



Compatibility and performance criteria for nano-lime consolidants

Rob P.J. van Hees, Barbara Lubelli, Timo G. Nijland, Adriana Bernardi





Nanomatch project

Nano-systems for the conservation of immovable and moveable polymaterial Cultural Heritage in a changing environment
(Grant n. 283182)





Consolidation

Consolidation is meant to re-establish the lost cohesion in a stone or stone-like material.





Consolidation of lime-based materials

Limited compatibility of ethyl silicates on lime-based substrates
as limestone, mortar and plaster/render



Recent developments:

- Modified ethyl-silicates
- Nanolimes
- New products developed in Nanomatch based on calcium alkoxides



Compatibility

Reversibility vs compatibility

A consolidation treatment can be considered compatible if it does not lead to technical (material) or aesthetic damage to the historical materials. The treatment as such should be as durable as possible



Assessment of treatment performance

Compatibility criteria

related to the properties of the consolidated material with respect to those of the untreated material.

Performance criteria

related to the effectiveness of the treatment, including long-term behaviour.

Technical requirements

further specifications, measurable and quantifiable, of compatibility and performance criteria.



Assessment

Consolidants should preferably be tested on decayed substrates:

- from site
- artificially decayed in laboratory
- reproducible & representative replica of decayed substrate





Compatibility criteria

Physical requirements

The consolidant treatment should not alter too much:

- Water transport properties of the material (absorption, drying, hygroscopicity)
- Thermal & hygric dilation
- Porosity & pore size distribution

Chemical requirements

- No harmful reaction with substrate and environmental factors
- Solubility similar to untreated stone (→ avoid selective weathering)

Mechanical requirements

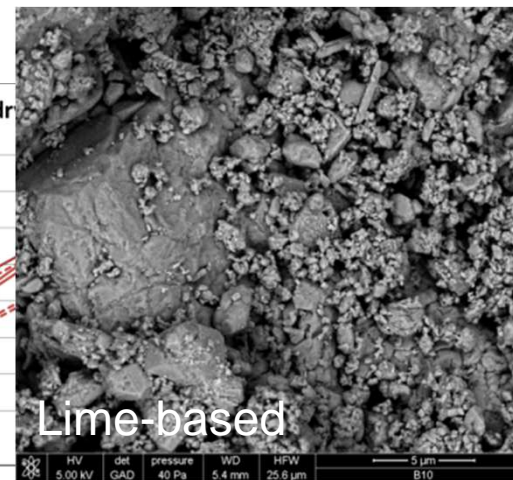
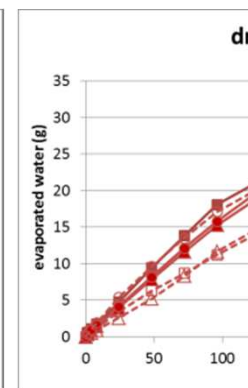
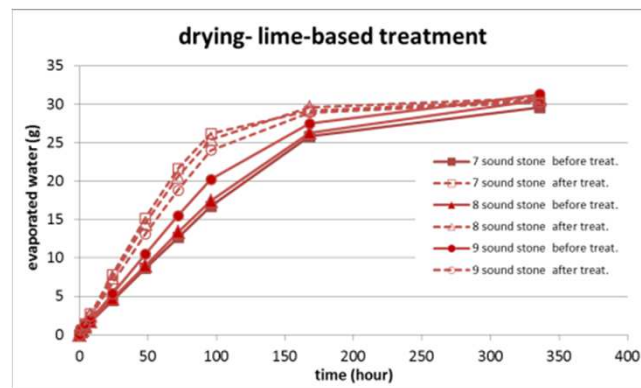
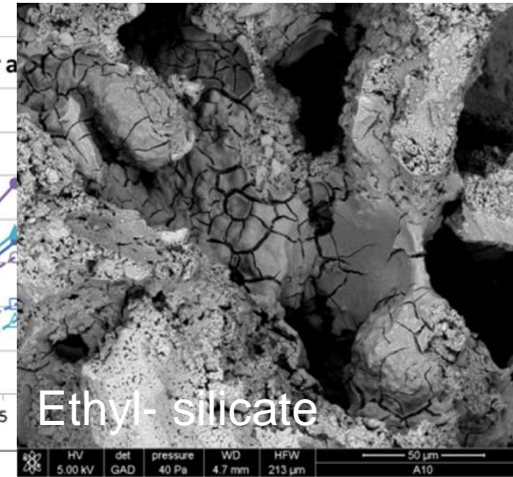
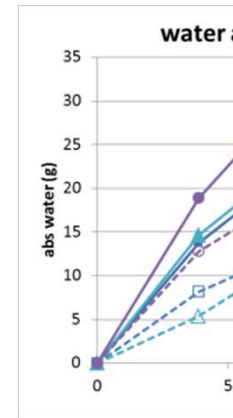
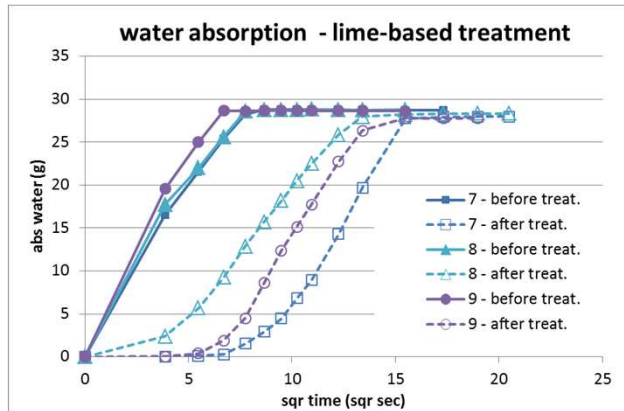
- Increased hardness and cohesion, preferably similar to that of untreated sound stone

Aesthetic requirements

- Not alter colour, gloss and structure

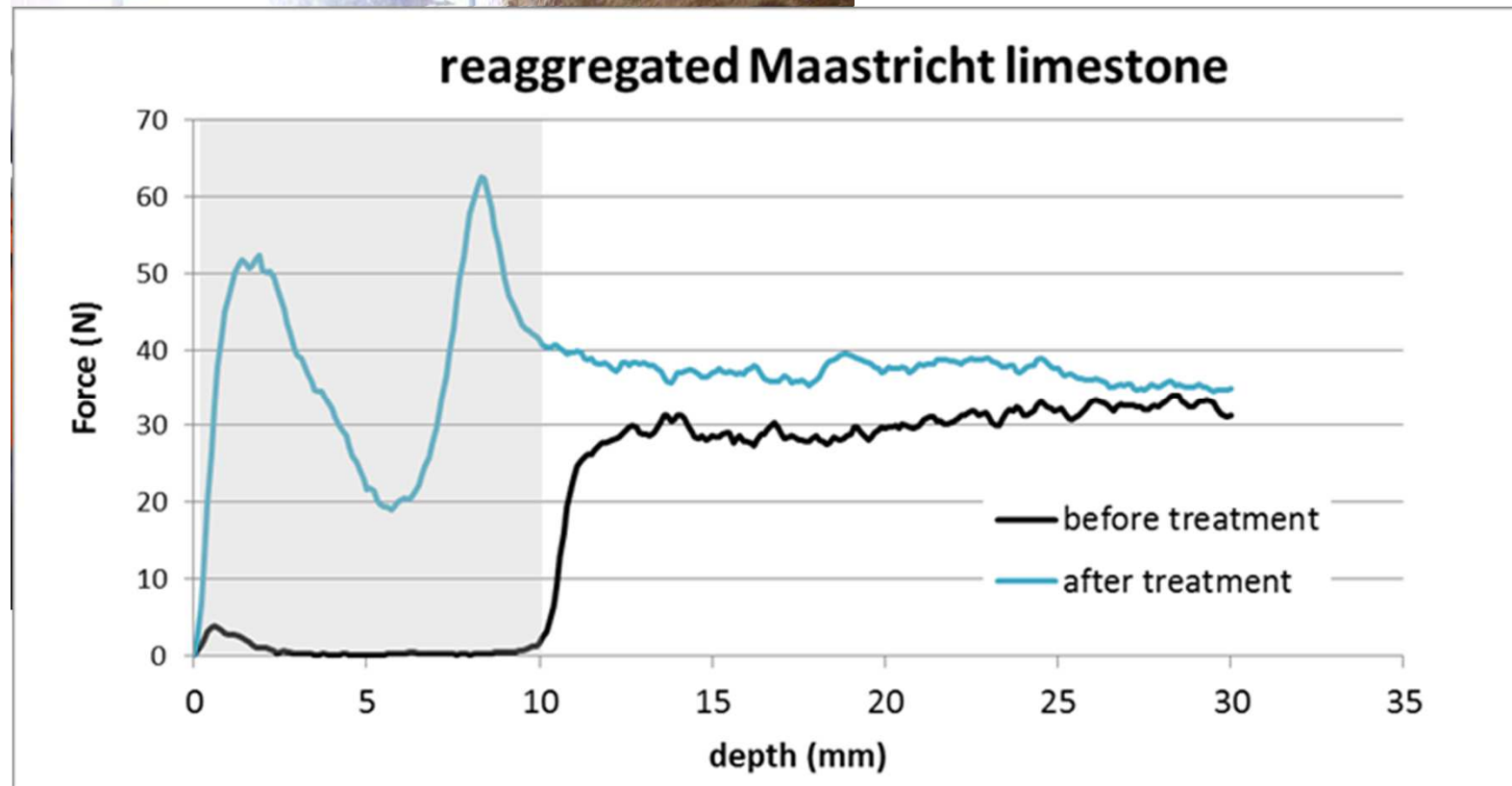


Compatibility – water transport behaviour





Compatibility – hardness DRMS





Performance criteria

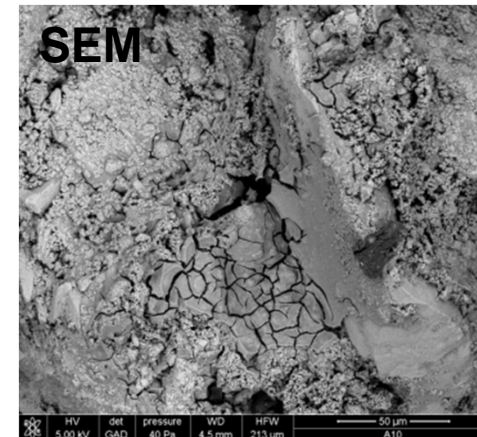
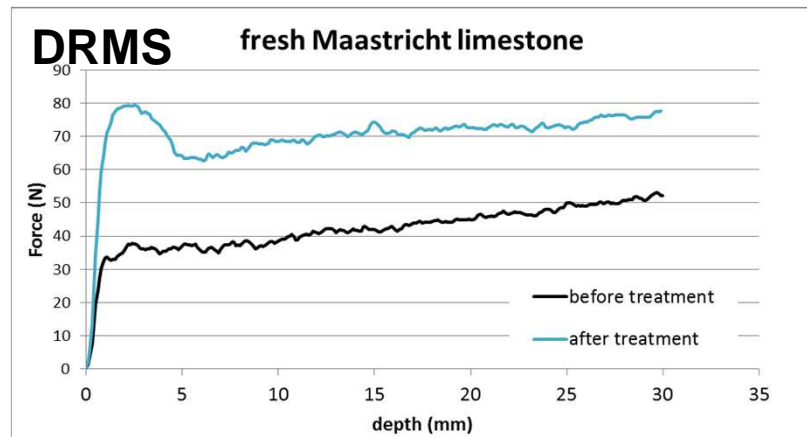
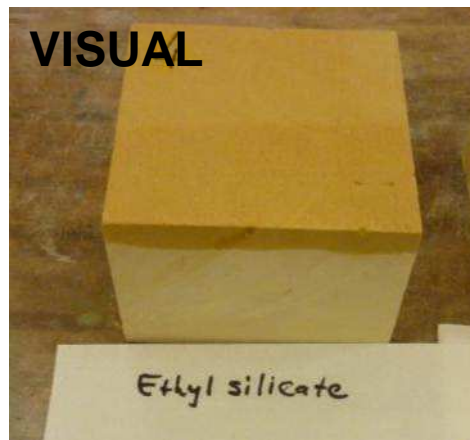
- Cohesive effect
- Penetration depth of the product
- Long term behaviour
 - Freeze-thaw (frost resistance)
 - Salt crystallization
 - Thermal shock
 - Biological growth





Penetration depth

Visual penetration during impregnation may differ from actual penetration and depth of consolidation effect → multiple techniques





Long term behaviour- crystallization test

Re-aggregated specimens



> Damage

Scaling, exfoliation

Fresh stone specimens



< damage

Powdering



Technical requirements

- **Performance criteria**

strength, 'hardness' and long term performance of a damaged material should increase after treatment with respect to those of the damaged untreated material.

- **Compatibility criteria**

properties as water transport, thermal and hygric dilation, colour, gloss and structure and, again, strength and 'hardness' should differ, after treatment, as little as possible from those of the sound, untreated substrate.

Requirement	Values
Colour & gloss	No change
Thermal + hygric dilation (increase after treatment)	= < 15%
Penetration depth	= Decayed zone
Hardness profile	> decayed material untreated; =< sound material;



Conclusions

A protocol for the assessment of compatibility and performance of consolidant treatments has been set up in the Nanomatch project. Defining precise quantitative values for each requirement remains difficult.

Consolidants should be preferably tested on decayed substrates. In the Nanomatch project a new method to make reproducible replica of decayed substrates has been developed and validated.



**Thank you
for your attention**