Composition of Raw Material

The importance of the composition of St. Astier raw material and the processing method of pure and natural hydraulic lime (NHL).

In 1833 Louis Vicat, still considered today one of the greatest authorities in hydraulic limes, surveyed the limestone of the St. Astier basin situated in the Perigord area of Dordogne. Archeological evidence shows that lime was produced here in Roman times, and even before then. Vicat concluded that the material was appropriate for the production of natural hydraulic lime. **Industrial production began in 1851**. Today, St. Astier's production capacity is over 100.000 tons per year.

The deposits extend between Montaceix and Neuvic sur l'Isle (approx. 6 miles) and the layer is over three hundred feet thick. It was formed during the Upper Cretaceous period (approx. 75 million years ago) by marine sediment (mostly crustacean and corals). The sea in the basin was not subject to severe currents and this allowed the formation of a uniform and undisturbed layer of calcareous rock infiltrated mainly by silica with only insignificant traces of other elements. This characteristic of the rock is unique in Europe and is the reason why the St. Astier products are so reliable.

The purity of this calcareous rock makes all the difference between producing materials with constant characteristics or being unsure of the final qualities as is commonly experienced when argillaceous or less pure limestone deposits are exploited.

The incoming EU norms (prEN 459.1/2/3) on natural hydraulic lime (NHL).

This states that natural hydraulic lime is the product of burning and slaking limestone. **It should not contain any additions** such as pozzolans, gypsum, air entrainers, ash or cement. Where additions are present they will have to be qualified and the resulting products will have to be named as NHL-Z indicating additions of pozzolanic or hydraulic materials of up to 20%. The norm also allows up to 3% of SO_3 content and between 3%-8% of free lime.

Although the distinction between pure NHL products and others, where additions have been introduced, is welcome, the opinion of many is that the tolerances given above are too wide and a possible result could be the use of non suitable materials, especially in restoration and conservation work.

Addition of pozzolanic and hydraulic material (cement being the most common) is clearly necessary in products derived from poor raw materials when hydraulic properties and other mechanical characteristics are not constant. The presence of these additions in some cases could be damaging and it is advisable to ask suppliers to state whether or not their products contain additions and, specifically, what has been added.

In the case of SO_3, the limit in the norm is considered too high, while the limit for free lime is considered too low, again making possible the use of non-suitable materials.

For their customers peace of mind, St. Astier Limes give the following figures for all their NHL products: no additions, only traces of SO_3 (0.45%-0.54%) and between 15% to over 50% free lime.

Most important of all, the St. Astier NHL products are totally compatible and will not react with old mortars because they do not contain reagent components. Salts, which might be contained in the structure or have been introduced by previous unsympathetic interventions, will be allowed to migrate out of the structure without affecting the soundness of an NHL mortar. Furthermore interventions with NHL mortars are not irreversible and materials recyclability is ensured.

The importance of the raw materials.

Limestone and argillaceous limestone that contains silica will also contain sulphates, alumina, iron, magnesium, manganese, potassium and other compounds. Burning the limestone at temperatures above 1500^0F will combine the above components with the calcium carbonate forming calcium silicates, aluminates and sulphates. The ideal result would be to obtain a product containing the required value of combined silica with the lowest possible presence of potentially damaging other components such as tricalcium aluminate (C_3A) and soluble sulphates.

Tricalcium aluminate starts occurring when materials are burned at 1650^0F and increases at 1850^0 F and over. The highest values are found in ordinary cement (sometimes over 10%). Obviously the lower the amount of alumina and sulphates contained in the raw material, the better the final product quality. St. Astier deposits are exceptionally low in alumina and in sulphates, the resulting products are therefore virtually free of these components.
Ordinary cement mortars and mortars made with lime where cement has been added are sure to contain high quantity of tricalcium aluminate which in contact with suplhates and water can produce sulphate attack starting with efflorescence and progressing to damaging joints, bricks and stone. The BS 5628 warns about this but does not indicate that a simple solution could be the use of a pure NHL mortar.
High presence of gypsum is also to be avoided. Its sulphate content can be disastrous.

Manufacturing process and quality control

The production process is extremely important to ensure the final quality and performance of the products. St. Astier's whole production, from rock extraction to packaging is fully automated and computer controlled.

The coal used for burning is the purest anthracite coal, imported from Wales despite availability of local coal (high in sulphates and residuals). This is dosed in the required amount and mixed with the stone before introducing the charge into the furnace (vertical kilns of 200 T capacity).

At the end of each burning all batches are checked for CO_2. The amount of CO_2 determines the efficiency of the burning and regulates the subsequent water addition during the slaking process.

Expansion tests (soundness) are also constantly made to ensure that no material with an expansion value over 1/16"(2mm) is processed further thus avoiding the use of sub standard materials which would result in products subject to shrinkage and containing a high level of reactive quick lime.

Laboratory tests are conducted continuously to comply with French mandatory tests (fineness, free water content, soundness, bulk density, compressive strength, setting time, penetration, SO_3 and available lime content). These, combined with other tests (tensile strength, elasticity moduli, workability, adhesion, whiteness), ensure the customer has access to the most comprehensive information allowing the correct choice of product to be safely made.

Apart from the virtual absence of soluble sulphates and tricalcium aluminate, directly due to the chemical composition of the natural stone, the sophisticated and controlled production process ensures the following:

1. That the correct amount of silica is combined in burning, to constantly achieve the required strength and hydraulic set with no need for additions of pozzolanic or other materials. This facilitates mortar design and ensures that mortars are quickly resistant to frost and rain.
   Excessive humidity or rain water will not stop the hardening process as in putties or air limes. In plastering, if good working practice is applied, jobs are completed efficiently and, in our experience, in considerably less time, reducing overall costs.

   Furthermore, the application season is extended to nearly the whole year and frost protection is necessary for a shorter time than mortars made with lime putty. The production of various strength materials as NHL 5, 3.5 and 2 (commonly defined as eminently, moderately and feebly hydraulic), reduces the need for blending.

2. That efficient slaking produces the pulverization of the burned lime to obtain very fine products #200 (0.08 mm) with low bulk density. Low density means large cost savings when mixes are made based on volume (on a 1:2 mix one needs only 19 lbs of NHL 3.5 per ft^3 (305kg per m^3) of sand versus 42 lbs. (675 kg per m^3) of lime putty or 45 lbs. (725 kg per m^3) of cement in an equivalent mix).

3. Mixed with the appropriate sand NHL mortars will have approx. 30% voids (versus 5% in cement based mortars). Calcite forming during carbonation will obstruct some of the voids but cannot obstruct them all. This is the reason why NHL mortars, although water resistant, have excellent vapour exchange qualities (permeability to air) avoiding the risk of trapping condensation, so common when cement based mortars are used.

4. That NHL products retain a high percentage of available lime (15% to over 50%). This explains their workability, their ability to accept re-working if required and the presence of self healing properties (re-working would also be impossible if cement or gypsum addition were present).

5. That the powders maintain the natural color of the limestone. This, the absence of additions and the use of Anthracite coal which burns efficiently, gives St. Astier NHL products a nearly white appearance (whiteness index from 67 to 76). This means that it will be easier to reproduce the natural color of the sand used.

St. Astier NHL products are used worldwide for their quality and reliability and in the most varied climatic conditions. Innumerable buildings of all ages have been preserved and restored with these materials over the last 150 years.

The St. Astier range of NHL products is available in North America solely through a network of specialist companies involved in conservation, restoration and new build. Part of their responsibility is to assist in the task of selecting the most suitable materials, mortar design, color matching, analysis of existing mortars, training and choosing the correct aggregates to use in mortar mixes, so essential to ensure optimal performance.