Quarterly Report #1

Development of Hand-held Thermographic Inspection Technologies
RI06-038

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End Date: February 28, 2009

Summary of Accomplishments and Activities

The project was initiated this quarter, and to date the focus of the efforts have been on Task 1, *Preliminary Study Development*. During this task, several subtasks have been underway to develop the foundation for the project, and these tasks are summarized below.

1. Development of Field Data Acquisition System

The field data acquisition system to be developed to assist inspector in determining the weather conditions at the time of testing, and to store images taken in the field, is being developed. Activities to date have focused on identifying the requirements for the field device, and developing a scope of software and integration activities that will be required to develop the desired capabilities.

An important feature of the thermographic methods being developed in this study is to make available to the inspector the weather data for his/her location over the previous two weeks. The weather data is collected from the National Climatic Data Centre (www.ncdc.noaa.gov/) (purchases→ Most popular→Quality controlled local climatological data). From this website we can access the past weather data for a given location, but the data lags by 12 hours. This website provides weather data which includes dry temperature, wet temperature, relative humidity, wind, etc,. The data is collected from weather stations located primarily at airports, where weather stations collect data and submit that data to NCDC database. This data will provide historical weather data that will show the trends in warming/cooling for a given location over the most recent two week period.

The data for the most recent 12 hours of weather reported from various weather stations is available as live content on the website of the National Weather service. This data is provided as web content, and access to the data in a more suitable format for inclusion in developed software is being investigated.

2. Procurement of Cameras

A site visit was arranged with the camera manufacturer, FLIR, to review there product line and determine which cameras would best fit the research project. During this visit, the heads-up display that can be used with the field camera was tested, and appears to provide a suitable display for field applications. A photo is included in figure 1 showing the heads-up display mounted on safety glasses. The display will help the inspector to view the data, particularly in direct sunlight that obscure the display mounted on the cameras.

Cameras manufactured by Jenoptik and Infrared Cameras, Inc. were also reviewed as possible solutions. However, these manufacturers do not provide matching hardware in terms of spatial resolution of the detector array as the FLIR cameras that are being

Figure 1. Hand-held thermographic camera with heads-up display mounted on safety glasses.

ordered as part of this project. These cameras may provide a suitable option once methods and procedures have been fully defined through the project. The ToughCam, manufactured by Infrared Cameras, Inc. is a ruggedized hand-held camera that is low in cost, approximately $10,000, but has a lower resolution detector array than the camera produced by FLIR.

The laboratory camera and a single hand-held field camera have been ordered from the manufacturer (FLIR). Additional cameras that will be utilized for the field testing portion of the study will be ordered later, when it is anticipated that the cameras will be available with an integrated digital camera, which is not currently available.

3. Test Block

As part of the project, a concrete test block with embedded, simulated defects is to be constructed for studying long-term temperature trends. The initial design of this test block has been completed. Two materials are being considered for the simulating the embedded defects, polystyrene and polyethylene. These materials have been used in the past, as they have a thermal conductivity close to air, and as such will provide a simulation of an embedded, horizontal crack (delamination). Experience has shown that these types of materials provide thermal contrast, though this is generally greater than a realistic defect. A schematic diagram of the test block is shown in figure 2. The test block will contain simulated defects at different depths relative to the surface of the block

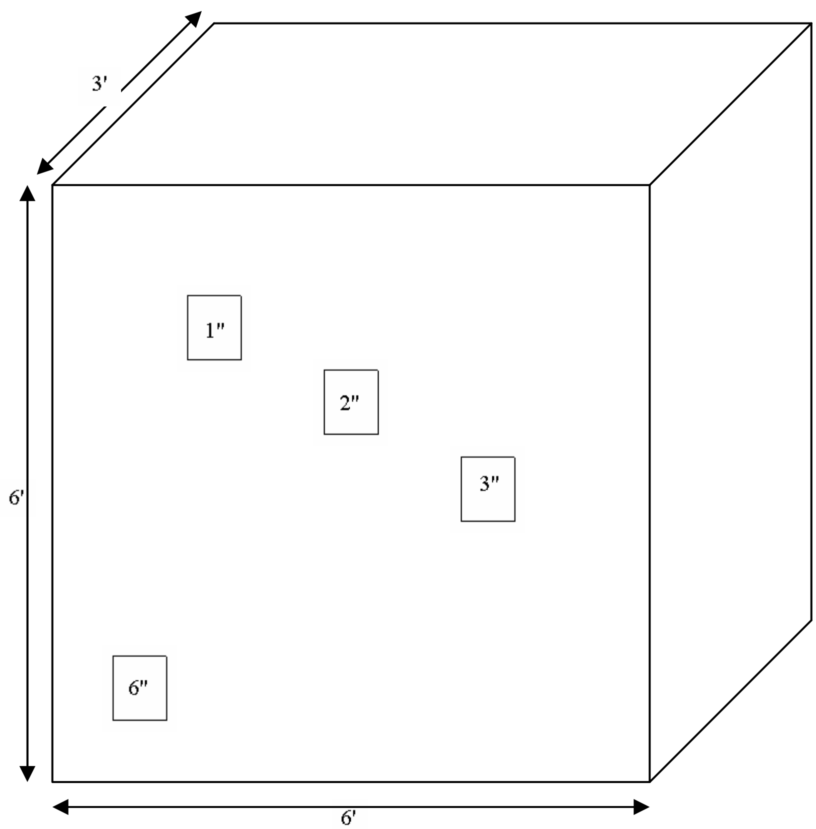

Figure 2. Schematic diagram of the test block to be constructed with simulated defects at different depths from the surface.

as shown in the diagram. This will allow for the evaluation of the effect of depth to the defect on the ability of the thermal camera to image the thermal contrast created. Defects will be implanted on five sides of the block to allow for evaluation of different exposure to direct sunlight.

The location for the test block has been selected at an off-site research park that is currently used by the geotechnical engineering group here at MU. This location is about 10 minutes driving from the MU campus, and is essentially an open field with a couple of utility buildings. This will provide a location where the block can be constructed in an open field, without the complications that would be encountered with nearby constructions. There is electric power at the site already, such that the camera can easily be operated manually over the long term. A design for a suitable enclosure for the IR camera that will enable the camera to be left in place for extended periods of time are in development.

4. Initial Testing

Initial testing has been conducted to explore the fundamental processes and develop experience using the IR cameras. Several tests have been run using the columns on the MU campus as a test subject that is conveniently located for developmental testing. One test that was run during the first quarter involved observing a known defect in the column, that could be located using the sounding method. This defect is a delaminated section of material that has a delamination approximately 2-3" deep. Observations of the defect were made over a hourly over 36 hour period, to examine the effect of longer-term weather conditions on the thermal contrast at the surface. The temperatures and relative humidity for the 36 hour period are shown in figure 3. This data was obtained from the NCDC database following the tests. Thermal images were captured hourly over this time period, throughout the day and night. Example data from the test are presented in Figure 4. This image was taken at 11:55 pm, which follows a morning of temperature increase from approximately 15 ºC to 24 ºC. The area of interest, where the delamination is located, is encircled in the image. The columns are not an ideal test subject, because the columns are round such that only a small portion of the surface area in normal to the camera. The columns also have many facets and architectural details that create anomalies in the images. However, challenges of this type are realistic for application of the technology to bridges.

5. Issues or Problems that need to be addressed.

There are two issues that have arisen since the project was initiated. First, the personnel identified as capable of integrating the field data acquisition system for the project has left MU. As a result, another resource for performing this task needs to be identified. The current thinking is that a resource outside the University system might be best qualified to perform this work. The necessary scope of work that needs to be performed to complete the development of the field data acquisition device is being developed by the project team, with the expectation that this scope of work will provide the foundation for identifying another resource to complete this work.

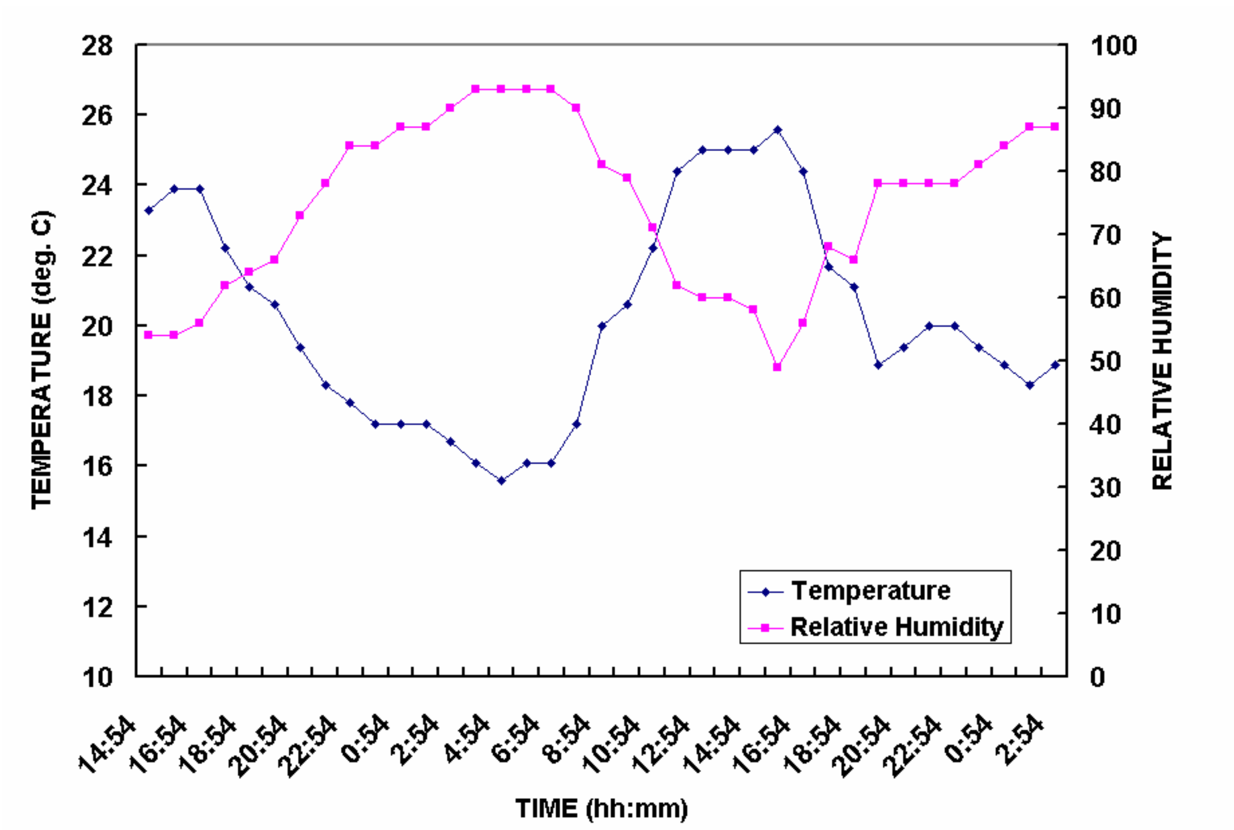

Figure 3. Temperature and humidity changes at the MU campus over the 36 hour period of initial testing.

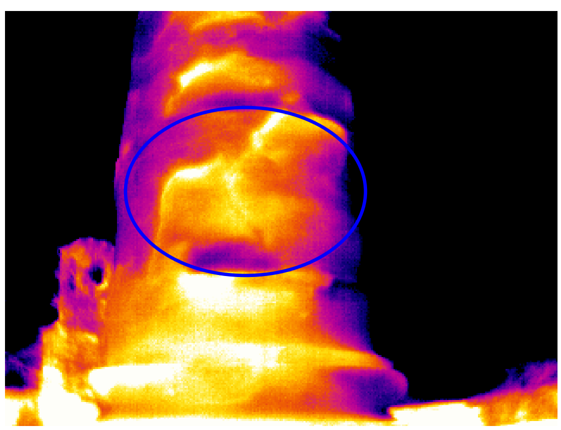

Figure 4. Example image from the 36 hr test (12:55 pm).

The second issue that has arisen is that the matching funds from the University Transportation Center (UTC) at the University of Missouri – Rolla are not yet available. This is due to delays in receiving administrative approval from USDOT for the strategic plan for the UTC. This approval is anticipated in the near future (in the next 60 days) and close contact is being maintained with the UTC to ensure that funding is provided to the project as quickly as possible. At the present time, this delay in funding is not expected to affect the project. Schedule

Schedule

The overall project schedule is shown below. At the present time, the project is at the end of the first quarter and on schedule.

		Months (Beginning February 1, 2007)																							
	Tasks	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J
1	Preliminary Study Development	■	■	X	■	■	■																		
2	Controlled Testing of Concrete Specimen							■	■	■	■	■	■	■	■	■	■	■	■						
3	Operational Testing										■	■	■	■	■	■	■	■	■	■	■	■			
4	Final Report																			■	■	■	■	■	■

% of Budget Expended: 25%