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Presentation Paper

Infrared Thermography for Detection of Pipes and Identification of Frames in a Concrete Wall
PLAN

Introduction
Principle of the method
Structure of the model
Simulations
Results
Conclusion
Abstract

Infrared thermography is a thermal method of non destructive testing which can contribute to the evaluation of the integrity of the civil engineering structures, especially when the question is to detect the defects close to surface. Its principle is based on the analysis of the thermal images captured on a surface of the suspect structure. This method has several advantages, among others, one can quote the nondestructive character, measurement can be done without contact with the suspect object and the results can be immediately exploited without any preliminary treatment.
Infrared Thermographic technique is investigated numerically and experimentally for location and sizing of water mains and to identify reinforcing steel in concrete members.

A finite element based numerical analysis demonstrated the feasibility of thermography as an evaluation technique for reinforcement in concrete.
Principle

The non destructive testing by infrared thermography is based on the principle that the speed of the heat flow penetrating in a structure depends on the thermophysical parameters of this structure; namely thermal conductivity, the calorific capacity and the density. When the structure is homogeneous, the heat flow is propagated in a uniform way; in the case of presence of an inclusion presenting thermophysical properties different from those of the structure, the heat flow will be accelerated or slowed down according to the nature of this inclusion (conductor or heat insulator). In this case, more or less hot thermal tasks will appear on the surface.
wall of concrete of parallelepiped form of dimensions: (2m x 1.2m x 0.25m) in which are introduced cylindrical pipes or bar for concrete reinforcement to be studied
### Characteristics of the used materials

<table>
<thead>
<tr>
<th>Material</th>
<th>thermal conductivity [W/(m*K)]</th>
<th>Density [kg/m³]</th>
<th>Heat capacity at constant pressure [J/(kg*K)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>PVC</td>
<td>0.18</td>
<td>1380</td>
<td>1000</td>
</tr>
<tr>
<td>Melting</td>
<td>56</td>
<td>6800</td>
<td>450</td>
</tr>
<tr>
<td>Cooper</td>
<td>400</td>
<td>8900</td>
<td>390</td>
</tr>
<tr>
<td>Frames</td>
<td>36</td>
<td>7800</td>
<td>473</td>
</tr>
<tr>
<td>Concrete</td>
<td>1.73</td>
<td>2200</td>
<td>837</td>
</tr>
<tr>
<td>Water</td>
<td>0.589</td>
<td>999.045</td>
<td>4180</td>
</tr>
</tbody>
</table>
the other faces are thermally isolated \((Q = 0)\).
Effect of the material nature

Pipe filled with water (Melting. PVC and Coper)

Thermographic images and temperature spatial evolution of pipes filled with water
Effect of the material nature

Empty pipe (Melting. PVC and Coper)

Thermographic images and temperature spatial evolution of empty pipes
Effect of pipe diameter

Structure of the model

- d1 = 36 mm
- d2 = 24 mm
- d3 = 16 mm
Effect of pipe diameter

Cast Iron

Thermographic images and temperature changes under the effect of pipe diameter cast iron
Effect of pipe diameter

PVC

Thermographic images and temperature changes under the diameter effect of PVC pipe
Effect of pipe position

Structure of the model

\[ h_1 = 50\text{mm} \]
\[ h_2 = 60\text{mm} \]
\[ h_3 = 70\text{mm} \]
Effect of pipe position

Iron pipes

Thermographic image and temperature changes due to the iron pipes position
**Effect of pipe position**

- PVC pipes

Thermographic image and temperature changes due to the PVC pipe position
## Effect of pipe position

### Temperature difference as a function of position

<table>
<thead>
<tr>
<th>Material</th>
<th>Position (mm)</th>
<th>$\Delta T$ (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PVC</td>
<td>h1</td>
<td>0.24</td>
</tr>
<tr>
<td></td>
<td>h2</td>
<td>0.14</td>
</tr>
<tr>
<td></td>
<td>h3</td>
<td>0.12</td>
</tr>
<tr>
<td>Fonte</td>
<td>h1</td>
<td>-0.18</td>
</tr>
<tr>
<td></td>
<td>h2</td>
<td>-0.16</td>
</tr>
<tr>
<td></td>
<td>h3</td>
<td>-0.13</td>
</tr>
</tbody>
</table>
Application to the iron bar Identification in reinforced concrete

Temperature difference as a function of position

Thermographic image and temperature evolution of reinforced concrete
Temperature difference depending on the diameter of the bars

<table>
<thead>
<tr>
<th>Material</th>
<th>Position (mm)</th>
<th>ΔT (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ø 6</td>
<td>5</td>
<td>-0.09</td>
</tr>
<tr>
<td>Ø 8</td>
<td>5</td>
<td>-0.14</td>
</tr>
<tr>
<td>Ø 10</td>
<td></td>
<td>-0.22</td>
</tr>
</tbody>
</table>
• The detectability of pipes is relatively simple in the case of empty ones.

• The detectability of pipes or iron bars in concrete wall is relatively simple for pipes and bars having a large diameter.

• The closest pipes or iron bars to the input face are easier to detect than those located more away.


[3] https://www.google.com/?gws_rd=ssl#q=infrared+thermography+applications +for+building+investigation


[8] S.Belattar« Notion d’impédance thermique appliquée à la caractérisation et au contrôle non destructif des systèmes ». Thèse de doctorat, Université de des sciences et technologies de Lille, 1992, France
Thank you for your attention