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High Resolution 3D modelling of Cylinder shape bodies applied to 1000 ancient BC columns

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A multi-technique high resolution 3D modelling is described here aimed at the investigation of the state of conservation of carbonate columns of the 1000 BC ancient church of Buon Camino located in the homonymous district of the town of Cagliari (Italy).

The integrated application of different Non-Destructive Testing (NDT) diagnostic methods is of paramount importance to locate damaged parts of the building material of artefacts of historical buildings and to plan their restoration.

In this study a multi-step procedure was applied starting with a high resolution 3D modelling performed with the aid of Structure from Motion (SfM) Photogrammetry and Terrestrial Laser Scanner (TLS) methodologies. For this delicate task we operated simultaneously a Nikon D-5300 digital Reflex 24.2 Mega pixel Camera and a Leica HDS-6200 Terrestrial Laser Scanner. Subsequently, starting from the information detected with the above methods deeper material diagnostics was performed by means of high resolution 3D ultrasonic tomography aimed at the capillary definition of the elastic properties in the inner parts of the building materials. Measurements of longitudinal wave velocity from ultrasonic data were performed using the transmission method, namely two piezoelectric transducers coupled on the opposite sides of the investigated columns. The ultrasonic data acquisition was planned designing an optimal survey and providing a very good spatial coverage of the investigated columns. The columns were then criss-crossed by a large number of ray paths forming a dense 3D net. The SIRT (Simultaneous Iterative Reconstruction Tomography) algorithm was used to produce the 3D rendering of the velocity distribution inside the investigated columns. With this method the damaged parts were located and it was possible to distinguish them from the unaltered areas. The information on the superficial material conditions obtained by SfM and TLS techniques were compared and integrated with the information of the inner materials obtained by 3D ultrasonic tomography.

The results of the above non invasive geophysical techniques have been interpreted in the light of the different textural and petrophysical features of the study carbonate building materials. The study of the main textural features, such as the relationship between bioclasts, carbonate matrix, or that of the cement and petrophysical characteristics such as the nature and distribution of porosity were found to be of fundamental importance in the interpretation of the geophysical data

(e.g. TLS reflectance and longitudinal acoustic wave propagation). Therefore a detailed analysis of the textures and pore microstructure were carried out from petrographic thin-sections in Optical and Scanning Electron Microscopy (OM/SEM). The final result of our multi-step-technique integrated methodology is a sophisticated 3D model with a high resolution 3D image representing the internal and external parts of the investigated columns in order to account for their static load resistance and possibly plan their conservation and restoration. The described procedure can also be applied to other cases in which a diagnosis is needed of the state of conservation of the variously shaped, layered-stones and composed artefacts typical of ancient historical buildings.

Key words: 3D Modelling, 3D Ultrasonic Tomography, Terrestrial Laser Scanner, SfM Photogrammetry, Non-Destructive Testing, Diagnostic, Ancient Columns, Stones