Cotswold House Maintenance

Part One. Why use lime mortar?

Mortar has a threefold purpose. It bonds masonry together, ensures that loads are spread evenly and fills the gaps between the bricks or stones. The latter function helps makes the wall weatherproof and thereby excludes damp. This is essential in traditionally built houses with solid walls. Unlike modern cavity or timber-framed walls, which separate the outer and inner layers of the construction, solid walls fulfill their weatherproof function by their ability to absorb and release water.

Limestone is porous; it can absorb large amounts of moisture, for example from driven rain, and in dry conditions needs to release equivalent volumes of water through surface evaporation. Therefore, it is important that the 'breathability' of the stone is not inhibited and that the correct type of mortar is used to carry out repairs, including repointing. Dense cement-based mortar severely limits evaporation from the mortar joints and causes moisture retention. Dampness can lead to rot in built-in and internal timbers, frost damage to stonework, poor thermal performance and surface erosion of the stone due to salt crystallisation.

Photograph 1 – honeycomb weathering

Salts are present in the soil; most historic stone structures were built with earth mortars, and lime mortar, a relatively expensive commodity, was only used at the exposed joints. Moisture will mobilise salts and as evaporation takes place, salts are left behind at the surface (efflorescence), or within the pores as crystals. During crystallisation, the salts expand in volume from their dissolved state. Erosion of the stone can take place when crystallisation occurs inside the stone. In stone with large pores, the crystals can form without causing any damage but finely pored oolitic limestone, such as that commonly found in buildings in the Stroud valleys, is susceptible to this form of weathering.

The combination of hard cement mortars, frost damage and salt crystallisation is the cause of the 'honeycomb' weathering (photograph). A certain degree of damp is inevitable in stone walls but it is clearly better that the salts crystallise in the mortar, which is easily replaced, rather than the stone. Moisture will tend to move from a dense material into one with higher porosity and evaporation will not take place from a material with impermeable characteristics, i.e. a cement mortar. It is a general principle that the mortar should have greater porosity than the brick or stone with which the wall is built. In this event, the mortar will act as a wick extracting moisture from the masonry. These characteristics needed are met by lime-based mortars.

Part Two Lime: different varieties explained

It may seem odd to start an article about lime to talk about cement but it warrants a mention because it is such a marvelous material. The use of Ordinary Portland Cement (OPC) has become widespread throughout the construction industry from the Second World War onwards. A type of cement was used by the Romans to make concrete; this was probably hydraulic lime mixed with material to make it set faster. However, these methods died out with the fall of the Roman Empire and were not rediscovered until the eighteenth century. John Smeaton, an engineer, pioneered the use of hydraulic lime. He built the Eddystone lighthouse 14 miles offshore on rocks submerged at high tide. This needed a mortar that set quickly and was incredibly strong. OPC was developed in the nineteenth century by using a new type of horizontal kiln and firing limestone and certain types of clay at higher temperatures. The cement produced using this method was even stronger and faster setting than its predecessors and could be manufactured to consistent quality standards. These qualities make it easy to use and construction a much quicker process. By contrast lime mortar, particularly lime putty based mortar, is slow to set, relatively weak (especially in the early stages of set), time-consuming to mix and apply and has become difficult to obtain.

Limes and cements set by different processes. The incorporation of clay impurities in the limestone used for cement production imparts a chemical process called a hydraulic set. Pure lime putties set by a process known as carbonation. The latter involves the absorption of carbon dioxide and results in a material that has the same chemical make up as limestone. Carbonation requires the presence of moisture to set properly.

Quicklime is the material produced by burning limestone. It is highly alkaline and caustic and was historically used for disposing of dead bodies. Dry hydrated lime, also known as bag lime (or calcium hydroxide for the technically minded), is made by adding water to quicklime (slaking). The result is a dry powder. The slaking process produces a lot of heat and drives off the water content. It is best practice to leave the mortar made with bag lime to mature in order to allow the lime to absorb water and distribute itself as fine particles around the aggregate. It is considered to be inferior to lime putty as it tends to absorb carbon dioxide in the bag and can fully carbonate before use. Lime putty (Hydrated Lime) is a material that has taken the slaking process a stage further and is fully slaked to form a putty-like material. Deprived of carbon dioxide by storage in a sealed container or covered by a layer of water it will remain in this form for many years and is said by many to improve with age. N.B. All putty should be stored for a minimum of 2 weeks before use.

Hydraulic limes have the ability to set without the presence of air, even under water, and combine to a lesser or greater degree both carbonation and a hydraulic set depending on the strength required, which is determined by the class of hydraulic lime used. Hydraulic limes come in three strengths designated by their Natural Hydraulic Lime class, which are NHL 2, NHL 3.5 and NHL 5. The number refers to the material’s compressive strength expressed in N/sq mm and these roughly correspond to the former designations of feebly, moderately and eminently hydraulic. NHL 3.5 is suitable for new construction, whilst NHL 5 is used in more challenging conditions, including sea defense walls, canal walls etc.

On an environmental note, the production of cement involves burning limestone at far higher temperatures than lime with the consequent increase in energy consumption. Moreover, the carbonation process involves the absorption of carbon dioxide.

Part Three: the choice of mortar and application

The usual constituents of mortar are the binder, i.e. lime, and an aggregate in the proportions of one part binder to two or three parts of aggregate. The choice of mixture and aggregate depends on the material to be pointed up. In wider joints, coarser aggregates and galleting (see below) can be used. This helps reduce shrinkage and prevent the mortar cracking. Fine joints should be filled with a stronger mix, up to 1:1, using stone dust as an aggregate.

Photograph 2

The type of lime used depends on the situation in which it is to be applied. As well as considering the material to be repaired the environment in which it needs to perform must also be taken into account. As noted stone needs to be repaired with a compatible mortar. Oolitic limestone, which incorporates small pores, needs a porous lime mortar made using lime putty. The more open textured weatherstones from the upper limestone beds, known locally as Minchinhampton stone, will be tolerant of a hydraulic lime mortar. Weatherstone is used in the more exposed positions on a building, e.g. parapets, sills and plinths, where a hydraulic lime will perform better than a ‘fat’ lime mortar. Accelerated setting of lime putty mortars can be achieved by the use of ‘pozzolanic’ materials; this term derives from volcanic ash found in Pozzuoli near Naples in Italy, which was used by the Romans to hasten the setting of lime mortar. Pozzolans include substances such as crushed brick or tile and PFA (Pulverised Fly Ash) which contain silica and alumina. These induce a hydraulic set and produce a stronger mortar with greater resistance to water. When used they typically make up a tenth of the volume of the mortar. The addition of small amounts of cement to lime mortars has been common practice but is not recommended as research has shown that these mortars are prone to failure.

Photograph 3

‘Fat’ lime mortars (made with lime putty) should be used externally when there is no risk of frost and ideally in temperatures over 5 degrees centigrade. Low temperatures will inhibit carbonation and in extreme conditions cause the water content to freeze. High temperatures and strong winds can dry out the mortar too quickly. In all conditions, the carbonation process will only take place when the mortar is damp. Before repointing the open joints should be thoroughly wetted. In wide joints wetted stones can be used to pack out the joint (galleting) and reduce the amount of mortar employed. A round ended gauging trowel or similar tool should be used rather than a ‘pointing’ or bricklayers trowel. When filling the joints the mortar needs to pressed firmly in and left slightly proud of the surface. After about 24 hours and as the mortar stiffens it should be pressed back to prevent cracks developing. Following this excess mortar and trowel marks should be removed with a stiff bristle brush; a churn brush is very effective. This also gives the mortar an open texture and consistent appearance.

During the carbonation process the mortar should be kept covered for at least two days with dampened sacking or plastic sheeting to reduce evaporation and the work regularly damped down with a water spray. The mortar should be finished flush with the surface of the stone to promote water run off. Ribbon pointing should be avoided as the ledges encourage damp penetration into the stone, see photo 2. The colour of the mortar is also important if only for aesthetic reasons; a light mortar highlights the stone whilst a dark mortar emphasises the pointing, see photo 3.