


THE DURABILITY OF DIFFERENT TYPES OF NHL MORTARS



10th September
Trondheim, Norway

- SECIL Group
- Secil Argamassas
- NHL – Natural Hydraulic Lime
 - Regulatory framework (Standard)
 - Characteristics
 - Study - **Durability of different types of NHL mortars**
 - Applications
 - Conclusions
 - Other solutions with NHL Mortars





SECIL - Leading producer of cement in Portugal, founded in 1930.

SECIL Group integrates about 40 companies which operate in complementary areas such as the production of concrete, precast blocks, hydraulic lime, plaster, coatings, fiber cements, etc., and quarrying.

Internationally, SECIL is present in Tunisia, with a cement factory - Société des Ciments de Gabes, Lebanon – Ciment de Sibline, Brasil and Angola.

SECIL Group Turnover – 479 M€

- Secil Outão factory was the first in Portugal, to receive the enviromental certificate (ISO 14000);
- **Secil invested 7 M€ in the plantation of 1 M plants from Arrábida natural park;**
- 1987 – Enviromental Managing Award for execution of the recuperation plan for the quarrys;
- **2008 - EMAS Register and Enviromental License;**
- 2009 - Environmental Innovation for Europe Award (EEP AWARDS 2009) - CO2 captation project and biomass production through the **industrial production of microalgae** in partnership with AlgaFuel in Cibra-Pataias.





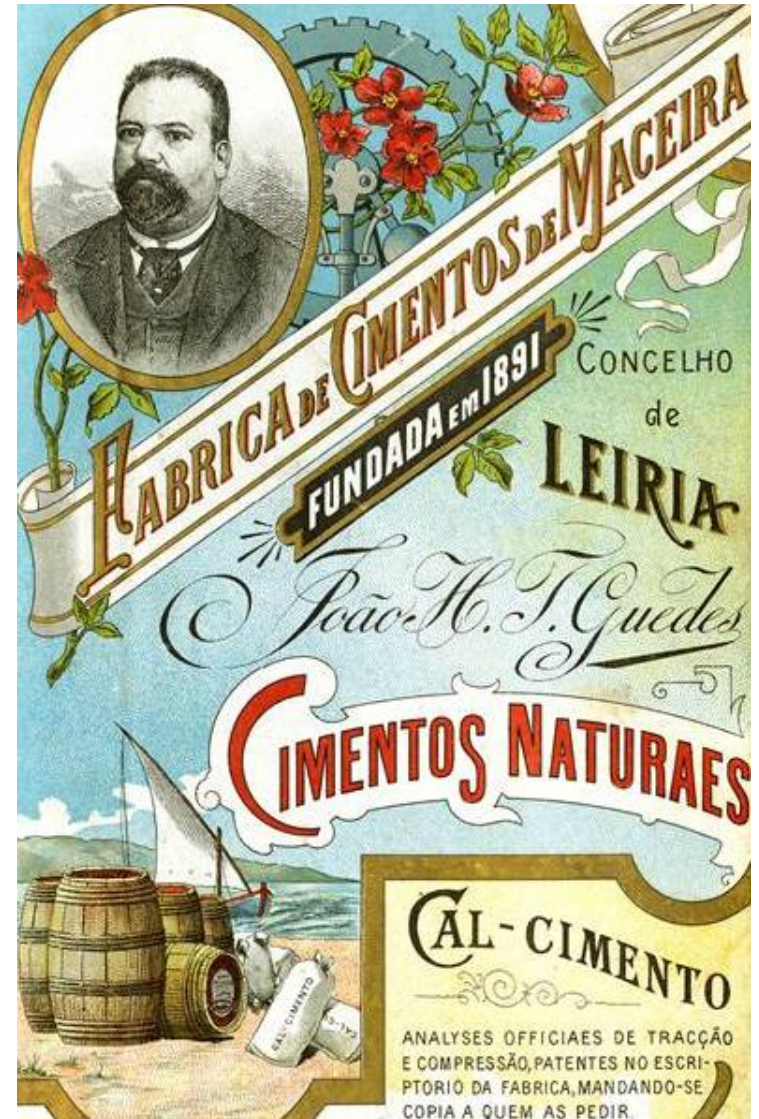
NHL Natural Hydraulic Lime

IN REHABILITATION





Secil Argamassas is the only Iberian company and one of the few world wide to produce **Natural Hydraulic Lime (NHL)** - 100 % Natural Premium Binder



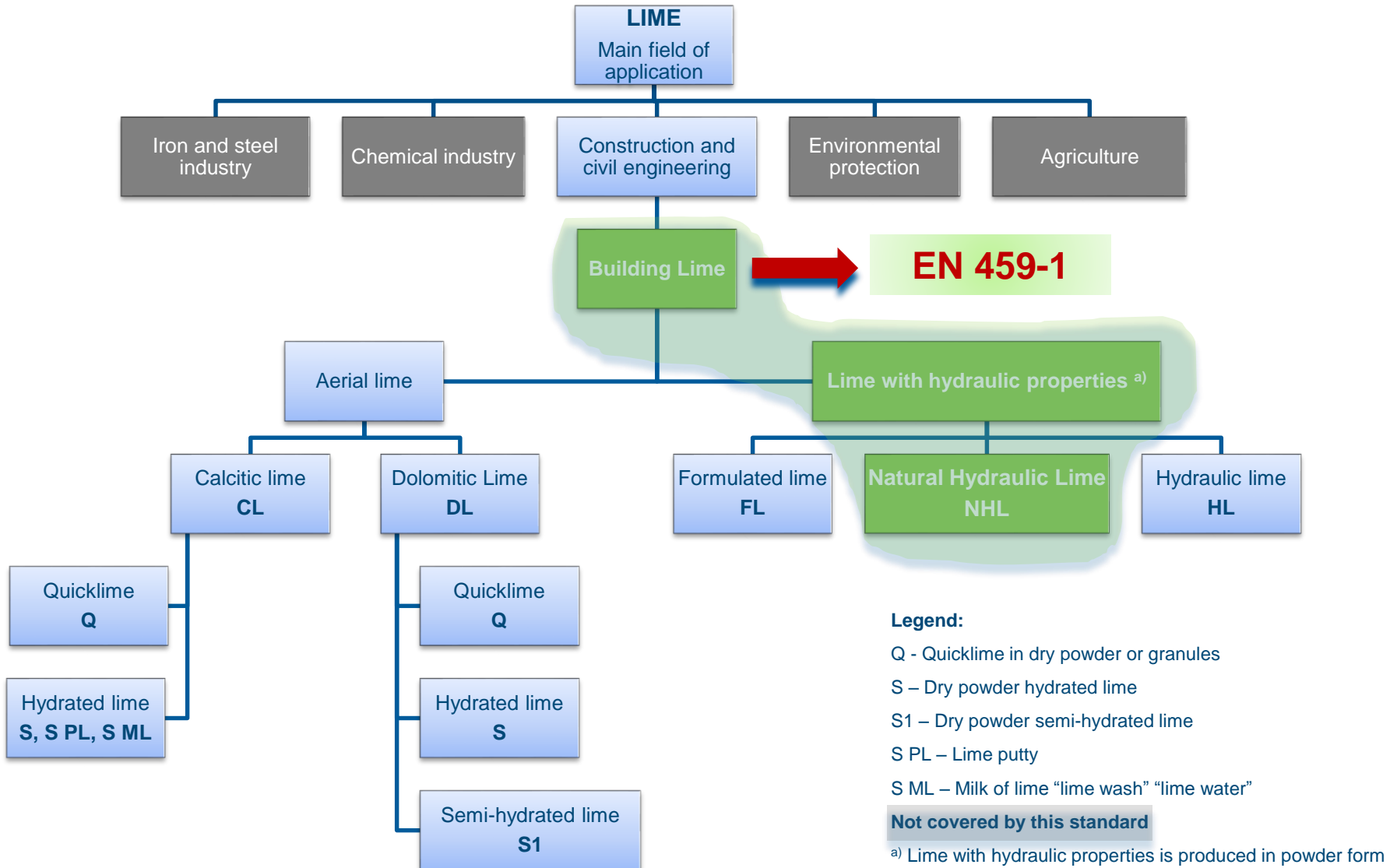
PRESENCE IN MORE THAN 10 COUNTRIES



Study

Durability of different types of NHL
mortars







Summary

- The purpose of this study is to evaluate the potential with respect to the **durability of NHL5 and NHL3.5 as sole binders in traditional mortar mixes**, and assess the **influence of an air-entrainment admixture** on parameters such as **resistance to freeze-thaw cycles** and **vapour permeability**.
- Traditional mortar mixes based on siliceous aggregates were therefore used, with a normalised grading curve and where the only binder used was Natural Hydraulic Lime (NHL).
- Finally, the performance of these mortars was compared with their performance after an **air-entrainment admixture was introduced**. In order to establish the mechanical strength of traditional mix mortars with a hydraulic lime base, **four mixes with a 1:3 and 1:4 ratio**, in which the binders used were **NHL 5 and NHL3.5** and regular siliceous aggregates were also analysed.



Composition of the mortars:

| Raw materials | Mixing ratio | | | | | | | |
|-----------------------------|--------------|-----|-----|-----|----|----|----|----|
| | M1 | M2 | M3 | M4 | M5 | M6 | M7 | M8 |
| NHL5 | 1 | 1 | - | - | 1 | 1 | - | - |
| NHL3.5 | - | - | 1 | 1 | | | 1 | 1 |
| Siliceous aggregate mixture | - | - | - | - | 3 | 4 | 3 | 4 |
| Siliceous aggregate | 1,5 | 1,5 | 1,5 | 1,5 | - | - | - | - |
| Air-entrainment amixture | - | 1 | - | 1 | - | - | - | - |



Mechanical strength results at 28 days

| | Flexural strength (MPa) | Compressive strength (MPa) | |
|----------|-------------------------|----------------------------|---------------|
| Mortar 1 | 3.31 | 6.21 | NHL5 |
| Mortar 2 | 2.39 | 4.39 | |
| Mortar 3 | 2.45 | 4.21 | NHL3.5 |
| Mortar 4 | 1.46 | 4.14 | |

- As expected, the use of the air-entrainment admixture led to a decrease in mechanical strength in mortars 2 and 4.

| Mortar | Compressive strength (MPa) | | | Modulus of elasticity (MPa) | |
|----------|----------------------------|---------|---------|-----------------------------|---------------|
| | 7 days | 28 days | 90 days | 28 days | |
| Mortar 5 | 0.4 | 1.0 | 1.7 | 3340 | NHL5 |
| Mortar 6 | 0.2 | 0.6 | 0.8 | 2170 | |
| Mortar 7 | 0.3 | 0.9 | 1.5 | 3340 | NHL3.5 |
| Mortar 8 | 0.2 | 0.5 | 0.6 | 1970 | |



Tests performed (Mortars 1-4) - Freeze-thaw cycles

Resistance to freeze-thaw cycles was determined based on test standard NP EN 12371:2010 indications for natural stone specimens.

At the end of each stage, the specimens were inspected visually and the flexural and compressive strengths were determined.

| Stage | Temperature | Duration |
|----------------|--|-------------|
| Start of cycle | $(20 \pm 2) \text{ }^\circ\text{C}$ | T0 |
| Stage 1 | $\leq 20^\circ\text{C} \geq -10 \text{ }^\circ\text{C}$ | T0 + 2.0 h |
| Stage 2 | $(-10 \pm 3) \text{ }^\circ\text{C}$ | T0 + 6.5 h |
| Stage 3 | [Immersion] $\geq -10 \text{ }^\circ\text{C} \leq 20 \text{ }^\circ\text{C}$ | T0 + 9 h |
| Stage 4 | $(20 \pm 3) \text{ }^\circ\text{C}$ | T0 + 12.0 h |



Behavior _ Freeze-Thaw cycles

Mortar 1



18 cycles



36 cycles



Behavior _ Freeze-Thaw cycles

Mortar 2



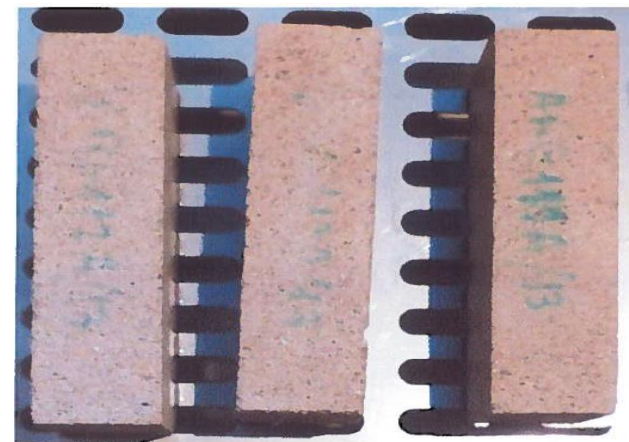
12 cycles



18 cycles



30 cycles



102 cycles

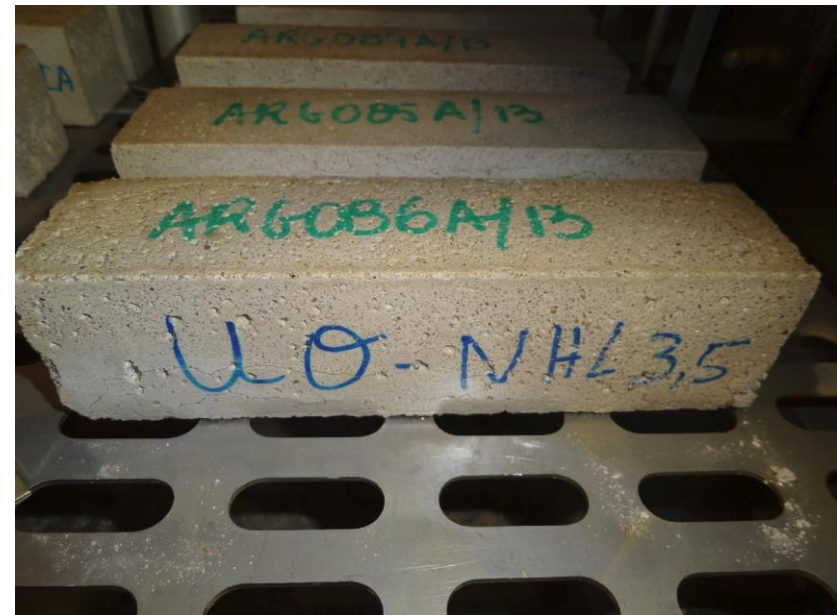


Behavior _ Freeze-Thaw cycles

Mortar 3



12 cycles



24 cycles



Behavior _ Freeze-Thaw cycles

Mortar 4



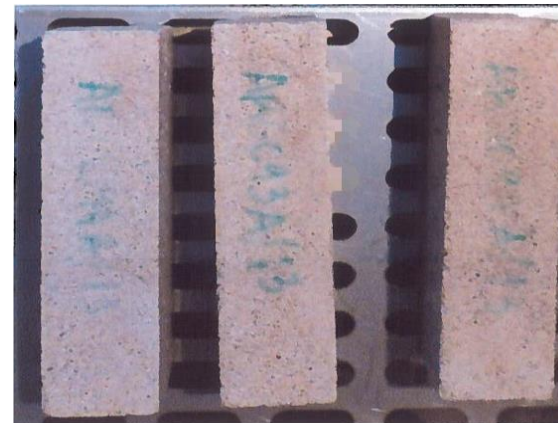
12 cycles



18 cycles



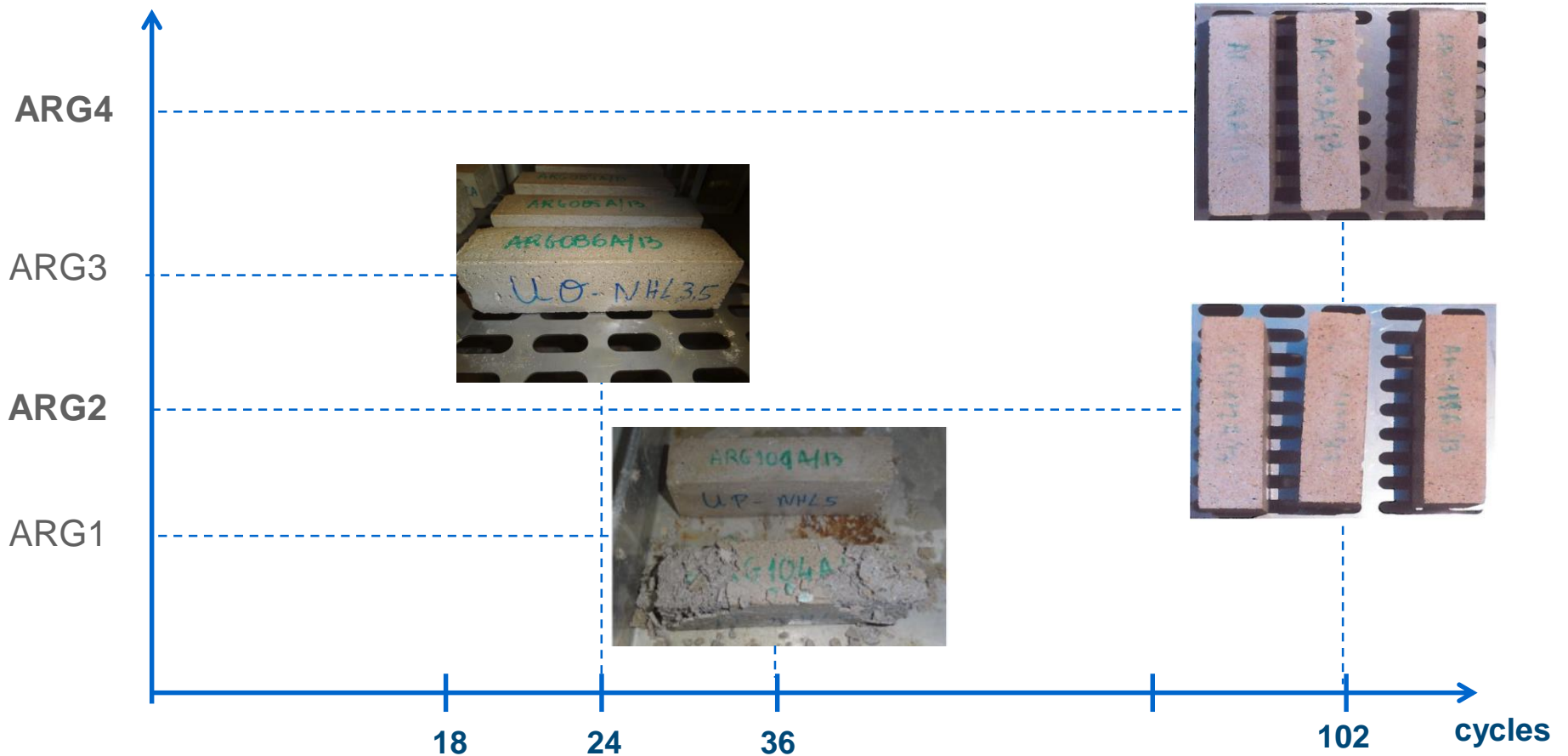
30 cycles



102 cycles



Behavior _ Freeze-Thaw cycles





Mechanical strength results (MPa)

| Mortar 1 | Cycle number | | | | | | | |
|----------------------|--------------|------|------|------|------|------|----|----|
| | 12 | | 18 | | 30 | | 36 | |
| | FS | CS | FS | CS | FS | CS | FS | CS |
| $\Delta R_{Average}$ | 0,89 | 7,24 | 0,51 | 5,7 | 0,23 | 3,98 | - | - |
| | -43% | -21% | -55% | -30% | -74% | -45% | - | - |

| Mortar 2 | Cycle number | | | | | | | |
|----------------------|--------------|------|------|------|------|-----|------|------|
| | 12 | | 18 | | 30 | | 36 | |
| | FS | CS | FS | CS | FS | CS | FS | CS |
| $\Delta R_{Average}$ | 1,69 | 6,98 | 1,69 | 6,59 | 1,54 | 6,8 | 2,21 | 8,5 |
| | 0% | -6% | -9% | 3% | 44% | 25% | 31% | 21%- |

| Mortar 3 | Cycle number | | | | | | | |
|----------------------|--------------|------|------|------|----|----|----|----|
| | 12 | | 18 | | 30 | | 36 | |
| | FS | CS | FS | CS | FS | CS | FS | CS |
| $\Delta R_{Average}$ | 0,55 | 5,65 | 0,55 | 5,75 | - | - | - | - |
| | -2% | -2% | - | - | - | - | - | - |

| Mortar 4 | Cycle number | | | | | | | |
|----------------------|--------------|------|------|------|------|------|------|-----|
| | 12 | | 18 | | 30 | | 36 | |
| | FS | CS | FS | CS | FS | CS | FS | CS |
| $\Delta R_{Average}$ | 1,84 | 7,26 | 2,06 | 7,26 | 1,97 | 7,06 | 1,79 | 8,8 |
| | 12% | 11% | -5 % | - 3% | -9% | 24% | -3% | 35% |

Compressive strength (CS) / Flexural strength (FS)



Water vapour permeability:

| | Vapour permeability index (μ) |
|----------|-------------------------------------|
| Mortar 1 | 14.0 |
| Mortar 2 | 10.5 |
| Mortar 3 | 17.6 |
| Mortar 4 | 13.9 |

NHL

Natural Hydraulic Lime

Conclusions





Analisis of results:

- As expected, the mechanical strength of the first group of tests, Mortars 1 to 4, were high for most rehabilitation uses, though their flexural strength values are also high, which shows that these mortars have good deformability.
- Mortars 2 and 4 specimens withstood 102 cycles and remained intact, without showing signs of degradation. The increase in mechanical strength values may be linked to the curing conditions due to the duration of all the cycles and the fact that the specimens remained immersed for half the freeze cycles favoured an increase in the relevant properties.
- With respect to water vapour permeability, there was an improvement in Mortars 2 and 4, which reflected the effect of the air-entrainment admixture (tensioactifs) that led to the improved pore structure and consequent increase in the vapour permeability index.
- Mortars 5 to 8 were less rich mixes and showed greater compatibility with old substrates, with mechanical strength and modulus of elasticity values within those recommended for this type of substrates.



Conclusions:

- Mortars produced with Natural Hydraulic Lime NHL5 and NHL3.5 **performed well in freeze-thaw cycle tests**, with **Mortars 1 and 3 withstanding 36 cycles** and **Mortars 2 and 4 withstanding 102 cycles**, which demonstrates the **positive effect on the air-entrainment admixture** on the microstructure of the latter two mixes.
- In terms of water **vapour permeability**, the **beneficial effect of the air-entrainment admixture has been demonstrated in mortars 2 and 4**.
- This difference may be helped by the grain size of the aggregate used in this study and also to a mix that was richer in binder.
- **Future work:** This study should be supplemented with open porosity tests and freeze-thaw resistance tests performed on mortars less rich in binder, Mortars 5 to 8.



Rehabilitation:

"Set of operations aimed at preserving and restoring the significant parts - in historical and aesthetic terms - of an architecture, including its overall improvement, in order to enable it to meet up-to-date performance levels and functional requirements."

In "Technical Guide for Homebuilding Rehabilitation"

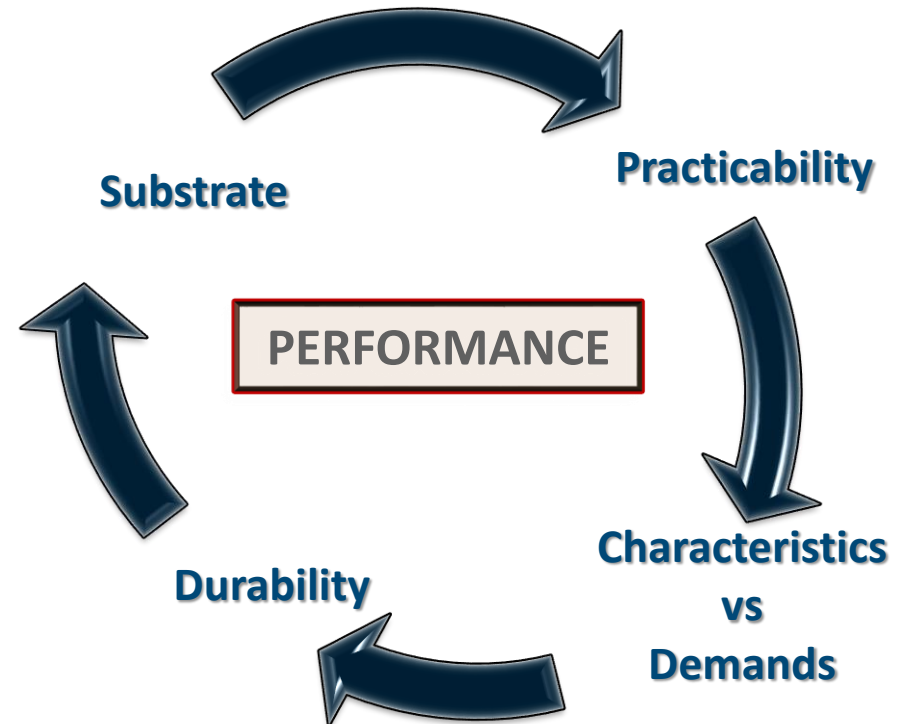
National Laboratory of Civil Engineering



Stairway – Bom Jesus de Braga



Thalia theater – Lisbon



Hydraulic Lime- NHL

Natural Hydraulic Lime mortars

Applications



REABILITA CAL

NHL replacement coating

- High durability
- Compatible with ancient masonry
- High water vapour permeability
- Traditional fine finish
- High bonding and elasticity



- 1 Suporte
- 2 **REABILITA CAL CONSOLIDAÇÃO**
- 3 **REABILITA CAL REBOCO** (Reboco armado)
- 4 **REABILITA CAL ACABAMENTO**
- 5 **SeciITeK AD 25** (Primário) + **SeciITeK SP 01** (Tinta à base de silicatos)



Bom Jesus stairway – Braga, Portugal











Thalia theater – Lisbon



TIL – Lisbon



Pombaline Building | Lisbon



TEATRO DA TRINDADE

Trindade Theatre | Lisbon



Monte-Real hot spring, Portugal



Machado Castro Museum | Coimbra, Portugal

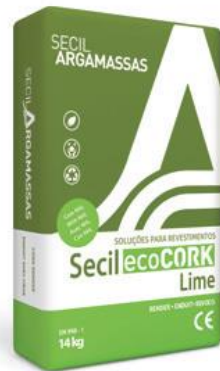


Douro Building | Porto

Secil ecoCORK LIME

NHL Thermal Render with Cork

- Lightweight
- High compatibility with ancient substrates
- High water vapour permeability
- Improves thermal and acoustic behavior



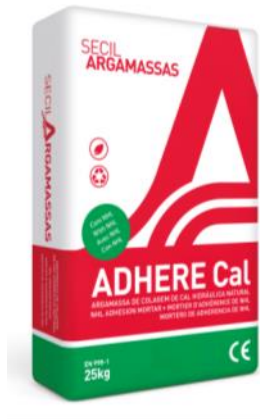
- 1 Suporte
- 2 REABILITA CAL CONSOLIDAÇÃO
- 3 Secil ecoCORK Lime
- 4 REABILITA CAL ACABAMENTO armado com SecilVit Rede 160
- 5 SecilTEK AD 25 (Primário) + SecilTEK SP 01 (Tinta à base de silicatos)



ADHERE Cal

NHL Adhesion mortar for traditional tiles

- High deformability
- Suitable for porous coatings
- Compatibility with ancient substrates



- 1 Suporte
- 2 REABILITA CAL CONSOLIDAÇÃO
- 3 REBILITA CAL REBOCO
- 4 ADHERE Cal
- 5 Cerâmico antigo



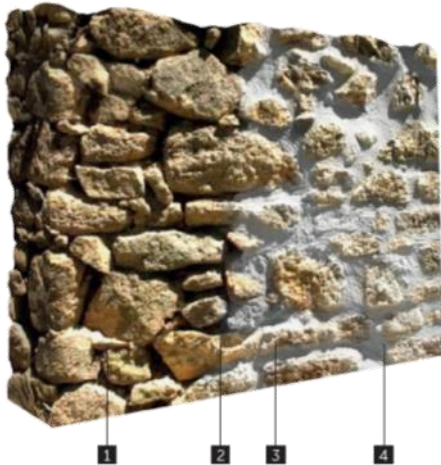
With a total area of 1,011 m² and 188 meters in length, the wall extension was covered with colorful elements. The mural was hand painted, resulting in a single piece composed of 52,738 tiles.



REABILITA RJ 35

Repointing mortar

- Compatible with ancient stone masonry and brick
- Traditional sanded fine finish
- High durability
- Adhesion and deformability compatible with ancient substrates



- 1 Alvenaria antiga
- 2 **REABILITA RJ 35**
- 3 **SecilTEK AD 40** para protecção total da alvenaria





Aqueduct of Louriçal Convent, Portugal



Brick repointing – Dublin - Ireland

REABILITA CaI INJECT

Injection NHL Grout

- High fluidity
- Recommended for porous substrates
- Compatible with ancient substrates



1 REABILITA CAL INJECT



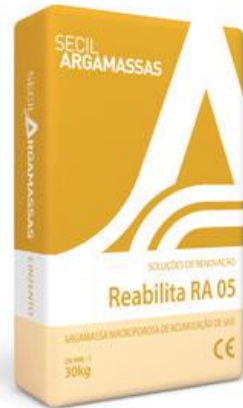
REABILITA RA 05

Macroporous salt retainer mortar

- High durability in presence of rising damp and salts
- High water vapour permeability
- Sprayed or hand applied



- 1 Suporte
- 2 REABILITA RA 05
- 3 REABILITA CAL ACABAMENTO
- 4 Pintura





São Francisco Convent, Coimbra - Portugal

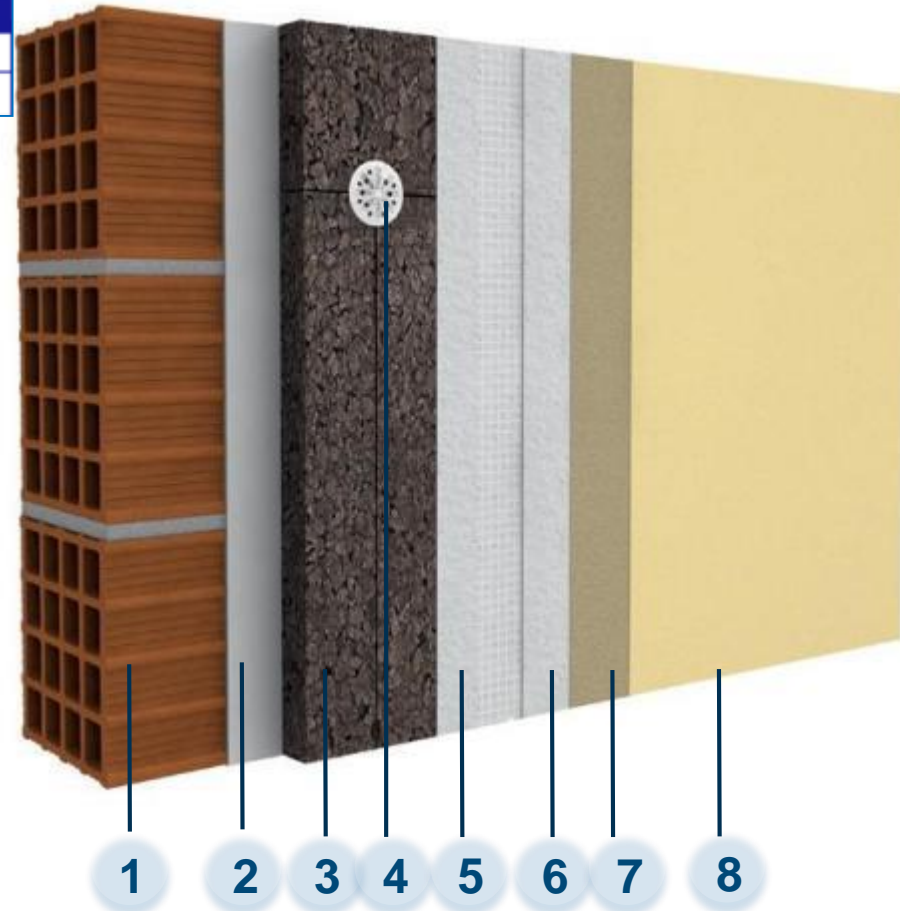
Other solutions with NHL Mortars





HOW DOES IT WORK?

- Thermal insulation fixed with mortar or mechanically fixed to the substrate - 3;
- Fixed to the support by adhesion and mechanical fastening with variable thickness – 2/4;
- A coating with an embedded reinforcement layer (base armed) – 5/6;
- Profiles, usually perforated, to improve the system performance (corner profile, starting, etc.);
- Finishing with REABILITA CAL Acabamento – 7;
- Silicate based paint SecilTEK SP 01 - 8.



LISBON REHABILITATION PROJECT:

18.000 m²

External Thermal Insulation System

SecilVit CORK





What is SecilVit CORK MD?

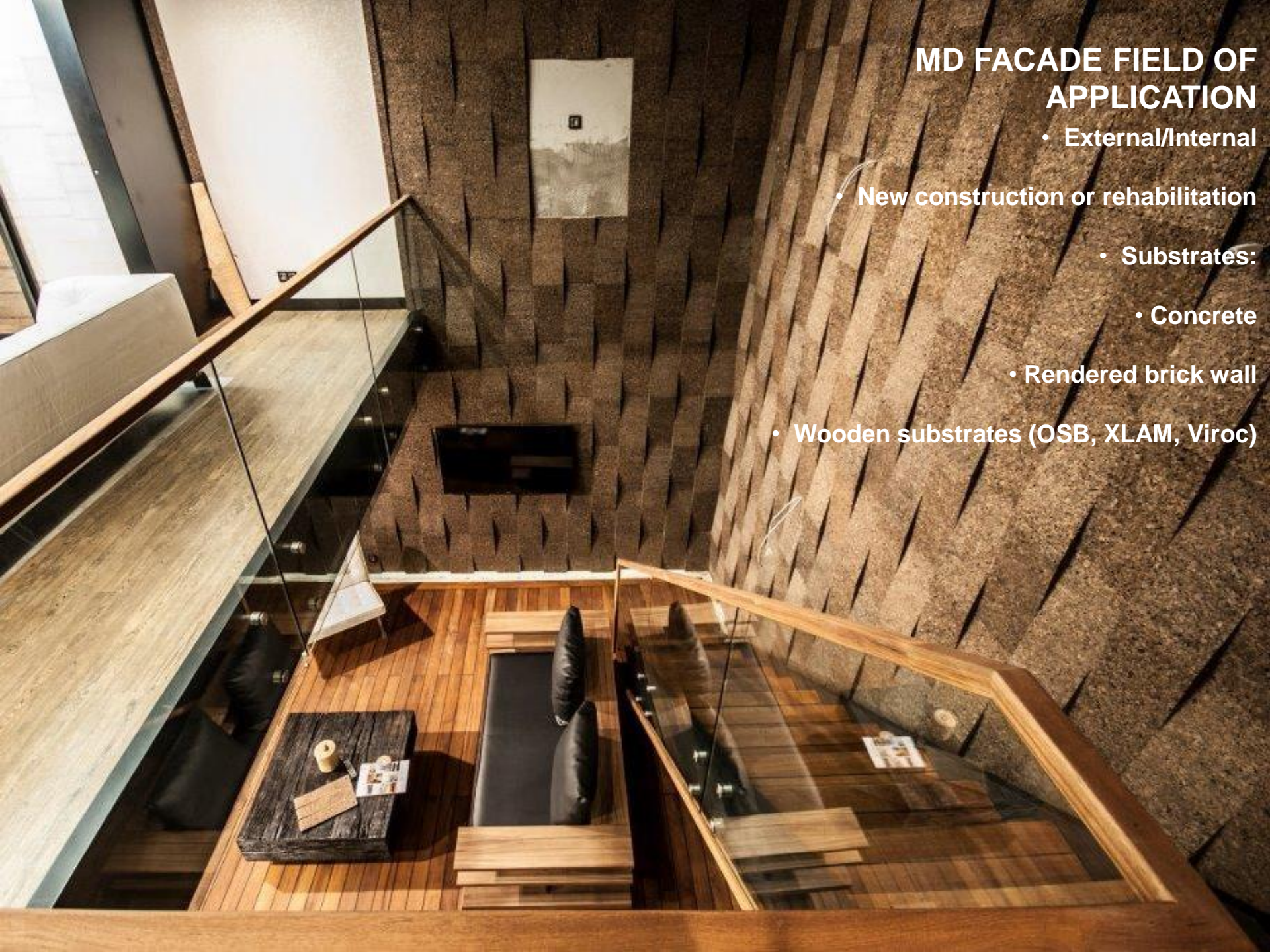
- External thermal Insulation System;
- Thermal and acoustical insulation for facades;
- Finishing with natural Cork look(with/without texture);
- Application thickness:
 - Mortar: 6 to 8 mm;
 - Boards 40, 50, 60 and 100 mm;
- Application over levelled substrates;
- Simple system, easy to apply.







Modena, Italy



MD FACADE FIELD OF APPLICATION

- External/Internal
- New construction or rehabilitation
- Substrates:
 - Concrete
 - Rendered brick wall
 - Wooden substrates (OSB, XLAM, Viroc)



THANK YOU FOR YOUR ATTENTION

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