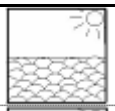
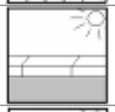
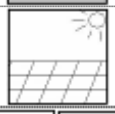
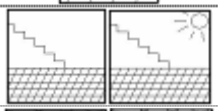
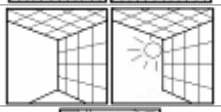
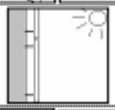
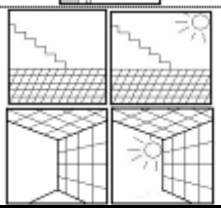
Identification characteristics

Characteristics concerning microstructure

- **Petrographic characterisation**

Petrographic characterisation allows the determination of the mineralogical composition of the natural stone. Based on this information the right geological name of the stone can be deduced. According to EN 12440, the name of the stone has to reveal the land of origin, the (geological) type and the colour of the stone. In this frame, the correct petrographical identification of the stone is important and the use of abusive appellations, as it is often the case in the actual market, should be avoided. Besides these geological features, it can also give information about the porosity, damage, chemical, physical and mechanical characteristics of the stone. (Figure 1).

Table 1 CE-marking

Type of product	Use	CE	CE-marking
setts	external paving		since October 2003
kerbs	external paving		since October 2003
slabs	external paving		since October 2003
	floor and stair covering (internal and external)		since March 2005
	walling and ceiling finishes (internal and external)		since March 2005
	cladding (external)		since March 2005
modular tiles	floor and stair covering (internal and external) walling and ceiling finishes (internal and external)		since March 2005

The logos will identify if this is a characteristic to declare in the frame of the CE-marking and for which specific stone application. This implies that the user should find the value of this characteristic on the packaging and/or the accompanying commercial documents.

Reference: EN 12407 & EN 12670

Test: Thin sections of the natural stone, with a thickness of 30 µm so that they allow light to pass through, are examined with a petrographic microscope. A macroscopic description of the material is also included.

- **Open porosity**

The open porosity is directly related with important stone characteristics, such as the mechanical strength and the behaviour in presence of liquids (water or potential staining products). When porosity is higher, the mechanical strength is lower and liquids can be more easy absorbed (more sensitive to staining) by the stone. (Figure 1)

Reference: EN 1936

Test: porosity is easily derived mathematically from the test for the determination of the apparent density and expressed in volume %. It represents the percentage of open space in the stone.

- **Pore size distribution (MIP: Mercury Intrusion Porosimetry)**

The pore size distribution (Figure 2) of the stone is important to know, because it determines essential characteristics, such as the frost resistance (which is not directly related to the open porosity). The frost action inside a porous material is a very complex phenomenon, but it is generally accepted that the most dangerous stresses will be induced by the crystallisation of ice in the smaller pores, while the non-capillary, larger ones, will provide space for the expansion of ice, reducing in this way the stress intensity in the material. Nevertheless, the measurement of the pore size distribution is not commonly asked and is more important for scientific researches.

Reference: ISO/WD 15901-1

Test: Determination of the size and the distribution of the pores by intrusion of mercury under different pressure conditions.

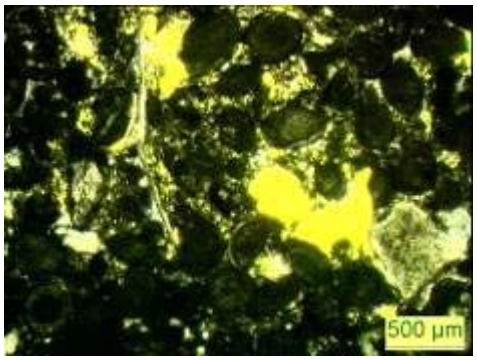


Figure 1 *A thin section of "Massangis Roche Jaune" limestone (The yellow spots are pores)*

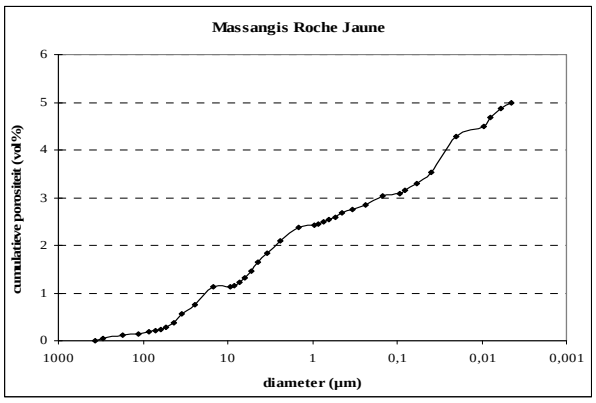


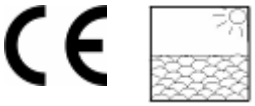
Figure 2 *Pore size distribution in "Massangis Roche Jaune" limestone*

Physical – mechanical characteristics

- **Strength**

This is clearly an essential characteristic for load-bearing applications (for example prEN1996-1-1, "Eurocode 6 – design of masonry structures), but also because in most cases it is linked to the stone value: the stronger the stone is, the higher the value is.

- *Compressive strength*



The uniaxial compressive strength is the load per unit area, under which a block fails by shear.

Reference: EN 1926

Test: The samples, with rectified surfaces, are placed and centred on the platform of a press. The press load is continuously increased until rupture. The load value at the moment of rupture is the compressive strength of the stone.

- *Flexural strength*

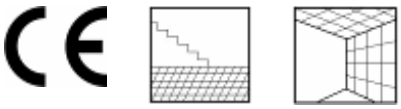
Flexural strength represents mainly the resistance to flexure deformation of the bed and the natural stone.

Reference: EN 12372

Test: The samples, with standardised dimensions, are placed and centred on two bars. A concentrated load exerts pressure on the sample that is continuously increased, until rupture. The load value at the moment of rupture is the flexural strength of the stone (Figure 3).

Figure 3 *Flexural test*

- ***Apparent density***



This property is defined as the ratio between the mass of a dry specimen and its apparent volume (i.e. the volume limited by the specimen external surface, including any voids). The apparent density reflects the degree of compaction of the stone and enables the estimation of the weight of a known volume.

Reference: EN 1936

Test: After drying to a constant mass, six samples are weighed. Then, they are placed into a vessel, under vacuum conditions, in which water is added. The samples absorb the added water, and after a certain time they are weighed wet (lightly wiped) and under water. With these three weights it is possible to determine the apparent density.

Note: for carbonate rocks, the samples drying has to be done at 40°C for a longer period of time, instead of 70°C (as described in the standard procedure). Several carbonate rocks already start to loose strength slightly above 40°C. This will affect the measurements of porosity, strength, E-modulus. This recommendation is applicable for the test in which the samples must be dried.

- **Water absorption**

Absorption reflects the ability of a stone to take up liquids and gases. However, mostly water absorption tests give valuable information, because they can determine the right application for a specific stone. For example, it is not recommended to use a natural stone with a large water absorption capacity in applications where the stone can be directly in contact with water (e.g. bathrooms, but also floors and all external elements in contact with the floor). Moreover, water absorption can provoke stains, salt migrations, inclusion of dirt in the surface texture, etc.

- Water absorption coefficient by capillarity

  The water absorption coefficient is a measure for the amount of water that a stone can absorb in a given time.

  Reference: EN 1925

  Test: After drying to a constant mass, the specimen is placed with one of his sides (never the working surface) in 3 ± 1 mm water. The increase of the mass is measured in relation with the time.

  Recommendations: It is considered that values above 100 $g/m^2.\sqrt{s}$ are characteristic for stones with a high capillary absorption.

- Water absorption at atmospheric pressure

  This test gives a value for the amount of water that can be absorbed by the stone when immersed in water.

  Reference: EN 13755

  Test: After drying to a constant mass, each specimen is weighted and then immersed in water at atmospheric pressure for a specified period of time. The ratio of the water mass absorbed by each specimen when constant mass is reached to the mass of the dry specimen is determined.

- **Dynamic modulus of elasticity**

The dynamic modulus of elasticity is a measure for the stone strength. It is a useful property to test before and after a durability test to see if the strength and internal structure has changed (for example, microcracks).

Reference: EN 14146

Test: The dynamic modulus of elasticity of a stone is calculated from the fundamental resonance frequency that is measured with a special device. Vibrations are generated on the samples (prismatic or cylindrical) by a little stroke of a little hammer. The special device transforms the vibrations into fundamental resonance frequency that can be read on the display.

***Figure 4**: Measuring E-modulus*

Recommendations: The loss of dynamic E-modulus should not be higher then 30 % after any durability test.

- **Sound speed propagation**

The sound speed propagation through a stone is defined by nature and condition of the tested stone: porosity, moisture content, mineralogy, micro-cracks, etc. The sound speed determination is an accurate, not destructive, simple method to define the homogeneity and distinguish the difference in quality of the tested natural stone. Sound speed measurements can also be carried out in situ.

Reference: EN 14579

Test: A pulse of longitudinal vibrations is produced by an electro-acoustical transducer held in contact with one surface of the tested stone. After traversing a known path length in the stone, the pulse of vibrations is converted into an electrical signal by a second transducer and electronic timing circuits enable the transit time of the pulse to be measured.

- **Thermal expansion coefficient**

When using natural stone elements one has to bear in mind that natural stone, as any building material, is subjected to thermal deformation. This is particularly important for the dimensioning of external floor, façade elements and joints. Experiments on facades have shown that the temperature of a dark stone cladding can reach 80°C.

Reference: prEN 14581

Test: After drying to a constant mass, the sample length is measured, usually in a direction which is parallel to the plane of anisotropy. Subsequently, the sample is brought up to at least two different temperatures and the length is measured each time the given temperature is reached and stabilised for a certain time. The linear thermal expansion coefficient is calculated from the difference in length at the two temperatures.

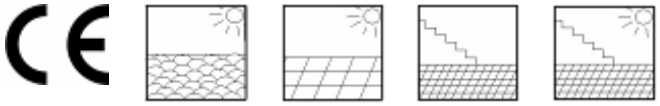
Figure 5 Cracks on flooring slabs due to an obstructed thermal expansion

Note: It is crucial for the stone performance assessment to measure the combined thermal and moisture induced expansion. In reality, the stone elements are subjected to such conditions.

The combination of the two types of expansion can induce a permanent dilation which is 10 – 100 times larger than the one generated by a dry expansion.

2 Performance of the stone in use

- ***Slip resistance***



Slip resistance of the stone surface is an important characteristic concerning the safety of a floor. When a stone finishing has a low slip resistance value, the risk of slipping while walking is permanent. It is generally considered that a slip resistance of more than 35 is safe. Coarse textured (relief > 1mm) and riven units are assumed to give a satisfactory slip resistance value.

Figure 6
SRT pendulum

Reference: EN 14231

Test: The slip is tested with a pendulum apparatus on the surface (with a certain finishing) of the natural stone. The pendulum tester consists of a spring loaded slider made of a standard rubber attached to the end of the pendulum. On swinging, the pendulum measures the friction between the slider and the test surface and provides a standardised value of slip resistance.

Recommendations: Generally, a slip resistance of more than 35 is considered to be safe.

- ***Resistance to mechanical fixing***

The determination of this property is important for the design of a façade cladded with thin stone slabs. Usually, based on the codes of practice the value, provided by this test, is needed to check if the slabs and their mechanical anchoring system are correctly designed towards wind pressure and mechanical shocks.

Reference: EN 13364

Test: The test consists of applying a force in a direction perpendicular to the face of a stone sample through a dowel previously placed in a hole drilled in one of its sides and measuring the breaking load of the sample.

Figure 7 *Anchoring system*

- ***Rupture energy***

This test gives an idea of the magnitude of impact a natural stone tile can sustain before rupture. It is an important characteristic for the applications that can be subjected to hard body impact (essentially floors, but also the lower parts of a façade).

Reference: EN 14158

Test: After drying each specimen to a constant mass, the energy of rupture by impact is determined by the dropping of a spherical steel ball (with a mass of 1 kg) from given increasing heights until the specimen breaks.

Recommendations: When tested according to EN 14158 (slabs on a sand bed), the heights before rupture presented in Table 2 are recommended.

Note: Hard body impact resistance of a stone system depends on the stone characteristics, but also on the fixing system and the underground. So, it is recommended to test the system in real conditions of use, which means for example a flooring tile embedded in mortar on a concrete slab (Figure 8). When tested in these conditions, the height recommendations are those shown in Table 3.

Table 2 Recommended heights for measuring the rupture energy according to EN 14158

Use	***Height before rupture (cm)***
Individual	*30*
Moderate	*45*
Intensive	*60*

Table 3 Recommended heights for measuring the rupture energy under real conditions of use

Use	***Height before rupture (cm)***
Individual	*100*
Moderate	*150*
Intensive	*200*

- **Stain sensitivity**

Sensitivity to internal staining is a characteristic dealing with aesthetic quality of a stone and is consequently impossible to specify. That means that the limit between what is acceptable and what is not cannot be unvaryingly fixed and that the results of the hereafter proposed tests have to be interpreted accordingly. In fact, a stone can be sensitive to three kinds of stains:

Figure 8 *Test results illustrating the influence of the setting: the tile alone (bottom) does not resist a drop of 35 cm, while the same tile embedded in a mortar of 2 cm thickness breaks at 60 cm (upper right). If the mortar is settled on a concrete slab, no damages are observed after a drop of 200 cm (upper left)*

- Stain type I:

This type of stain is due to oxidation of iron bearing minerals (pyrite, biotite, etc.) present in the stone. Depending on the size of these minerals, the stains will appear as yellow to brown spots (in case of outcropping minerals) (Figure 9), or diffused shadows on the surface (in the case of finely dispersed minerals) (Figure 10). Both types can be very difficultly removed and studies have shown that they need different testing conditions to be reproduced in laboratory.

Reference: EN 14066 (only for stones with outcropping iron bearing minerals)

Test: see "Thermal shock test".

<u>Note</u>: For stones with finely dispersed, non visible iron bearing minerals, like some white marbles, an adapted thermal shock test is proposed: 20 cycles consisting of 6h in an alkaline solution (1M and pH 9, obtained by dissolving $NaHCO_3$ in water), followed by 18h in an oven at 55 ± 5°C.

Figure 9 *Jura*

Figure 10 *Carrara*

- Stain type II:

This type of staining is induced by a reaction of organic matter (stone) with alkalis deriving from cement. The staining appears as a brown shadow/film on the surface of the slabs, a few days after the placing. These stains are relatively soluble in water and normally can be easily removed. Until now, no normalised test exists to reproduce the staining type II in laboratory conditions.

Reference: adapted "Venuat" test.

Test: Four stone tiles embedded in mortar (white sand and white cement) are used. After hardening, the units are placed in demineralised water at 20°C and 60 % RH, in such a way so only the base of the units is in contact with the water.

- External stain:

External stains are induced by a reaction with substances that appear at a bad moment and a bad place. Until now, no normalised test, specific for natural stones exists.

Reference: from EN ISO 10545-14 (for ceramic tiles) – adapted version.

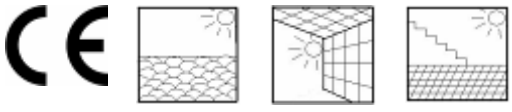
Test: substances that are known for their staining of natural stone are spilled on stone samples. On one hand daily used substances, like ketchup, ink, wine, etc are tested and on the other hand there is a more chemical test, where acid and basic solutions are dropped on the stone. After their application, the substances are wiped off after 15 minutes and after 24 hours.

Figure 5.11 *spilled substances*

Note: the test is very severe (because it is a test for ceramic tiles) and every kind of natural stone will leave stains; therefore it is better to use the test as an evaluation test between different stone types or a test to evaluate the performance of protective treatment products.

3 Durability characteristics

- ***Frost resistance***



Freeze-thaw resistance is certainly the most important issue to consider when specifying a stone type for external use, because if frost damage occurs, it is so destructive that the affected stone elements are generally smashed to pieces, threatening the service life of the whole building. Unfortunately, this is also one of the most difficult stone properties to evaluate and especially in the case of natural stones where the following

Figure 12 *Cracks due to frost*

difficulties have to be overcome:

- *"natural stone" is a generic denomination covering a large number of materials with a very broad variation of characteristics. A frost test suitable for all types must take this variation into account. For example, the water impregnation method must be suitable for granites with a very low porosity as well as for very porous limestones;*
- *unlike manufactured materials, which are designed for one specific use, natural stone has many applications in a building and one type of stone can be suitable for only a few of them. Consequently, a frost test for natural stone must have one or more varying parameters (impregnation level and/or number of cycles) to allow the simulation of the different stresses on the material in function of its use.*

Figure 13 *Smashed stone due to frost*

Influential parameters, which define different categories of use: For a given climate, a classification for the intensity of the frost action on the **different external parts** of a building can be the following (from the highest to the lowest):

- paving and flooring;
- elements in direct contact with the floor (base courses, plinths, etc.);
- non vertical parts in elevation and all elements sticking out of the facade (cornices, mouldings, windowsills, etc.);
- solid masonry units (not ventilated wall, with no possibility of drying from the back face of the stone units);
- wall cladding units or cavity wall units with ventilation allowing the inner face drying.

Of course, the intensity of the stress is also depending on the **type of climate**. The relevant parameters, which define the severity of a climate regarding the frost action, are:

- the intensity of the rain fall during the winter period;
- the number of freeze/thaw cycles during one winter.

There is, up to now, no official classification of the climatic zones in Europe concerning the frost action. But by combining these two parameters, it is possible to define a critical climatic event as a frost period preceded by a certain quantity of rain, which is likely to affect the durability of the exposed material when repeated. For example, climatic data in Belgium show that external flooring materials undergo between 20 and 30 critical climatic events per year, which is considered as severe climate towards the frost action. On this basis, three different climate classes can be defined, as presented in Table 4.

Table 4 Climate classes defined towards frost action

Type of climate towards frost action	***Number of critical climatic events during one year*** *(flooring exposure as a reference)*
severe	*more than 20*
moderate	*between 10 and 20*
light	*less than 10*

Tests:

- Identification test

Reference: EN 12371

Test: The samples undergo a number of cycles of frosting in air and defrosting in water. After a set of 14 cycles, the samples are checked in order to determine any damages. When frost damage is observed, the test is completed and the number of cycles (240 cycles is the maximum) that has been carried out is an indication of the frost resistance (although no specifications are yet developed).

- Technological test

Reference: EN 12371 & EN 1926 or EN 12372

Test: The samples undergo 48 or 12 cycles of frost in air and defrost in water, followed by a compression or flexure test (according to the type of application).

Recommendations for use: The European test method is available only since October 2001; this means that sufficient experience is lacking in order to have reliable specifications based on the test results. However, the experience so far allows the following proposal, as a first estimation: when frost resistance is tested according to EN 12371 – identification test, the stone should at least pass the number of cycles given in Table 5.

Table 5 number of cycles a stone should at least pass (for different uses and climatic conditions) when its frost resistance is tested according to EN 12371 – identification test

CLIMATE / ***USES***		*LIGHT*	*MODERATE*	*SEVERE*
EXTERIOR	*paving and flooring units*	*48 (*)*	*98*	*154*
	elements in contact with the floor	*48*	*98*	*154*
	non-vertical elements in elevation or elements that stick out of the facade	*28*	*56*	*84*
	solid masonry units	*12*	*28*	*70*
	facade cladding units	*0*	*12*	*48*

(*) declared value for CE-marking

- ***Abrasion resistance***

Abrasion can be defined as the wear caused by fine solid particles. It is certainly the most important form of stress on natural stone slabs, as far as flooring is concerned.

A floor, badly designed in relation to abrasion resistance, will rapidly wear and its surface finishing will change (loss of brilliance, colour modification, etc.) in the most walked areas. Sometimes, the abrasion effect will provoke the formation of a "patina" on stones composed of essentially one mineral (limestones).

Influential parameters, which define different categories of use: The intensity of the pedestrian traffic on a floor is the parameter that has to be considered first. From the entrance hall of a station to the private bathroom, there are many different degrees of traffic intensity. Moreover, it is generally recognised that wear resulting from the movement of pedestrians is most severe in places where changes of direction occur and where people are moving in a confined area, for example moving slowly through a ticket barrier. A possible classification of uses taking into account these effects is presented in Table 6.

Reference: EN 14157

Tests: The standard method describes three possible tests, the first one being considered as the reference:

- Method A: wide wheel abrasion test (Capon) (Figure 14).

  The test is carried out by abrading the face of a sample, which will be exposed in use, with an abrasive material or wheel under standard conditions. The abrasion wear is determined as the width of the indentation caused in the sample.

Table 6 Classification of uses taking into account the wear resulting from movement of pedestrians

Use	***Examples***
Intensive	*. public halls in stations, airports, shopping centres;* *. halls in an apartment block with more than 30 housing units;* *. common rooms of an office building with more than 50 employees;* *. floorings in supermarkets, etc.*
Moderate	*. common rooms of multifamily houses (with max. 30 housing units);* *. common rooms of block offices (max. 50 employees);* *. rooms with moderate commercial use.*
Individual	*. all rooms in private housing units.* *note: in this category, the areas most susceptible to wear are the ones which are directly accessible from outside.*

- *Method B: Böhme abrasion test*

  The test specimen is placed on the test track of the Böhme disc abrader, on which standard abrasive is strewn, the disc is rotated and the specimens are subjected to an abrasive load of 294 ± 3 N for a given number of cycles. The abrasive wear is determined as the loss in the sample volume.

- *Method C: Amsler abrasion test*

  Samples are placed on the Amsler disc on which standard abrasive is strewn, the disc is rotated and the samples are subjected to an abrasive load for a given number of cycles. The abrasive wear is determined as the loss in the sample thickness.

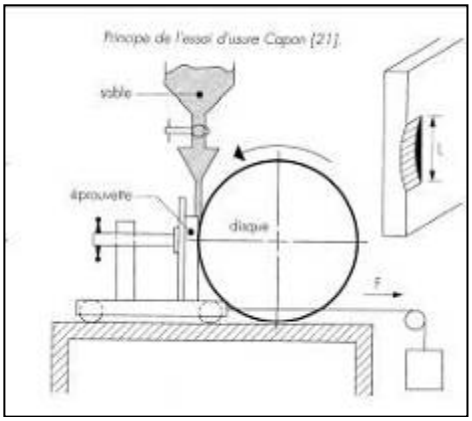


Figure 14 *Wide wheel Capon principle*

Recommendations for use: Table 7 shows indicative values of the above tests for the use of a natural stone in a particular application. It is important to note that these values are currently subjected to additional research so that the categories not to be too absolute. In Figure 15 a comparison between the results of Capon Wide wheel and the Amsler method, as obtained by BBRI, are presented. The comparative results (Table 7 and Figure 15) have shown a poor correlation between the Capon test and the other two abrasion tests, especially between 20 and 30 mm (Capon test).

Although the finishing of a floor covering is a personal choice, there are certain recommendations. The polished finish is not recommended for floor coverings intended for frequent passage, like in buildings for common use (moderate and intensive, according to the classification of Table 6). Even for private houses it is favourable not to use polished stone units in areas that are directly accessible from outside. The reason for these recommendations is that a polished finishing becomes rapidly mat in those areas where there is frequent passage, so that after a certain time the difference between the passable and impassable areas becomes visible (Figure 16).

Table 7 Values of abrasion resistance determined by the 3 different standard test methods for the different use categories proposed in Table 6

USE / ***TEST METHOD***	*INDIVIDUAL*	*MODERATE*	*INTENSIVE*
Capon wide wheel (mm)	*≤ 42*	*≤ 35*	*≤ 24*
Böhme	*??*	*≤ 38*	*≤ 27*
Amsler (mm/1000m)	*≤ 12*	*≤ 8*	*≤ 4*

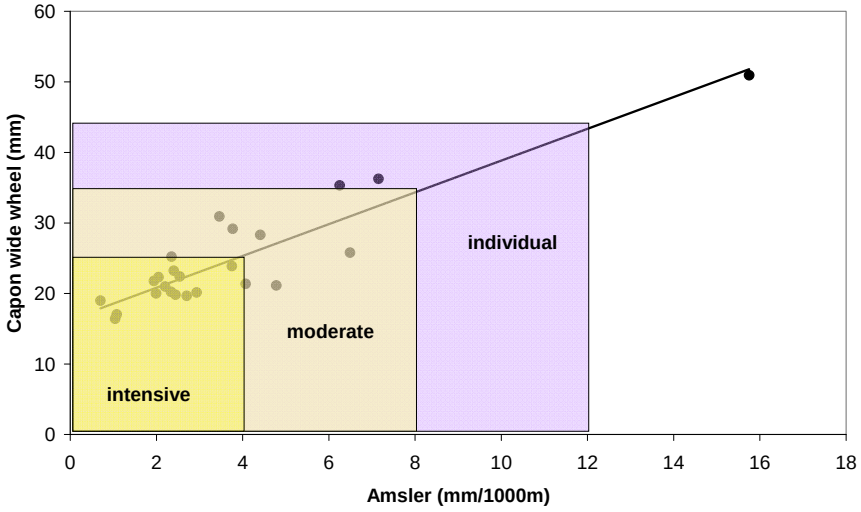
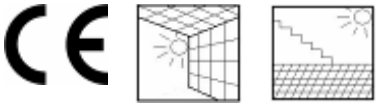


Figure 15 Comparative results and related categories between the Capon wide wheel and the Amsler method, obtained by BBRI

The three abrasion tests described above do not allow evaluating the durability of a surface finishing. For that, specific surface abrasion tests, like the PEI-test (EN ISO 10545-7), are needed. This test was originally developed to test the wear resistance of glazed ceramic tiles. A number of tiles are attached on the apparatus, and on top of the stone a reservoir containing water and standardised little balls (of different sizes) is placed. The apparatus makes a number of rotations (combined with vibrations) to simulate a certain degree of wear (Figure 17)

- ***Resistance to thermal shocks***



Thermal shock refers to the stress that a stone tile undergoes when it is subjected to abrupt temperature changes, inside as well as outside. Stone tiles that are placed inside can come in contact with cold and hot substances, such as boiling liquid or a hot saucepan. In cases of outside uses, a rapid temperature change, for example sun followed by rain, can cause damage to stones. Damage is often observed in cases of cladding on a south orientated wall.

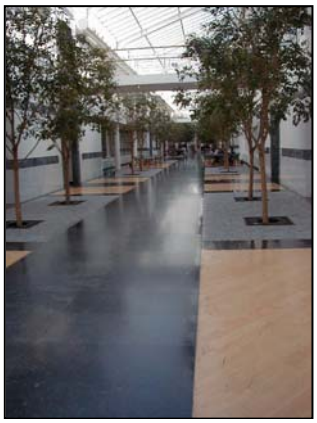


Figure 16 *In frequently passable zones, evolution to a lighter colour of the surface of blue stone floor that was initially polished*

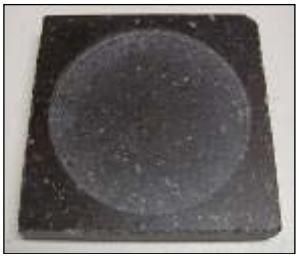


Figure 17 *Change of the surface of an originally polished blue stone, after 200 rotations during the PEI-test*

When a natural stone is heated (or can already be at 40°C) all the composing minerals will expand in relation with their thermal expansion coefficient. If then, for some reason, the temperature rapidly drops, the outer minerals will shrink. Depending on the thermal conductivity of the stone and the dimensions of the unit, a stress will be caused between the inner expanded hot body and the outer, shrunk, cold shell. This phenomenon results in flaking of the stone. When the stone mineral composition is not homogenous, cracks may appear between the different mineral types (Figure 18).

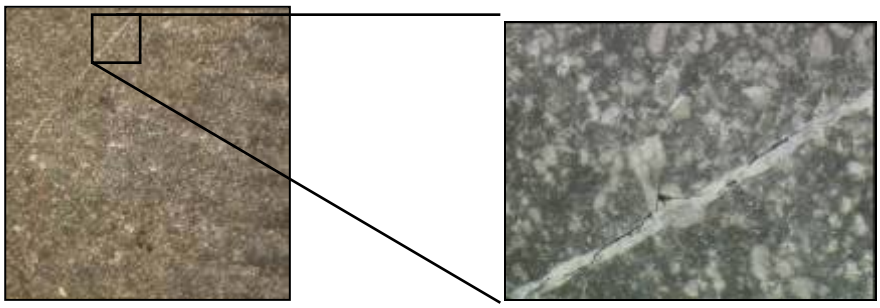


Figure 18 *Crack along a calcite vein in a blue stone after a thermal shock test.*

Influential parameters, which define different categories of use: The most important parameter for outside stone applications is the climate. Most dangerous are the climates with rapid temperature changes, combined with rain. The application of the natural stone can also play a role in its thermal shock resistance (from the highest effect to the lowest):

Exterior:
- *paving and flooring;*
- *solid masonry units;*
- *wall cladding units.*

Interior:
- *kitchen tops;*
- *tablets;*
- *flooring.*

Reference: EN 14066

Test: After drying to a constant mass, the samples undergo 20 successive cycles of drying at 105 ± 5°C followed by immersion in water at 20 ± 5°C. Before and after this test the dynamic elastic modulus is measured, to determine any change in intern structure.

Recommendations for use: When the difference of the dynamic elastic modulus value before and after the thermal shock test is more than 30 %, it is not recommended to use the natural stone in case where there is a chance of abrupt temperature changes.

Note: In relation to changes due to thermal influence it is worth mentioning the potential risk of bowing, an associated strength loss of marble cladding. The process is one of differential thermal and moisture induced expansion, which leads to granular disaggregation and, in some cases, to bowing/warping. A testing procedure for both of these issues has been developed within the EC financed project TEAM (Contract no. TEAM G5RD-CT 2000-00233). The test stimulates the moisture gradient developed in the cladding and also one sided heating up to 80°C in 25 or 50 cycles.

- **Ageing by SO_2**

As a result of air pollution, there is a considerable amount of sulphur dioxide in the air. Depending on the mineralogical nature of the stone, SO_2 can alter its surface. Therefore, it is useful to know in advance how the stone will react to exposure to an environment that contains sulphur dioxide.

Reference: EN 13919

Test: To test the resistance of a natural stone to the combination of temperature, humidity and sulphur dioxide, the samples are placed in two containers, each one having a different concentration of sulphur dioxide, for 21 days. Subsequently, the alteration and mass loss of the samples are determined.

- **Resistance to salt crystallisation**

This test refers not only to the crystallisation of salts in a natural stone and the following damage, but also to the mechanical action of the crystallisation process that exerts pressures in the pores of the material, which are similar to the ones generated by the formation and growing of ice, during freezing. This is why the crystallization tests have been developed and used since many years to assess the frost durability of building materials in general, and particularly of ornamental natural stone and aggregates for concrete. For example, this method is standardised and often used in United Kingdom for the evaluation of the durability of limestone, instead of the freeze-thaw cycles.

Reference: EN 12370

Test: After drying to a constant mass, the samples are immersed in a solution of sodium sulphate. Subsequently, the samples are dried and “warmed up” at the laboratory temperature. This cycle is repeated for 15 times and the mass variation, expressed in percentage, is determined (Figure 19).

Figure 19 *during the salt crystallisation test the samples will flake and lose weight*

Recommendations: Table 8 shows durability classes for limestone, based on weight loss in the crystallisation test, and the suitability of the stones for use in particular exposure zones of a building under different environmental conditions.

Table 8 Durability classes for limestone and corresponding uses of each class in particular exposure zones of a building under different environmental conditions

LIMESTONE DURABILITY CLASS	WEIGHT LOSS (%)	INLAND				EXPOSED COASTAL			
		LOW POLLUTION		HIGH POLLUTION		LOW POLLUTION		HIGH POLLUTION	
		no frost zones	frost zones	no frost zones	frost zones	no frost zones	frost zones	no frost zones	frost zones
A	< 1	1 - 4	1 - 4	1 - 4	1 - 4	1 - 4	1 - 4	1 - 4	1 - 4
B	1 to 5	2 - 4	2 - 4	2 - 4	2 - 4	2 - 4	2 - 4	2* - 4	2* - 4
C	> 5 to 15	2 - 4	2 - 4	3 - 4	3 - 4	3* - 4	4	-	-
D	> 15 to 35	3 - 4	4	3 - 4	4	-	-	-	-
E	> 35	4	4	4*	-	-	-	-	-
F	Shatters early in test	4	4	-	-	-	-	-	-

The different exposure zones of a building:
Zone 1: paving, steps;
Zone 2: copings*, chimneys, cornices*, open parapets, finials, plinths*;
Zone 3: strings, plinths*, quoins, tracery hood moulds, solid parapets (excl. copings stones*), cornices*, mullions, sills;
Zone 4: plain walling.

* probably limited to 50 years' life

Note: According to EN 12370 the crystallisation test is to be performed in stones with more than 5% open porosity.