8th. World Congress on Computational Mechanics (WCCM8)
5th. European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 – July 5, 2008
Venice, Italy

SIMULATION OF IRREGULAR STONE MASONRY BASED ON IMAGE PROCESSING

Alessandra Barbanera, Seymour Spence and *Massimiliano Gioffrè

Department of Civil and Environmental Engineering, University of Perugia
Via G. Duranti, 93 - 06125 perugia - IT
corresponding author: mami@unipg.it

Key Words: *Irregular Masonry, Image Processing, Simulation Techniques.*

ABSTRACT

Historical buildings are often built out of irregular stone masonry. This represents a two phase heterogeneous material consisting of stones in a matrix of mortar. The mechanical characteristics of this material depends on various parameters, including the individual mechanical properties of the two components, and on the shape, orientation and size distribution of the inclusions as well as the general morphology of the packed specimen. Therefore the mechanical modelling of this type of building depends on the proper description on these variables. In particular the parameters associated with the geometrical characteristics of the wall can vary tremendously between different buildings situated in separate regions. Indeed historical buildings in many cases where built using unworked stones which came from local quarries. Therefore the masonry reflects the local stone type and obviously the local techniques adopted by the masons. On the other hand the variation in morphology found in a single building is often contained. Therefore the development of probabilistic techniques that can describe the geometrical morphology from a limited representative area of a particular masonry is possible and would represent an extremely useful tool for the mechanical characterization of this material.

In this paper a technique is proposed for probabilistically describing a particular irregular stone masonry directly from a digital colour image of a representative area of the masonry. In particular, the grey-level version of the original colour image is enhanced with image pre-processing techniques [1] in order to improve the contrast therefore allowing a first identification of the regions within the image that represent the stones. The identification is further improved through a segmented binary representation of the image using histogram thresholding. The segmentation operation works on the grey-level histogram of the image employing a particular grey-level to separate the pixels representing the stones from those belonging to the mortar [2]. Before identifying the boundaries of the stones, the result of the thresholding is improved with morphological operations in order to correct possible errors due to imperfections in the acquisition method. The boundaries of the stones are then modelled as to enclose star-like domains. These domains are then used to implement a method for probabilistically characterizing and simulating the geometry of the individual stones through a sequence of scaled translation random fields [3, 4]. The simulated stones are then used in a

packing algorithm that reproduces the global morphology of the original masonry by distributing the stones according to a modified soft-core Poisson field with matching size distribution curve [4, 5, 6]. The proposed technique allows the simulation of an unlimited area of a particular irregular stone masonry from a single digital image of a representative area of limited size.

REFERENCES

[1] R. C. Gonzalez and R. E. Woods. *Digital Image Processing*, 2th. Ed., Prentice Hall, 2002.

[2] N. Otsu. "A threshold selection method from grey-level histograms". *IEEE Trans. Syst. Man. Cybern.*, Vol. **SMC-9**, pp. 62–66, (1979).

[3] M. Grigoriu, E. Garboczi and C. Kafali. "Spherical harmonic-based random fields for aggregates used in concrete". *Powder Technology*, Vol.**166**, pp. 123-138, (2006).

[4] S. M. J. Spence, M. Gioffrè and M. Grigoriu. "Random field models for Monte Carlo simulation of irregular masonry walls". *International Symposium on Recent Advances in Mechanics, Dynamical Systems and Probability Theory MDP – 2007*, Palermo, 3-6 June, (2007).

[5] S. M. J. Spence, M. Gioffrè and M. Grigoriu. "Multi level probabilistic characterization and Monte Carlo simulation of irregular masonry walls". *9th Us National Congress on Computational Mechanics*, San Francisco, 23-26 July, (2007).

[6] S. M. J. Spence, M. Gioffrè and M. Grigoriu. "Probabilistic models and simulation of irregular masonry walls". Journal of Engineering Mechanics, ASCE, in print.