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Non Destructive Testing by active infrared thermography coupled with shearography under same optical heat excitation

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As infrastructures are aging, the evaluation of their health is becoming crucial. To do so, numerous Non Destructive Testing (NDT) methods are available. Among them, thermal shearography and active infrared thermography represent two full field and contactless methods for surface inspection. The synchronized use of both methods presents multiples advantages. Most importantly, both NDT are based on different material properties. Thermography depend on the thermal properties and shearography on the mechanical properties. The cross-correlation of both methods result in a more accurate and exact detection of the defects. For real site application, the simultaneous use of both methods is simplified due to the fact that the excitation method (thermal) is the same.

Active infrared thermography is the measure of the temperature by an infrared camera of a surface subjected to heat flux. Observation of the variation of temperature in function of time reveal the presence of defects. On the other hand, shearography is a measure of out-of-plane surface displacement. This displacement is caused by the application of a strain on the surface which (in our case) take the form of a temperature gradient inducing a thermal stress To measure the resulting out-of-plane displacement, shearography exploit the relation between the phase difference and the optical path length. The phase difference is measured by the observation of the interference between two coherent light beam projected on the surface. This interference is due to change in optical path length as the surface is deformed [1].

A series of experimentation have been conducted in laboratory with various sample of concrete reinforced with CFRP materials. Results obtained reveal that with both methods it was possible to detect defects in the gluing. An infrared lamp radiating was used as the active heat source. This is necessary if measurements with shearography are to be made during the heating process. A heating lamp in the visible spectrum would hinder the projected light beam since a laser with wavelength of 532 nm was used as the coherent light source. Experimentations were successful, but only with mitigated efficiency for shearography [2]. The thermal response was the fastest and it was possible to fully locate all defects. For shearography, the available equipment forced us to restrict the area of observation to only one defect at a time (roughly 100 cm^2).

Numerical models were designed based on the multiple sample tested in the experimental step of the study. Using the COMSOL© finite elements modeling software, numerous simulations yielded results in accordance with experimental data. Different types of defect could be modeled and showed that both shearography and thermography have different sensibility in function of the nature of the defect. Furthermore, analysis of the simulated results demonstrated a relation between the contrast evolution of the temperature and displacement field.

In the near future, we expect to make several improvement to our experimental setup. As for the numerical model, some small disparities between the theoretical and experimental results still remain to be addressed. The numerical model could be improved but to do so it requires to raise the shearographic measurements sampling rate close to the one used for infrared thermography. Once this issue will be resolved, it will be possible to use experimental data to refine the numerical model. So, accurate models will be helpful to optimize the overall efficiency of the coupling of thermal shearography and active infrared thermography for in situ NDT application.

References

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