RESTORATION AND CONSERVATION MORTARS

Today all of us are charged with the responsibility of ensuring the survival of our historical and vernacular built heritage through careful and considered conservation, restoration and renovation. All too often buildings are repaired with inappropriate materials and poor skills. Many are the subject of interventions that in time lead to their total loss. Others are simply changed out of all recognition.

In many cases, the mortars used for restoration or conservation work are not suitable. Suitability should not be confused with “like for like”. The reason for this is that today, in most cases, it is NOT possible to reproduce exactly the mortars of the past. The binders are different, the sands might not be the same and in many instances the buildings have changed.

The properties that one should look for to qualify a mortar as SUITABLE are:

1. COMPATIBILITY
2. LOW CAPILLARITY AND SHRINKAGE
3. ADEQUATE $Ca(OH)_2$ OR FREE LIME CONTENT
4. RESISTANCE TO FROST
5. RESISTANCE TO SALTS
6. VAPOUR PERMEABILITY (BREATHABILITY) & GOOD SANDS
7. EARLY SETTING, GOOD ELASTICITY/WORKABILITY/RE-WORKABILITY
8. SUITABLE COMPRESSIVE AND BONDING STRENGTH
9. ENVIRONMENTAL CONSIDERATIONS
10. GOOD WORKMANSHIP AND SITE PRACTICE

A brief look to each of these points.

1: COMPATIBILITY

Compatibility should be both Chemical and Mechanical.
In chemical terms what is important is that mortars introduced into existing structures will NOT chemically react with existing mortars and the surrounding masonry by introducing in the masonry soluble salts such as Sulphates and Aluminates or Alkalis (Potassium and Sodium) causing Sulphate Attack or Alkali-Silica reaction.
In Mechanical terms, mortars should NOT be too dense to impede breathability or have poor Elasticity resulting in cracks that will allow water/moisture penetration.

2: LOW Capillarity AND Shrinkage

High capillarity allows moisture penetration and, if a mortar has poor breathability (such as cementicious mortars), there will be creation of condensation and, eventually, damp. The main causes of high capillarity are poor sands and void structure and high quantity of Free Lime in the binder. Free Lime crystallises in the voids, reducing their size and therefore increasing their capillary action.
Poor building details and drainage increases the amount of water in touch with the masonry which can be absorbed by capillary action.

High Shrinkage is also a source of cracking and it is to be avoided.

Shrinkage is caused by:

- Inadequate suction control of the masonry units.
- High free lime content. This is because free lime is very fine and demands more water at the moment of mixing the mortar. The evaporation of this water leaves micro cracks in the mortar (Shrinkage).
- Wrong dosage in the mortar mix. Commonly occurring when too much binder is used. Over-binding produces a heave effect, causing cracks.
- Poor mixing of the mortar can cause over-binding in certain areas and low binding in other with cracks as a result.
- Poor protection from drying wind, direct sun, driving rain and frost when the mortar is still fresh will also cause cracking and shrinkage. So will poor Curing: mortars, especially lime mortars, need time to cure.

I briefly mentioned Low Free Lime content. I think this deserves a little more explanation:

3: Adequate $Ca(OH)_2$ OR FREE LIME content

FREE LIME / HIGH CALCIUM LIME / AVAILABLE LIME / AIR LIME/ HYDRATED LIME / PORTLANDITE/ FAT LIME/SLAKED LIME are basically all the same and consist of Calcium Hydroxide - $Ca(OH)_2$

Free Lime makes mortars more workable and this is liked by the mason. However Free Lime affects a number of important properties in mortars such as:

- **Setting and hardening time:**
  an early set and a relatively quick hardening are important to be able to build with some speed. Initial setting of an hydraulic mortar is within 1 or 2 hours, the final set is within 24 hours. Mortars made with binders with high free lime content (CL and some NHLs in the BS 459 Standard) need contact with Air to re-absorbe CO_2 to harden by reconstituting itself to $CaCO_3$ or LIMESTONE. This process called CARBONATION may take a very long time. Damp environment, rain, location of the mortar (exposure to air), contribute to slowing and in some cases even stopping Carbonation therefore greatly increasing the setting and hardening time
- **Free lime**, because of its fineness, increase water demand in the mortar. One of the causes of shrinkage, as already discussed.
- It also increases **capillarity** by crystallising in the voids, reducing breathability
- The reduction of the voids size affects also the **frost resistance**, as we will shortly see.

High free lime mortars such as 1:1:6 and 1:2:9 mixes or hydrated (powder or putty) lime mortars might not be as suitable as they are supposed to be.

Careful judgement has to be made in relation to their use.
This also applies to lime mortars made with hydraulic lime with very high free lime content.

4: Resistance to frost

The reduction in void size by free lime crystallisation or a poor void structure caused by poor sands and the slow carbonation of free lime, makes the mortar more susceptible to frost damage.

Frost starts always from the surface and goes inward. Frozen water particles in the surface voids push the water in the voids behind further in and so on. A hardened mortar with a good void structure accommodating the water movement will resist frost.

5: Resistance to salts

The same mortar will also resist the outward migration of salts contained in the masonry.

A Macro void structure in the mortar will accommodate the pressure exercised by salts when moving or crystallising.
When structures contain salts it is almost impossible to control them if they become unstable. Their behaviour is linked to the Relative Humidity at which is each salt is stable. A lower RH will cause crystallisation, a higher RH will cause the salt to go into a solution and migrate.

If the void space is sufficient, these phenomenons will not cause a damaging heave. If crystallisation occurs, they stay in the wall and if there is no space in the voids the pressure can be great enough to crack the mortar. If they go into solution, they will eventually come out and can be cleaned off the wall.

6: Vapour permeability (Breathability) AND good sands

A breathable mortar is essential in the control of condensation. No damp, no rot, a much better living environment.
It also helps in consuming less energy in heating. If a room is damp, a lot of the heating will go in drying out the damp before heating the room....
The two main factors in achieving good breathability are: a relatively low Free Lime content in the Binder to avoid too much crystallisation in the mortar voids and the use of well graded sands.

7 : Good setting, elasticity, workability

Setting and Hardening determine the work rate. They are also related to the mortar dosage, the water addition and the weather conditions during execution of the work. Protection and curing methods are directly connected with Setting, Hardening and Curing mortars.
See: **Protection Document**

Elasticity determines the amounts of movement that the mortar will take before cracking. It is also relevant in calculating the positioning of joints. A good Elasticity will help in accepting thermal movements.

Workability of a mortar is in many cases left to the mason that is executing the work and almost invariably this result in excessive water addition to obtain the “plasticity” that masons like. This is wrong as too much (or too little) water can have serious effects on setting time, shrinkage, capillarity and so on.

8 : Suitable compressive and bonding strength

It is no good to look just at quick setting and hardening. A very hard mortar, especially when made with cement, is NOT the solution to all requirements.

Quick setting and strong hardening have become synonymous with "a good mortar" since the advent of cement but in Restoration and Conservation Setting and Hardening should be only part of the evaluation to be made on the most suitable mortar for the job.

Of course we need setting and hardening, especially in adverse climatic conditions and seasonal work. But this should NEVER be to the exclusion of all other considerations made up to now such as Compatibility, Breathability, Elasticity and so on.

9: Environmental considerations

It is common knowledge that lime mortars re-absorbs part of the CO_2 emitted.
St. Astier NHL mortars will re-absorb between 38% and 49% of the CO_2 emitted in the production of the binder.
See: **Emissions Document**

NHL mortar are also non toxic and once hardened, they will not increase the water pH.
Cementicious mortars can contain Chromium VI directly related to skin allergies and, depending on the type of cement used, components like Pulverised Fly Ash (PFA), Granulated Ground Blast furnace Slag (GGBS) and others that contain a number of dangerous elements such as Heavy Metals and toxic components.

NHL mortars will also be easily removed from masonry units, allowing them to be re-cycled. The breathability of NHL mortars eliminates condensation and contributes to a better living environment.

10. Good workmanship and site practice

Good materials can become useless if the correct site practices are not followed.
Good workmanship and supervision are essential.

If mortars are not dosed or mixed properly, if they are not cured and protected correctly, if they are applied badly, if the application surfaces are not properly prepared, if suction is not controlled, if salt movements are not taken into consideration and so on, the result will be a failure.

Architects, Engineers – Specifiers in general – should work with the Contractor to ensure that he has the necessary comprehension and skills to apply the mortars and follow the necessary site practice.

However, it is the responsibility of the mortar manufacturer to give Architects, Engineers and Specifiers all the information necessary for the evaluation of the mortar to be adopted.
This information should start with the Chemical and Mineralogical composition of the raw material and derived products, the performance of mortars on multiple parameters* and technical back-up to Specifiers and Contractors whenever requested.

*** St. Astier Limes provide 2 years multiple parameters performance figures of NHL mortars at various dosages and straight comparison with blended mortars (NHL+Putty and Cementicious mixes as 1:1:6 and 1:2:9).**
See: 24 months Test Results

Ugo Spano
smkt@btinternet.com

For further Guidance, contact your St Astier Distributor.
Copyright © 2016 CESA, Chaux et Enduits de St Astier