A taste of lime

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Using inappropriate materials can cause problems and long-term damage to buildings, warns Chris Gibbons, especially for those originally constructed using lime-based mortar

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Ordinary Portland cement (OPC) is a material that is widely understood, readily available and generally commercially convenient to use as, among other things, a binding agent for mortar. Most DIY stores even publish simple pamphlets explaining how to use it. Unfortunately, lime-based materials are often poorly understood and deliberate avoidance of their use by ill-informed practitioners and contractors can cause irreversible damage not only to ancient buildings but also commercial and residential properties constructed in the pre-war period of last century.

Attitudes towards lime mortar within the industry are varied. Commercial surveyors and property owners tend to think that lime-based construction materials are the preserve of the conservation movement. However, failure to maintain an older building with appropriate materials can cause a lot of heartache, especially for occupiers and end users.

Nurtured buildings

You do not need to look very far in most established UK commercial centres to find a building that was originally constructed using lime-based mortar. The chances are that such a building will have been 'nurtured' at some point during the past 80 years and, almost inevitably, OPC will have been introduced for repointing, rendering and possibly even tanking ? the process of improving the water resistance of building fabric by coating it with a sand and cement render with a synthetic additive to impede moisture penetration.

Compared with lime, cement-based materials tend to offer greater resistance to moisture penetration once set, adhere well (even with low suction backgrounds) and have greater compressive strength. These facets in particular are generally the antithesis of the characteristics required from a lime-based mortar. It is easy to understand, therefore, that problems may arise when OPC mortar is used in a building originally constructed with lime.

Figure 1: Severe erosion of soft sandstone blocks on an ancient building following inappropriate repointing with OPC mortar

All buildings in the UK are exposed to damp penetration from rain, particularly parts that are unprotected by a roof structure or eaves/canopy overhang. Brick and many common types of stone used for wall construction are usually porous and rainwater striking the surface will tend to be absorbed evenly through the outer face. Lime mortar tends to be much more porous than OPC-based mortar and hence, any dampness in a wall constructed from lime-based materials will evaporate from the surface more readily than OPC mortar construction. Importantly, where OPC mortar is used to repoint an older wall in place of lime, the 'new' mortar joints can alter evaporation paths through the outer face. Where soft limestone, sandstone or clay bricks are pointed with OPC mortar, these elements can take much longer to dry after rainfall. Consequently, they will be more susceptible to freeze-thaw damage where the damp host material freezes and spalls, eroding the surface of the wall.

The slower rate of evaporation through a solid wall construction repointed with cement mortar means that damp staining is much more likely to appear on the internal finished surfaces. Additionally, harder OPC-based cement mortar can alter the structural characteristics of an older wall if sections are rebuilt with relatively inflexible OPC materials.

It is important for building surveyors dealing with the maintenance of pre-war buildings to recognise, understand and know when to specify lime-based materials. First, it is necessary to understand about lime materials and the common forms and constituents of lime mortar.

There are basically two types of lime for construction: hydraulic and non-hydraulic lime. In simple terms, hydraulic lime hardens (sets) in the presence of moisture, much like OPC mortar, whereas non-hydraulic lime hardens in the presence of carbon dioxide through a process called carbonation.

Lime impurities

Both types of lime are a product of burning raw calcium carbonate (e.g. in the form of limestone and chalk). The difference between them is not just the levels of impurities in each, but the impact of these impurities on the way newly formed lime reacts with water throughout the process of carbonation.

Non-hydraulic lime is usually created by burning limestone that is relatively pure at around 800?C to produce unslaked lime. The process of creating hydraulic lime is similar, but the raw limestone materials contain impurities, usually clay, and the kiln temperature is much higher at circa 1,200?C. This triggers a complex chemical reaction that creates quicklime, which converts to a powdered form on hydration. This is stored in airtight containers or sealed bags before use because exposure to air or moisture can initiate the setting process.

The appropriate selection of either type of lime for mortar pointing and small maintenance works, such as rebuilding a window lintel, depends on the location and exposure of the wall. The nature and type of the original lime materials used in construction are also important.

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There are three common classifications of hydraulic lime: feebly, moderately and eminently hydraulic lime. These have been redefined more recently as NHL 2, 3.5 and 5 respectively, where NHL denotes natural hydraulic lime (not to be confused with non-hydraulic lime) and the number its compressive strength in N/mm?. In general terms, non-hydraulic lime and feebly hydraulic lime tend to be used for low exposure areas, with moderately and eminently hydraulic lime for areas where greater levels of durability are required. In either case, the original lime materials present in a structure should be considered before embarking on maintenance works.

Several organisations and specialist suppliers can be found and that can examine original mortar samples removed from a building and then provide advice on lime, aggregates, pozzolanic additives and appropriate mix ratios for a given setting.

Pozzolanic additives can change the characteristics of a mortar mix and, for example, improve durability or introduce pigmentation for coloured mortar. However, the science of pozzolanic additives is complex and must be carefully considered when specifying a mortar.

It is important to note that lime mortar mixes require a well-graded aggregate with a range of

particle sizes, typically between 3mm and 150microns for general brick wall repointing work. Simply mixing lime with bagged sharp sand from a builders merchant will not usually provide a suitable range of surfaces for the lime binder to work effectively.

Compressive strength

The set time for lime-based mortars takes considerably longer, relative to OPC-based materials. While this does provide the benefit of extended working times on site, it takes more time for lime mortar to reach the designed compressive strength. This is not usually a problem with repointing works, however, because the majority of the compressive strength provided by mortar is within the bed joint rather than the pointing zone.

Site conditions for lime mortar works are also very important. As a general rule, pointing should be avoided during the UK winter months because there is a risk that un-set mortar will be damaged by frost. Lime mortars typically take many years to harden fully, but achieve an early set within two to seven days and must be protected from frost during this time. The programme constraints this presents must be considered at an early stage to avoid inconvenient and potentially costly project delays.

As mentioned earlier, it is usually inevitable that older building will have had some OPC additions during the past 80 or so years. Historic walls can become damaged when OPC mortar is removed, taking the square edge (arris) of bricks and stone blocks with it. The extent of possible damage tends to correlate directly with the depth of pointing, strength of mortar mix and porosity of original masonry. Poor workmanship in the past will often result in less damage, conversely, when removing OPC mortar now, particular where bed joints were not adequately raked-out during previous maintenance works. Notwithstanding this, current best practice advice from conservation bodies recommends that OPC mortar is left in place unless there are other overriding issues, such as widespread damp penetration, to avoid damaging the original fabric.

There are many practical reasons for the use of lime-based materials for the maintenance of older pre-war buildings that will aid durability and longevity of a property. There is also a strong case for the use of lime materials in any ancient or historic structures where there is a need to preserve the original appearance of a structure.

Care must be taken when inspecting a property and specifying maintenance works where the introduction of inappropriate materials can cause problems and lasting damage to a structure. Contractors for maintenance works must be carefully selected to ensure that appropriately skilled personnel will undertake the necessary works. It is up to the surveyor, however, to ensure that the correct materials are identified, selected and used correctly to provide the best advice and service to the owners and occupiers of any property constructed using lime-based materials.

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Further information

- Technical Pamphlet 5 ? Repointing Stone and Brick Walling , Society for the Protection of Ancient Buildings
- Practical Building Conservation: Mortars, Renders and Plasters , English Heritage
- BRE Digest 362 ? Building Mortar , Building Research Establishment
- Related competencies include: T006 , T012 , T021