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Image analysis for stone durability: two different techniques

Rossana Bellopede, Fiorenza Baudana, Lorena Zichella, Paola Marini

Synopsis

The presence of pores, cracks and micro-cracksin compact rocks is one of the main features that govern the processes of decay of stone materials and, although the marbles are characterized by a modest porosity, there is a clear correlation between the presence and movement of fluids of the water, and the phenomena of alteration. Through the study of porosity it is possible to better understand the phenomena of alteration and degradation in order to obtain useful information in the field of modern building, but also for the protection and recovery of historical and artistic heritage goods. The purpose of the research is to characterize the physical and mechanical properties of four different varieties of marble, exposed to external degradation agents for about ten years and then compared with the original properties measured on slabs of the same marble protected from atmospheric agents. The study was conducted through the characterization of physical and mechanical parameters directly correlated with the degree of alteration of the materials: water absorption by contact sponge(UNI 11432), water absorption at atmospheric pressure(EN 13755), flexural strength (EN 12372)and bowing(EN 16306 par. 8.2). In addition, to verifying the porosity of the materials studied, two different image analysis techniques were compared: ImageJ with Jpore and AGA.The results obtained from the two techniques found a better analysis of the degradation with Image J than the AGA that cannot be representative of the tendency to decay or bowing of the marble.

Keywords

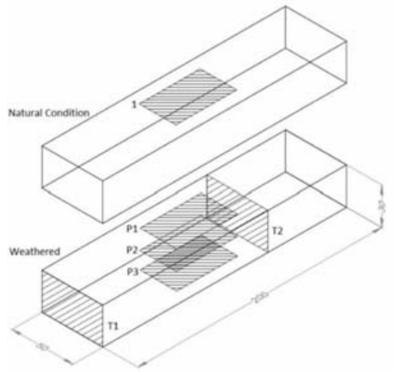
total optical porosity, adjacent grain analysis, decay, fabric, porosity

Introduction

Decay affects aesthetics and structurals (including microstructurals) characteristics of natural stones. The progress of decay leads to a worsening of mechanical properties of materials, such as the increase in water absorption, due to the increased porosity of the rock.On the base of recent researches Akesson et al. 2003, (Bellopede et al 2016, Andriani and Germinario 2014) there is a direct connection between durability of natural stones and structural characteristics observable by microscopy analysis. Lots of recent works are referred to the Image Analysis methods for the evaluation of decay in natural stones. These techniques are potentially useful but they are not yet standardized: for this reason it is necessary to validate the test methodology and to verify the test results reliability.

Total Optical Porosity method

Total Optical Porosity (TOP) determination has been performed using the free software Irfan View 4.40 and the macro file jPOR.txt (Grove and Jerram, 2011) for ImageJ. Four different kind of marbles has been tested; for each one, six thin sections has been made and soaked with epoxy resin and methylene blue as illustrated in Fig. 1a. In order to obtain a better analysisof the increase of decay, five thin sections obtained from the weathered marble has been cut, respectively three along the upper (P1), medium (P2) and lower (P3) sections parallel to the exposed surface and two along a transversal section (the external T1 and the internal T2). The impregnation process was repeatedly performed under vacuum in order to obtain a smooth surface when viewed against light .All the thin sections have been analysed using the optical macroscope LEICA MZ6 and the PANASONIC LUMIX DMC-GF6 digital camera. For each thin section, ten photos have been made uniformly spaced among its surface (Fig. 1b) and then pre-processed using Irfan View. Each 24-bit image has been converted to an 8-bit image using the custom blue palette of jPOR created in order to reach a colour thres holding that requires less preprocessing and removal of noise, thereby reducing inter-operator variability. The threshold values used to determine the porosity were left as constant as possible (lower threshold = 0 and upper threshold = 69/70) in order to find representative and comparable results between different marbles. At the end of this process, the average porosity value has been calculated and compared for each thin section.



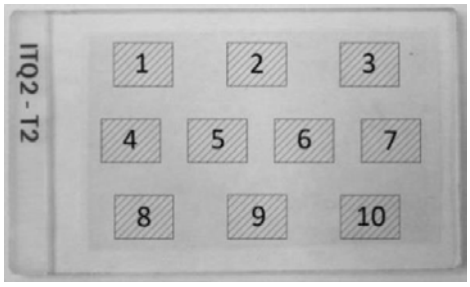


Fig. 1 a) On Left: Cutted areas from the specimens to obtain thin sections. b) On right: Position of pictures taken from thin section for image analysis.

This new unconventional technique was used to verify if the marbles shows different kind of weathering after being subjected both to natural ageing and to accelerated ageing tests (Bellopede et al 2016). Even if the values on the TOP are characterized by high uncertainty, for GI marble has been possible to detect the different answer in term of porosity distribution between artificial and natural weathering, giving an explanation to the different results obtained by means of conventional tests (with particular reference to water absorption and bowing values).

AGA method

The AGA Analysis (AGA) was carried out in accordance with the EN 16306 Annex C (2013) by means of the free software ImageJ in order to calculate the number of adjacent grains (AG) around median-sized grains. This analysis method gives information on the microstructure of natural stone and its potential durability (Åkesson et al. 2010); it has been suggested as a screening method. Initially, the value of the median grain size has been calculated, measuring the Feret diameter (longest axis) of at least 100 grains along the plotted linear traverses (Figure 2). Afterwards, at least 50 median sized grains were chosen and a manually count of the number of their adjacent grains was carried out; the mean value of all counts represents the AGA index. According to Annex Cof EN 16306, values from 8 upwards represent marbles with good characteristics, an AGA of 7 is intermediate, and 6 indicates a low level material. Is important to highlight that, according to the standard, this classification is valid only for calcitic marbles.

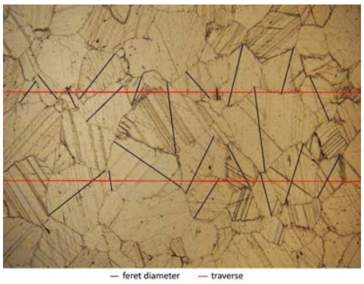


Fig. 2 Linear traverse method for determination of the grain size distribution

The stone tested

The marble tested and the petrographic characteristics are shown in Tab. 1. GI, SG and PS are mainly calcitic while IK is composed by 96% of dolomite.

Table 1: Marble tested and petrographic descriptions

MARBLE TYPE	DESCRIPTION
GI	Italian marble totally calcitic composition with polygonal structure and equigranular grains (size from 0.1 to 0.5 mm) with no presence of subgrains
SG	Portuguese marble: composition is mainly calcitic. Grain size from 0.7 to 1 mm. Rare quartz grains Seriate polygonal/ interlobate. No subgrains
IK	Greeke marble: composition is 96 % dolomitic. Grain size from 0.05 to 0.17 mm Interlobate/polygonal. Inequigranular. Few subgrains
PS	Portuguese marble: composition is totally calcitic. Grains size from 1 to 2.8 mm Seriate polygonal. Subgrains

Results

In the table 2 the result of change in flexural strength, UPV water absorption and bowing after 20 thermal cycle in presence of humidity according EN 16306 are shown. The results of the image analysis by means AGA and JPOR are reported in table 3.

Table 2 Results of physical mechanical properties, also after artificial ageing tests.

	Flex. Str.	UPV	Water abs	Bow
	%	%	%	mm/m
GI	-40	-55	46	0.89
SG	–19	–19	12	0.04
IK	12	-14	-0.9	0.05
PS	-21	-8	-6	0.06

Table 3 JPor results and AGA.

		NAT.CONDITION	ARTIFICIALLY AGED				
	AGA	JPor (1)	JPor(P1)	JPor(P2)	JPor(P3)	JPor(T1)	JPor(T2)
		%	%	%	%	%	%
GI	6.1	0.34	0.66	0.77	0.29	1.84	0.42
SG	6.8	0.16	0.40	0.07	0.21	0.18	0.16
IK	7.7	6.29	15.50	5.89	13.02	4.57	8.13
PS	10	0.20	0.04	0.11	0.03	0.02	0.07

Discussions and conclusions

From the results obtained AGA cannot be fully representative of the tendency to decay or bowing of the marble. Infact SG, despite the AGA value 6.8 (indicating a low level material according Annex C of EN 16306), doesn't show bow tendency and decreasing in mechanical properties (tables 2 and 3).For the future revision of the EN 16306, test method is therefore advisable, because of the difficulties of interpretation, to build a broader database and understanding by training and inter-comparison trials among laboratories trained on the AGA calculation. Major investigations could be executed focusing on the influence of grain size on bow tendency and the Image analysis an instrument to evaluate this further feature.

The use of Total Optical Porosity by means of JPor and soaked thin section could be useful to better explain the decay mechanism of stone tested. In particular the comparison of the results obtained from the specimen portion P1with the sections formed by the central part P2 is an indicator of the evolution of porosity or cracks inside the stone For example, GI, with high value of water absorption after artificial ageing (table 2),is characterized by high values of TOP both in the upper and in central parts of specimen (P1 and P2 thin section) respect the TOP calculated in natural condition (1 thin section - table3).IK, instead, with a very low water absorption, show values of TOP higher in correspondence of the upper and bottom portions (P1 and P3 thin sections) and lowest value in the center of specimen (P2 – table 3).

References

ÅKESSON U., STIGH J. , LINDQVIST JE., GÖRANSSON M., The influence of foliation on the fragility of granitic rocks, image analysis and quantitative microscopy, In Engineering Geology, Volume 68, Issues 3–4, 2003, Pages 275-288, ISSN 0013-7952, https://doi.org/10.1016/S0013-7952(02)00233-8.

ÅKESSON U, LINDQVIST JE, SCHOUENBORG B (2010) AGA - the method to demonstrate the relationship between microstructure and bowing properties of calcite marble claddings. Global Stone Congr. 2010, Alicante, Spain, pp 1–5

ANDRIANI, G.F. &GERMINARIO, L. (2014) Thermal decay of carbonate dimension stones: fabric, physical and mechanical changes, Environ Earth Sci .72: 2523. https://doi.org/10.1007/s12665-014-3160-6

BELLOPEDE, R., CASTELLETTO, E., SCHOUENBORG, B. et al. (2016) Assessment of the European Standard for the determination of resistance of marble to thermal and moisture cycles: recommendations for improvements Environ Earth Sci 75: 946. https://doi.org/10.1007/s12665-016-5748-5

BELLOPEDE et al 2014

GROVE, C., JERRAM, D.A., 2011, jPOR: An ImageJ macro to quantify total optical porosity from blue-steined sections, Computer & Geosciences", 37, 1850-1859.

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