TECHNICAL ADVICE

Calcareous Aggregate
TAN5

Traditional lime mortars carbonate within as well as on the surface.

Two groups of aggregate have a positive chemical effect on mortar performance:

- Calcareous or limestone aggregates

- Pozzolanic materials.

Calcareous Aggregates

This is calcium carbonate present as limestone aggregate but also as unburnt material in the lime. The reaction series that is critical to the performance of historic lime mortars is carbonation, and not the hydration of calcium silicates and calcium aluminates.

To understand this, it is necessary to understand the chemistry of carbonation, and this is more complicated than generally thought.

Carbonation is generally understood in the oversimplified reaction of:

$$Ca(OH)_2 + CO_2 \longrightarrow CaCO_3 \quad (\text{lime} + \text{carbon dioxide} = \text{calcium carbonate})$$

As moisture is necessary, this reaction should be written:

$$x.H_2O + CO_2 + Ca(OH)_2 \longrightarrow CaCO_3 + y.H_2O$$
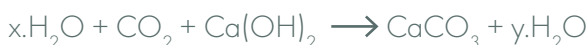
In fact:

The first reaction is that of $CO_2 + H_2O$ to form H_2CO_3 (carbonic acid). Reactivity increases in the presence of acidity in rainwater. It is this carbonic acid that reacts with lime on the surface of mortar to produce calcium carbonate.

$$Ca(OH)_2 + H_2CO_3 \longrightarrow CaCO_3 + 2H_2O$$

The depth of this surface reaction depends on many factors including time, permeability of mortar, and relative humidity.

Later:

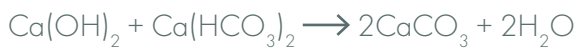Carbonated lime on the surface of mortar reacts with carbonic acid to form calcium bicarbonate:

$$CaCO_3 + H_2CO_3 \longrightarrow Ca(HCO_3)_2 (aq).$$

Both the calcium bicarbonate and the carbonic acid permeate into the mortar where they both react with lime to produce calcium carbonate:

$$Ca(OH)_2 + H_2CO_3 \longrightarrow CaCO_3 + 2H_2O$$

$$Ca(OH)_2 + Ca(HCO_3)_2 \longrightarrow 2CaCO_3 + 2H_2O$$

In a Traditional Lime Mortar containing calcareous material, carbonation occurs within the mortar:

As long as sufficient CO_2 is available to stabilise the bicarbonate in solution which is likely to occur in the long term, calcium carbonate present as limestone aggregate, or as unconverted, partially converted, or reconverted material, will in turn dissolve in the carbonic acid to produce calcium bicarbonate. This bicarbonate will in turn react with lime to form calcium carbonate.

$$CaCO_3 + H_2CO_3 \longrightarrow Ca(HCO_3)_2$$
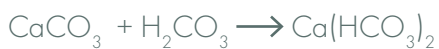
Limestone aggregate + Carbonic acid = Calcium bicarbonate

$$Ca(HCO_3)_2 + Ca(OH)_2 \longrightarrow 2CaCO_3 + 2H_2O$$
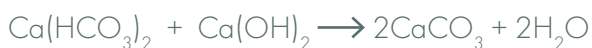
Calcium bicarbonate + Lime = Calcium carbonate + water