Active Intrared Thermography for Non-Destructive Control for Detection of Defects in Asphalt Pavements

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Abstract

Active infrared thermography has been used for the detection of sub surface defects in road materials. The step heating method was selected, and two different infrared cameras selected. Defects were detected with an heating phase as short as 60 seconds. Some images treatments were employed, and have been able to extract signal in spite of the porosity and of the high heterogeneity of a road material. Numerical model calculations were run, and have lead to experimental validations.

1. **Introduction**

Within the policy frame of the diagnosis and the maintenance of the French roads and bridges network, some investigations have been undertaken on non-destructive methods for roads pavements. Such methods could be applied on the field on real sites as much as possible. They should be able to detect hidden defects from the surface. Indeed, defects such as un-sticking zones between the top layer and the structural ones could induce a quick deterioration of the pavement surface (potholes …). When the defect is punctual, or is located on a small road stretch, some efficient repair might solve the problem. Sometimes, it involved a larger number of kilometres. The renewal of the road is then the solution. Their detection as soon as possible has therefore a great importance and is an important challenge. It might implies some savings and avoid major traffic disruptions.

Active infrared thermography for the detection of defects has been used now for many years for non-destructive control of materials such as metals, composites and so on, as described in the literature [1]. The objective of this study was to evaluate to which extent this technique could be applied to road pavements. There is a large variety of materials used for road pavements, from asphalt to concrete. They might have different granular constitution and therefore different thermal and radiative properties. Their structures could be non to highly porous, and could include several layers. These variations could also appear within the same pavement due to construction constraints. These heterogeneities would induce some difficulties in the use of active thermography. Furthermore, one main obstacle would be to detect defects at great depths within a reasonable period of time. Such challenge would have to cope with the fact that the thermal properties gradients between the considered sound materials and the ones with defects could be weak.

2. Experimental Set up

This preliminary study has consisted in setting a first measurement protocol for the use of active infrared thermography to detect defects within a laboratory frame. As a start, some semi-granular asphalt pavement material was considered. It is one of the most commonly used material either on national roads and highways. Samples were made of granular materials with a bitumen matrix. They consisted in parallelepipeds (10 cm x 18 cm x 50 cm). Defects were either made of wood and air, which thermal conductivity and diffusivity were lower than the ones of the road material. The defects shapes were a parallelepiped and a pyramid. They were located at different depths under the samples surfaces.

The experimental setup consisted in two 500 W halogen lamps each, described in a previous paper [2]. A reflector was used to get roughly constant flux density over the whole sample surface. The selected active thermography method was the step heating. It consisted in heating the sample for a given time length and then in proceeding to observations during the whole relaxation process. The heating phase lengths ranged between 60 s and up to 1 hour. Two different infrared cameras were employed to monitor the process of the surface temperature. The first one was a CEDIP camera Jade (MWIR), and the second one was a FLIR S65 (LWIR). In both cases, infrared images of the samples surface were taken at a given frequency. The experimental setup is illustrated on the following figure.

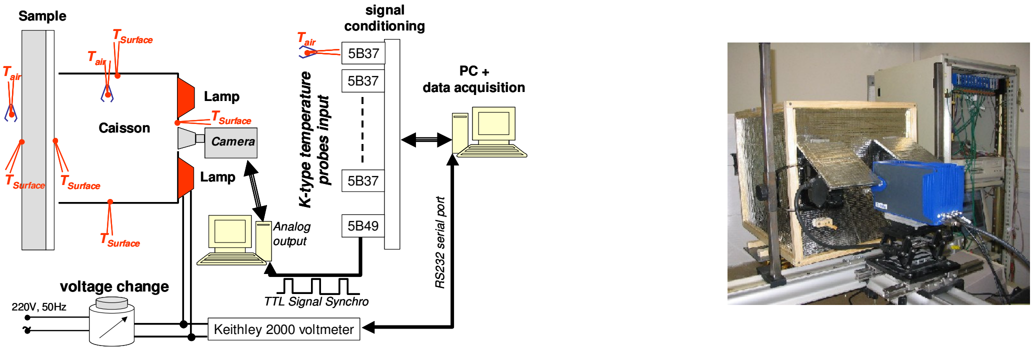
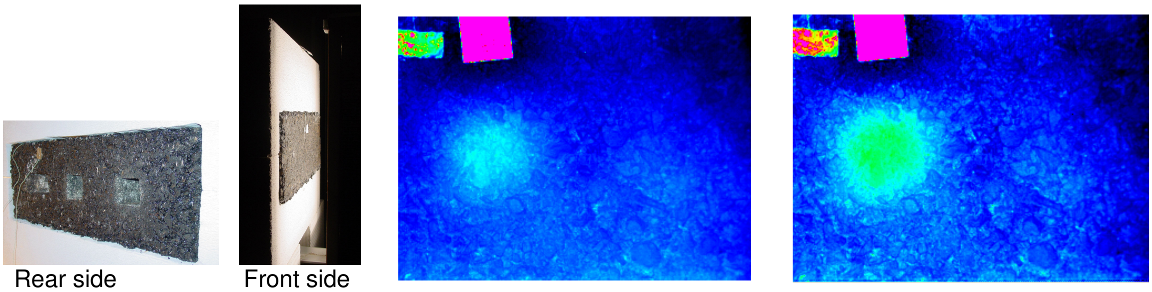


Fig. 1. *Step-heating experimental setup*

3. Results

Image analyses were used to locate the defects within the samples. They consisted in calculations of thermal contrast, in filtering the signal, and in generating contrast images, illustrated on Figure 2. Defects located under the surface were easily found even with a short heating phase. The thermal behaviour of the structure was greatly affected by the defect presence around it. The nature of the samples (porosity, heterogeneity) did not seem to affect the ability of the technique to non destructive control of road structures.



Rear side Front side

(a) Road sample (b) infrared image on one defect (c) contrast image on one defect

Fig. 2. *Images of a sample ((a) visible, (b) infrared and (c) contrast)*

Furthermore, some mono-dimensional models could be used to reach thermo-physical properties of the material through an estimation of parameters with an inverse method. Such a technique has been used in the past for more conventional materials [2,3]. Some calculations were undertaken with the numerical model FLUENT with a proper grid of the samples. A comparison was then made between experimental and numerical results.

References

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