Ground Penetrating Radar (GPR) & Infrared Thermography (IRT) Inspection of Thirty-Six Bridge Decks in Seven Counties throughout Missouri

1. Objective
Penetradar Corporation conducted a ground penetrating radar (GPR) and infrared thermographic (IRT) inspection of thirty-six bridge decks in Missouri. The objectives were to provide an up-to-date assessment of the physical condition of the concrete decks, including the overall quantity of corrosion induced deteriorated concrete within the bridges and identification of locations where repairs may be required. The survey was conducted for the Missouri Department of Transportation.

2. Equipment
For this inspection two non-contacting, nondestructive test methods were utilized: Ground Penetrating Radar (GPR) and Infrared Thermography (IRT). The Integrated Radar Inspection System (IRIS), a vehicular based GPR inspection system installed with an array of one-nanosecond (1GHz), air-coupled (non-contacting) antennas, was used for the GPR tests. The Penetradar IRIS GPR equipment was developed under the Strategic Highway Research Program (SHRP) for the nondestructive evaluation of bridges and roadways, (see link - SHRP-S-325). Penetradar’s ThermaMap infrared thermographic bridge deck inspection system was used for the IRT deck inspection (shown combined with GPR in Figure 1.) Both the IRIS and ThermaMap systems are capable of high-speed inspection and quantitative assessment of bridge deck condition.

3. Data Collection & Analysis: GPR
The IRIS bridge deck inspection system was installed in a specially designed vehicle equipped with an array of GPR antennas and consists of a computer based data acquisition subsystem used for digital data collection and processing of radar signals. Delaminated and deteriorated concrete are detected by the IRIS GPR system and data analysis is performed by computer automated and computer assisted signal processing software that determines the quantities and location of deteriorated bridge deck concrete. The radar survey provides the information necessary to accurately estimate concrete repair quantities and includes plan-view, scale-sized maps of the deck, graphically showing locations and extent of detected deterioration.

The deterioration maps produced by this survey, show areas that are considered delaminated but in addition, include areas of probable or incipient delamination. These are areas of the concrete deck that may contain high chloride, moisture, and/or corroded reinforcing steel, i.e. the basic prerequisites to future delaminated concrete. Areas of incipient delamination, although possibly not currently delaminated, are typically taken into consideration when developing an overall deck repair strategy. The GPR bridge deck inspection technology and into consideration when developing an overall deck repair strategy. The GPR bridge deck inspection technology and methodology, including signal analysis utilized for this project were developed...
by Penetradar Corporation as part of the Strategic Highway Research Program (SHRP) project C-101.

**Figure 3.**
Plan-view output from Penetradar’s software showing GPR & IRT detections of probable delaminations overlaid on the same map for comparison.

**Figure 4.**
View of full lane capture using infrared camera showing potential delaminations in one-point perspective

**Figure 5.**
Plan-view (raw data) output from Penetradar’s ThermaMap IRT processing converting one-point perspective video into a fully scaled top-view thermal image of the bridge deck

**4. Data Collection & Analysis: IRT**

The method utilized for this project represents leading-edge technology developed by Penetradar Corporation for IRT and video surface mapping of pavements and bridge decks. Our technology represents a significant improvement over conventional IRT techniques which utilize lower resolution imaging and typically rely on manual interpretation of one-point perspective IRT images.

Our technique addresses these problems by utilizing specially developed video editing software to remove the oblique (one-point) perspective and to enhance detected thermal anomalies occurring within the concrete deck. The resulting thermal image that results from our method is a direct Windows bitmap format file, created from an “ensemble” of video lines based upon distance, which when assembled together produce a correctly scaled, plan-view image of the bridge deck. The size, dimensions and location of thermal anomalies are accurately preserved with our technique, thereby removing much of the subjectivity and errors that are inherent with older analysis methods. This translates into more accurate and reliable IRT inspections.

**5. Results**

The GPR & IRT data acquired during the survey were processed at Penetradar Corporation utilizing computer based signal processing hardware and software. This provided accurate and objective location and quantity estimates of deteriorated concrete. Results of the survey were presented as plan-view maps of the deck area showing the location and spatial extent of the detections and as a percent of deck area. Overall repair quantities (Type 2 repairs) were also provided for each bridge deck, which were based upon delamination detections from the GPR and IRT surveys. These results were determined by “squaring off” the total delaminations detected by the GPR & IRT to represent the area typically removed during deck rehabilitation.