



FORMULATING PROMPT WITH LIMES

Prompt Natural Cement dates back to 1842 on the site of an existing limestone quarry. The production process employed is virtually the same as for lime.

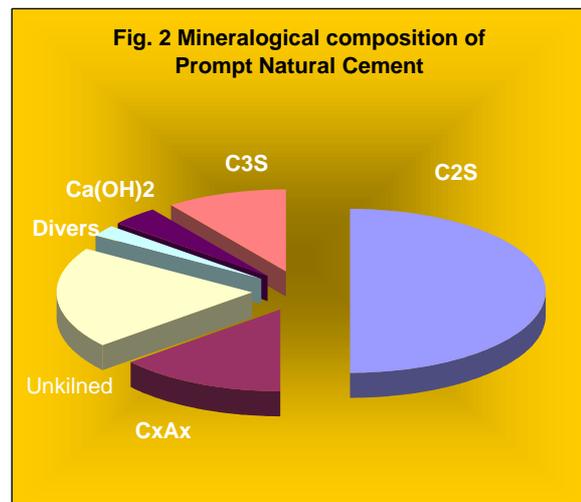
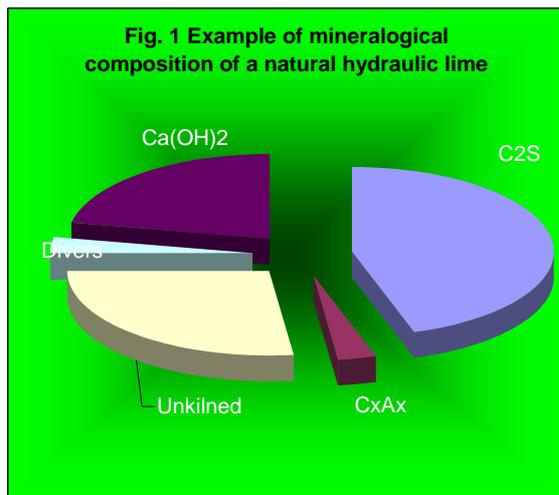
While considerable changes have occurred in kiln design, the kilning process for Prompt Natural Cement is still much the same as that for lime production.

Prompt has many properties in common with the natural cements of the last century, with limes and with hydraulic limes in particular:

- Both are natural products, there are no additives, and a single type of limestone is kilned.
- Raw materials are selected from clearly-defined geological strata to ensure regular, optimum chemical composition.
- The kilning process is identical, conducted at the same temperatures in a vertical kiln.

As shown in Figures 1 and 2, some two-thirds of the mineralogical compositions of the two kilned products are similar:

- The low temperature kilning process means that part of the stone is not sintered.
- The dicalcium silicate (C_2S) content is high in both cases.



The raw material for these two binders belongs to the limestone family. A specific siliceous limestone is used for St.Astier natural hydraulic lime (NHL) and a unique argillaceous limestone for Prompt.

NHL is consequently richer in hydrated calcium oxide ($Ca(OH)_2$), while Prompt is richer in calcium aluminate (C_xA_x) and alite (C_3S).

The alite content is nevertheless very small in the case of Prompt. Its existence is due to partial and local fusion during the kilning process. The fast-setting and early hardening characteristics of Prompt result from hydration of the calcium aluminates.

The small quantity of C_3S is fully hydrated very rapidly, resulting in additional increase in strength up to 7 days.

The slower hydration of the C_2S ensures a continuous increase in strength over a period of several months.

PROPERTIES OF PROMPT NATURAL CEMENT

Setting time

Many applications require a setting time that is sufficiently long to ensure that the product can be applied properly. To meet these requirements, the setting time for Prompt can be adjusted by adding specific retarders such as trisodium citrate and citric acid.

A setting time of at least one hour is possible with a Prompt and NHL mix.

To maintain workability with a setting time of (up to) one hour, it is essential to use a retarder with Prompt-NHL mixes.

Experimental conditions

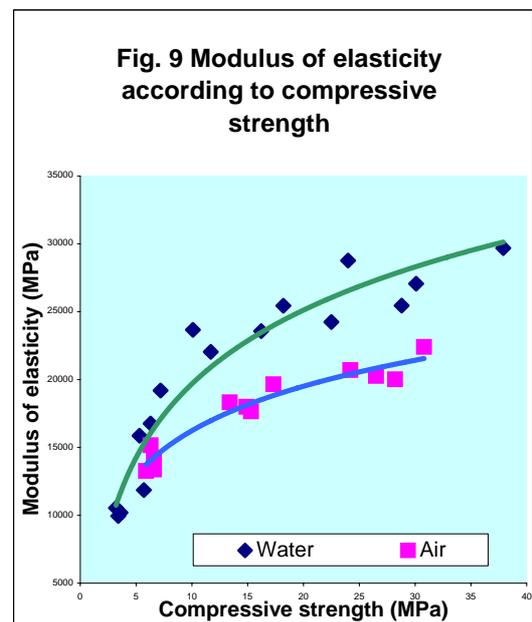
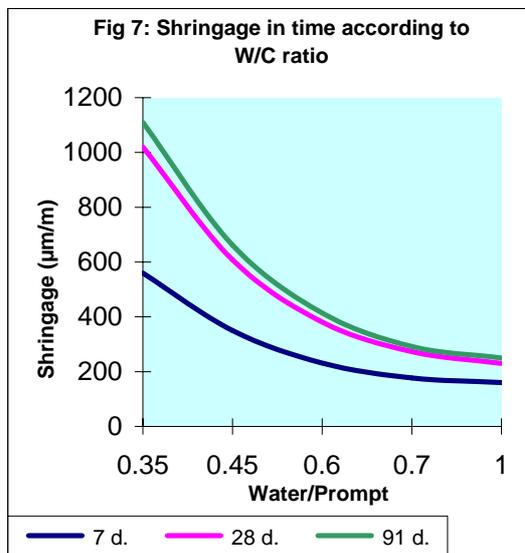
All the tests described below were carried out using a series of mortars with varying water/cement (W/C) ratios. The binder content was altered to maintain a constant level of workability: as the W/C ratio increases, the binder content drops. The relationship between the W/C ratio and sand/binder ratio (S/B) is practically linear.

Strength

Any formulation based on Prompt must take account of the “advantages” of strength values and of the increase in strength, which continues over a period of several months, far beyond the conventional 28 days. Compressive strength increases according to W/C ratio.

Shrinkage

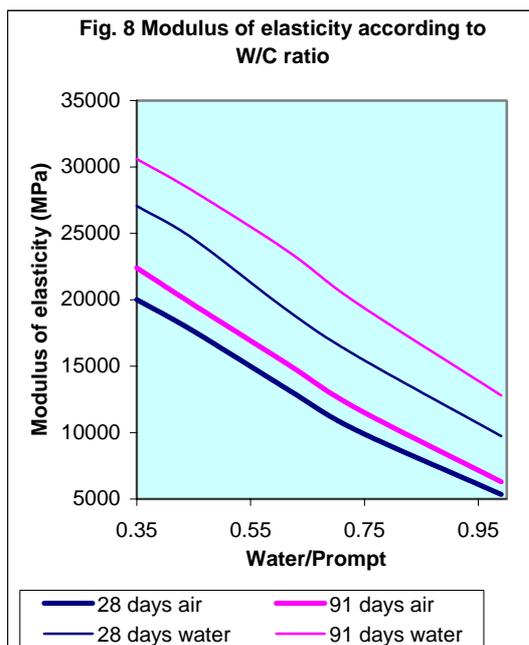
The shrinkage of quick-setting natural cement is low for W/C ratios exceeding 0.5 and S/B ratios exceeding 2. Shrinkage increases with lower W/C ratios and a S/B ratio below 2:1



Modulus of elasticity

The variation of the modulus of elasticity of Prompt with the W/C and S/B ratios is more linear.

Figure 8 below shows evolution of the modulus of elasticity of Prompt mortar after storage in water and in air.



A correlation between modulus of elasticity and compressive strength is shown in Figure 9 below.

PROMPT NATURAL CEMENT – NHL MIXES

We have demonstrated the many common characteristics of quick-setting natural cement and natural hydraulic limes:

- Both are natural products,
- The same kilning process is used, and
- Strength increase in time is identical.

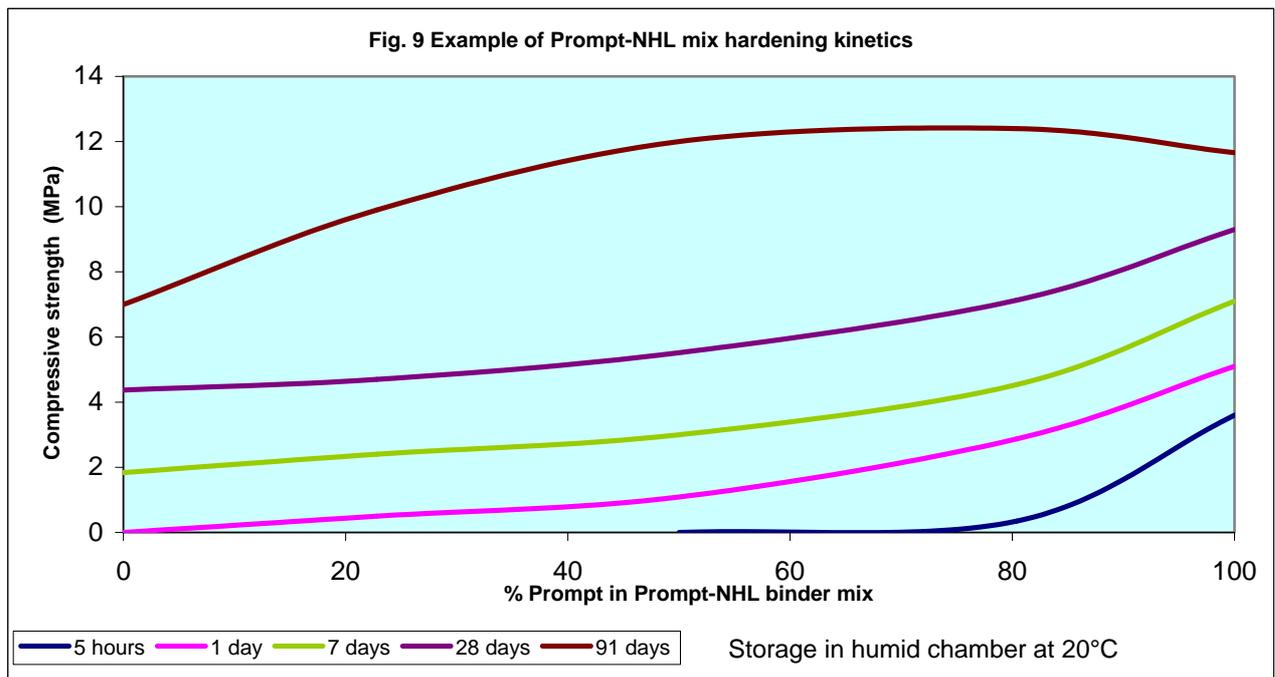
These aspects emphasise the compatibility of quick-setting natural cement when mixed with lime.

Furthermore, in the same types of application as limes (rendering and masonry joints), but at lower mix rates ($W/C > 0.6$ in the figures above), Prompt contributes a number of interesting properties to the mix:

- Low shrinkage,
- Satisfactory modulus of elasticity,
- Moderate strength values,
- Rapid setting.

This latter property gives Prompt-NHL mixes characteristic of faster setting than NHL alone, and an increase in early strength values between a few hours and 7 days. Setting and hardening rates can also be altered by adjusting the Prompt content in a Prompt-NHL mix. An example of a Prompt-NHL5 (from St ASTIER) mix is given in Figure 10 below.

The mix rate is 300 to 350 kg/m³, corresponding to a sand/binder ratio of 4 by weight, with setting time adjusted to one hour. It is essential to use a retarder in these mixes to avoid any loss of workability during setting.



Conclusion

Prompt Natural Cement and NHL have complementary properties. Prompt contributes the degree of reactivity required for faster setting applications. In addition to its plastic and flexible qualities, NHL serves to retard Prompt so as to obtain the required setting times. The fact that both are natural products, and involve very similar production processes, means that their long-term performance is similar. This enhances their compatibility, and ensures excellent durability for the structures in which these mixes are used.

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