by these elements.

6 Placing of the concrete

Vibration shall be used when the concrete is placed.

When concreting in hot weather, the aggregates and water must not be directly exposed to sunlight.

When concreting in cold weather, the following precautions shall be taken:

- Frozen aggregates shall not be used.
- The temperature of the recently mixed concrete shall be sufficient to ensure that this remains above 0°C until setting and, as a result, the exothermal cement hydration reactions have begun.

7 Curing

In the case of pavements or slabs, initial curing of the concrete must be carried out immediately using curing products or the concrete must be protected with damp cloths. In the case of other structures or elements with a smaller surface area, once setting has ended, curing

shall begin using continuous spraying or watering. This shall continue for at least the first 24 hours after the concrete is placed.

As with Portland cement, it is advisable to avoid premature drying of the cast concrete elements, particularly in hot and dry environments. A good practical recommendation is to keep the concrete elements covered and it is advisable to water them periodically during the first few days.

Unless a special study is carried out, heat curing must not be used.

8 Applications

In accordance with Article 26, the use of calcium aluminate cement in concrete must be specially studied in each case, setting out the reasons for its use and strictly observing the specifications contained in this Annex.

Calcium aluminate cement is best for:

- Refractory concrete.
- Urgent and rapid repairs.
- Temporary footings and beds.

Where its use is justifiable, it may be used in:

- Structures and elements precast using plain concrete or non-structural reinforced concrete.
- Certain cases of plain concrete foundations.
- Sprayed concrete.

Calcium aluminate cement is not recommended for:

- Structural reinforced concrete.
- Large volumes of plain or reinforced concrete.
- Cement-treated substrates for roads.
- Soil stabilisation.

Calcium aluminate cement is prohibited for:

- Prestressed concrete in all cases, according to Article 26 of this Code.

With regard to the exposure classes, concrete produced in accordance with the specifications of this Annex will behave appropriately in:

- Non-aggressive environments I
- Marine environments III
- Slightly aggressive chemical environments Qa
- Moderately aggressive chemical environments Qb