4 The Use of Image Analysis for Quantitative Monitoring of Stone Alteration

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ABSTRACT

This paper presents a methodology to quantify through image analysis the colour alteration of dimension stones caused by weathering. Specific image acquisition techniques and calibration methods are developed including practical solutions to avoid spatio-temporal noise and drift, colour calibration and positioning calibration. The procedure consists of grabbing and comparing images of polished granite tiles before and after accelerated ageing tests. This method is non-destructive, allowing initial and final image acquisitions on the same sample after repositioning with an accuracy of 0.4 millimetres. Lighting properties and grabbing parameters are kept identical during both imaging phases. Colour alteration is quantified by computing the Euclidean distance in a (pseudo)-L*a*b* colour space. The results of a practical study on three granites are presented and discussed.

INTRODUCTION

The aim of this paper is to propose technical solutions and analytic methods for monitoring the colour decay caused by weathering using digital image analysis. The mineralogy and sampling of the three studied granites are first briefly described, followed by an overview of the complete protocol of tests. The two main sections develop the calibration procedure for the imaging system and the image analysis methods. Finally, the most significant results are presented and commented upon, with a brief discussion of potential extensions of the proposed techniques and its limitations.

The quantitative description of visual change in ornamental stones submitted to natural or artificial weathering is a crucial scientific and economic challenge. Colour is one of the most important characteristics of these materials, which determines their use in the building market. Mineralogical or geochemical mechanisms of rock alteration have been widely studied.[1] Some studies have tried to quantify the degradation of mechanical and physical properties,[2] but very little information is available about the aesthetic alteration of stones after weathering. However, from the consumer's point of view, visual appearance of stone is probably the most important consideration. For example, any deviation, even slight, in the predominant colour of adjacent tiles in a paving badly affects the aesthetics of the work as a whole by emphasizing the colour discontinuity induced by the cement joints.

Of course, standard colorimeters or spectrophotometers are available for quantitative measurement of colour. But both devices integrate very limited fields of investigation (typically 1 cm^2). They are thus largely irrelevant for monitoring colour variations in textured materials like granites.

The idea of using digital image analysis to characterize or control the quality of ornamental stones or ceramic is not a revolutionary idea.[3] For the last five years various consortia have managed

ambitious research programs at the European level with the aim of integrating automatic inspection systems for ceramic tiles.[4,5] This recent interest in quantitative colour quality control using digital video cameras demonstrates the usefulness and further potential of the technique and may meet the need for an accurate and objective tool to control the visual aspect of tiles in the stone industry.

The work described in this paper extends these studies by conducting colour image analysis over a longer time scale, which is relevant to colour alteration by weathering and colour durability. The test methods used have been applied under laboratory conditions, but could be adapted, with some limitations, for use *in situ* on paving, façades and natural stone outcrops.

MATERIALS AND METHODS

Granite selection

For this study, three granitic rocks were selected (Table 4.1) for their high propensity for chromatic alteration.[6] Three polished flags (300×300 mm) of each rock type were prepared and analysed. The tiles were randomly selected from the daily production of the source quarries.

General testing protocol

To ensure representativeness and reproducibility, it is essential that a rigorous test protocol is devised and strictly adhered to. Each fresh sample tile is first imaged and its initial colour statistics are computed and stored. The tiles are then submitted to standardized accelerated ageing tests. After precise repositioning, a second colour image is acquired from which final colour statistics are computed.