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Integrated optical and thermal data analysis for a rapid surface diagnostic of transport infrastructures: the cement beam case study in Montagnole (France).

Simone Pascucci (1), Angelo Palombo (1), Cristiana Bassani (2), Rosa Maria Cavalli (2), Federico Santini (2), and Stefano Pignatti (1)

(1) National Research Council - Institute of Methodologies for Environmental Analysis (CNR IMAA), Via Fosso del Cavaliere 100, 00133, Rome, Italy (pascucci@imaa.cnr.it, palombo@imaa.cnr.it; pignatti@imaa.cnr.it), (2) National Research Council - Institute for Atmospheric Pollution (CNR IIA-LARA), Via Fosso del Cavaliere 100, 00133, Rome, Italy (cavalli@lara.rm.cnr.it)

The integrated use of hyperspectral (0.4-1.0 micron) and high sensitivity thermal camera data for surface diagnostics of transport infrastructures is a challenging investigation tool that can be combined with other non-destructive penetrating techniques (e.g. GPR) in order to acquire actual information on infrastructure status to prioritize the intervention areas to be maintained.
Since the surface analysis of critical and transport infrastructures is not always satisfied by visible and thermographic imagery, the proposed research aims to exploit the integration of hyperspectral VNIR reflectances, temperature and apparent thermal inertia behaviours.
As regard VNIR reflectances, their potential lies in discriminating materials and their status on the basis of their different patterns and of wavelength-specific absorption [1-3]; whereas, by means of thermography data analysis real-time information on the internal structure can be extracted if thermally connected to the external surface of the structure [4-6]. The jointly use of the reflective and infrared (emitted, absorbed, reflected and transmitted) radiation for this study is supported by the technical and operative performances of the instruments used in terms of high spectral resolution and high-frequency images with low NeDR e NeDT values. The sensors sensitivity is, indeed, adequate to capture the ranges of variability of the surface phenomena related to the status of materials and building elements used in transport infrastructures.
The following ground-based instruments are used for this study: (a) a HYSPEX hyperspectral scanner working in the VNIR (0.4-1.0 micron) spectral region, which is an imaging spectrometer with a very high spectral and spatial resolution, (b) a FLIR SC7000 Thermal cam working in the LWIR (8-12 micron) spectral region, and (c) ASD-FieldSpec FR Pro spectroradiometer, a portable hyperspectral device operating in the 0.4-2.5 micron spectral range.
The proposed study shows the preliminary results of the surveys performed on a concrete reinforced beam structure typically used for transport infrastructures.
The optical and thermal imagery on the beam, loaded up to 16,000 kJ in order to test its resistance to big shocks, were acquired in the Montagnole test site (April 2010 in the French Alps, owned by LCPC) within the ISTIMES project framework (“The research leading to these results has received funding from the European Community’s Seventh Framework Programme (FP7/2007-2013) under Grant Agreement n=C2=B0 225663”).
The processing of the reflectance imagery allowed us to detect on the beam spectral surface anomalies related to the unconformities (i.e. cavities and cracking) of the beam related to the dropping of heavy loads on it. Whereas, high sensitivity thermograms provide (a) at first a general sketch of the beam inner iron rebar, (b) during the loading and impact the vibration frequency of the beam and the exchange of energy between the falling blocks and the beam and (c) the thermal surface behaviour of the beam after the impacts (causing also cracking effects).
Moreover, the integration of the in situ thermographic data with the hyperspectral scanner imagery allows a better understanding of the beam status in terms of its surface distress.
These preliminary results are encouraging, even though suitable integration approaches also with the classical geophysical investigation techniques (e.g. geo-radar) have to be improved for a rapid and cost-effective infrastructures diagnostics and monitoring.

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