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Route 130 Bridge Snowfree Installation Electrical Analysis and Recommendations

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16. Abstract

Results of an experimental investigation on the properties of a snowfree installation for a bridge deck are reported. The New Jersey Department of Transportation has contracted the Superior Graphite Company to provide a heated pavement system for a small bridge on Route 130 in South New Jersey. The system uses synthetic graphite to make the asphalt conductive so that when electrical power is applied the pavement will dissipate heat to melt snow and ice. The initial installation was unsuccessful and the main objective of this proposal is to provide support to eliminate or mitigate the problems of the initial installation. The recommendation concerning construction and material procedures will be employed in the installation of an improved system which could potentially serve as a model for future heated pavement systems.

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OBJECTIVE

The New Jersey Department of Transportation has contracted the Superior Graphite Company to provide a heated pavement system for a small bridge on Route 130 in South New Jersey. The system uses synthetic graphite to make the asphalt conductive so that when electrical power is applied the pavement will dissipate heat to melt snow and ice. The initial installation was unsuccessful and the main objective of this proposal is to analyze, reevaluate, and reengineer the construction and material procedures and then to provide support to eliminate or mitigate the problems of the initial installation. The recommendations concerning construction and material procedures will be employed in the installation of an improved system which could potentially serve as a model for future heated pavement systems.

PROJECT TASKS

The proposed system support consists of two phases. The first phase dealt with the existing structure and had two principle tasks: 1) analytical study and 2) recommendations. The second phase will deal with the reapplication of the conductive paving material and has two principle tasks: 1) field-testing and evaluation and 2) recommendations. A detailed description of each task is as follows:

PHASE ONE:

The present heated pavement system consists of a base layer of insulating asphalt upon which the cables are placed and over which the layer of conductive asphalt and a second insulating layer are placed. The high power operation of the system, which demands a total power input of nearly 350,000 watts, requires the employment of a three-phase power system. A single three-phase network consists of three sinusoidal voltage sources whose voltages are equal in both magnitude (115 volts in the present system) and frequency, while differing by 120 degrees in phase. The presence of neutral conductors that are grounded is essential to the proper operation of the heated pavement system. The present system functions by employing two three-phase networks, each controlled by a central control system, to induce current in the conductive pavement as shown in the cross-section depicted in Figure 1.

The system was theoretically designed to provide that each section be equivalent in terms of dimensions and resistivity, resulting in a balanced electrical load and the uniform dissipation of heat throughout the asphalt. Despite these intentions, the actual operation of the system fails to produce the uniform dissipation of heat necessary to effectively prevent the accumulation of wintry precipitation. A detailed electrical analysis of the system was conducted to determine the problems of the initial installation and provide recommendations for improvements to the system. The electrical analysis included a detailed study of the materials used to make up the conductive pavement, in order to determine the principle factors influencing the resistivity. Furthermore, data taken from measurements of asphalt core samples was studied and compared to resistivity charts to ascertain the possible causes of the inconsistent cable currents. An analysis of the control circuit was performed to determine precisely how the circuit contributed to the overall system performance.

To supplement the data necessary for a thorough electrical analysis, the load resistance from each main bus cable to ground was obtained by implementing the four-point probe technique for accurately measuring small resistances. The four-point probe procedure initially requires the series application of a constant current source and an ammeter to the load whose resistance is being determined. The result is the establishment of a constant current through the load whose value can be monitored with the ammeter. A voltmeter is then employed to attain the voltage dropped across the load for the constant current being applied, and the resistance is determined with the basic equation Resistance = Voltage / Current. The mean load resistance of the present system was determined by four-point probe procedure, which is portrayed in Figure 2, to be approximately one ohm. The actual load resistance values are recorded in Figure 3, which shows the voltage and current measurements obtained for each individual cable, and the resulting load resistances.

The load resistance values shown in Figure 3 are inconsistent and differ significantly from the resistance necessary for proper operation of the system, indicating the importance of alterations to the current system. The following recommendations arise as a result of the field studies, analysis of the load resistance measurements and core samples, and correspondence with DOT technical staff:

1. The first recommendation is to measure the current consumption of each live wire in order to determine the extent to which it has degraded over the two years since the system was installed. This will provide some indication as to the potential lifetime of the current system, as well as some insight into the length of time any SNOWFREE system will remain effective before it requires some form of maintenance or possibly replacement.

2. A second recommendation is to alter the conductive asphalt production process to alleviate the problem of the inconsistent resistivity due to an inconsistent asphalt mixture. In order to ensure proper operation of the SNOWFREE system, the asphalt must contain the specified amount of graphite. Instead of opening the bags of graphite and dumping the graphite directly onto the conveyor belt, which results in an insufficient amount of the required graphite reaching the asphalt mixture, the bags should be placed on the conveyor belt without opening them. As the bags of graphite enter the asphalt mixture the bags will quickly dissolve, ensuring that the proper amount of graphite reaches the mixture. The resulting improvement in the consistency of the asphalt mixture should provide increased consistency in the cable currents and uniform heat sufficient to prevent the accumulation of snow and ice on the roadway.

3. The third recommendation calls for a minor change in the present layering of the asphalt and cables. An insulating layer of asphalt currently serves as the base layer upon which the cables are place. The cables are then covered by a conductive layer of asphalt, which is in turn coated with an insulating layer of asphalt. The recommended change is the addition of a second conductive layer of asphalt above the insulating base layer and below the cables. Layering conductive asphalt below the cables, in addition to the original layer above the cables, will produce a considerably ameliorated contact and therefore more consistent cable

currents. The final result should be a significant improvement in the overall quality of operation of the system.

4. The fourth recommendation involves a change in the type of cables currently being utilized in the heated pavement system. With the round cables it is extremely difficult to establish a good connection between the wiring and the conductive asphalt. Assuming a proper connection could initially be established, the asphalt surrounding the wires can potentially crumble, eventually resulting in a poor connection and a subsequent decrease in the effectiveness of the system. A simple solution to this problem is to replace the round cables with flatter ribbon cables. The ribbon cables will adhere to the conductive asphalt better and will substantially reduce the probability of crumbling around the cable. The result will be the improved connection required to disseminate the correct amount of heat to ensure proper operation of the SNOWFREE system.

5. The final recommendation, already employed in studying the present system, is the use of the four-point probe technique for accurately measuring small resistances. Following the construction of the improved SNOWFREE system, the four-point probe technique should be employed to verify that the recommended alterations to the system have indeed resulted in the correct load resistances.

PHASE TWO:

During the reconstruction of the system, routine visits to the site will be performed to evaluate the procedure and to measure resistance values as the layers of pavement are applied. Additional four-point probe resistance measurements will be performed to determine the resistance of each of the main bus cables to ground, and an inspection of the road surface will be done to look for potential problems. Following the field testing the technical support will include an evaluation of the overall performance of the improved heated pavement system. The desired values will be compared to measurements to determine whether the proper resistivity was obtained and the system is drawing the specified current. These results will assist in the final electrical analysis of the improved structure and will provide a solid foundation for recommendations for future projects involving heated pavement systems.

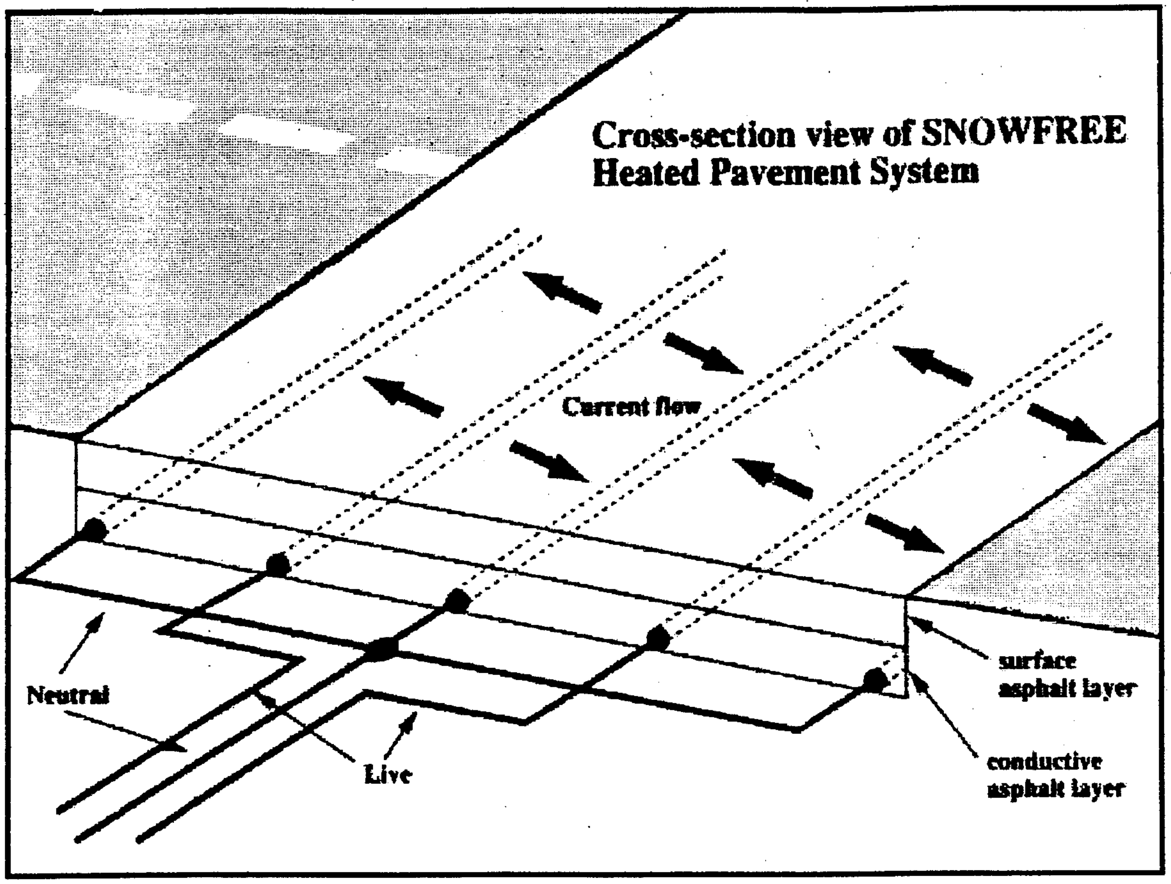

Figure 1: Cross-section view

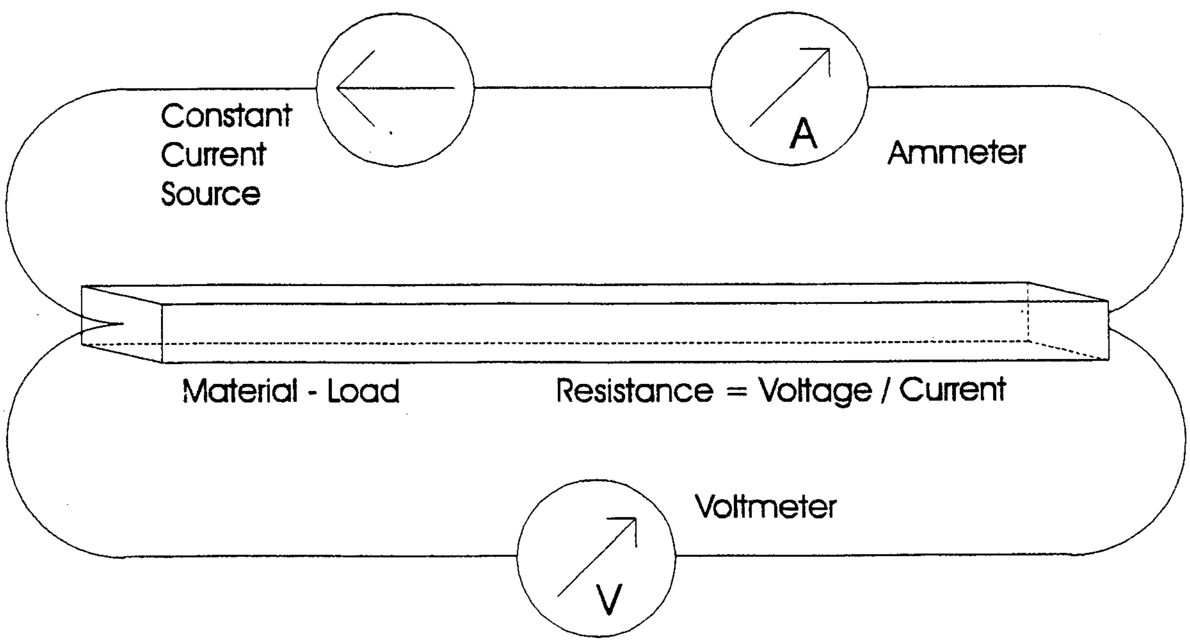

Figure 2: Four-point probe procedure

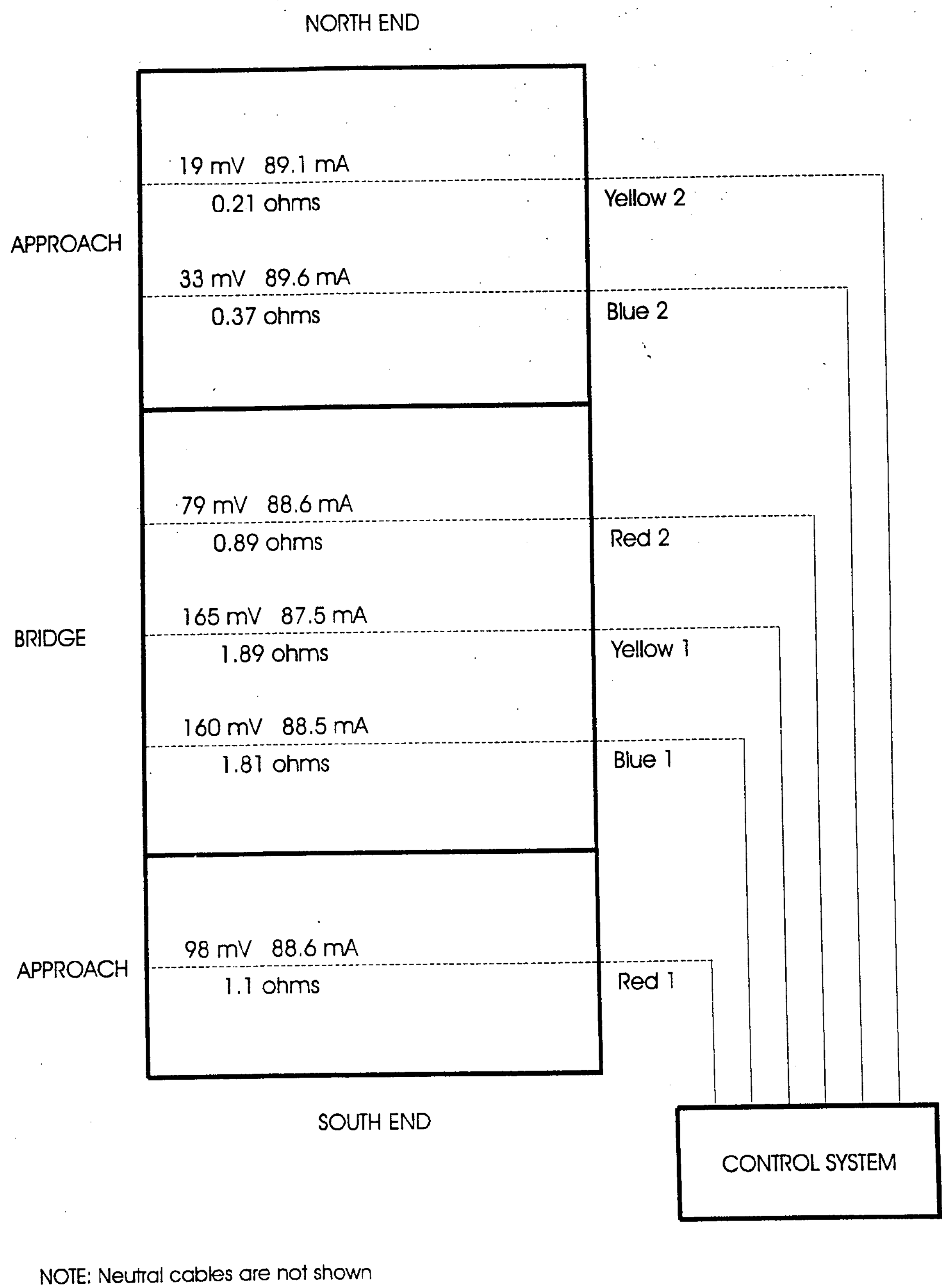

Figure 3: Load resistance measurements using four-point probe