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Identification of Pathologies in Bridges Using Infrared Thermography

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ABSTRACT
The bridges are essential for the development of cities. To maintain the appropriate safety standard for its functionality, routine inspections are necessary to check the parts that need maintenance. Currently, these inspections are carried out visually and through resistance and durability tests. Despite this, it is observed that some regions cannot be detected during the common visual inspection. Thus, this research aims to perform the inspection of a bridge using the technique of infrared thermography. The inspection was carried out in the morning, without rain and with parameters set so as not to interfere with the results of the analysis. Considering the refraction of the positive and negative heat observed in the inspections carried out in the morning, it was possible to point out the existence of humidity in the verified areas, which was confirmed through visual inspection. In the presence of cracks, it was possible to detect the existence of moisture inside them. Thus, it is possible to conclude that the use of infrared thermography is a very promising technique for the inspection of bridges.

Keywords – Bridges, Durability, Infrared thermography, Inspections.

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I. INTRODUCTION

In civil engineering, the term pathology is used to study the manifestations that are presented, the reason for their origins and whether such defects alter the structural and visual aspect of a building. Pathologies are part of the different buildings present in the world. As an example, it is possible to mention apparent humidity, fissures and detachment of coatings. Currently, it is rare to see a structure that has never had any pathology [1].

According to [2], there is a need to inspect bridges to reduce pathological manifestations and increase the useful life of the structure. Three are the basic activities mobilized to guarantee the satisfactory performance of a structure and, in particular, of bridges: design, construction and maintenance.

In order to guarantee a longer useful life and satisfactory structural and functional performances, periodic and adequate maintenance is essential. They are part of a management process through continuous inspections, enabling the study and indicating recovery actions [3].

Carrying out inspections of structures as a preventive measure, whether in buildings or bridges, increases the useful life of the system. Late and unplanned repairs promote excessive spending, which can be avoided by corrective actions before the onset or as soon as the pathology appears.

To assist professionals in carrying out these inspections, the main normative texts used today in Brazil are the standards ABNT NBR 9452 [4] and DNIT 010 [5]. Through these standards, it is possible to increase the service life of existing bridges. Currently, to perform these inspections is done visually and with the help of equipment such as a fissurometer, in addition to conducting tests to check the carbonation and strength of the concrete.

Pathological problems usually have a characteristic external manifestation. From it, it is possible to deduce the nature, origin and mechanisms of the phenomena involved, as well as to estimate their probable consequences [6]. Despite this, the human eye is not always able to detect all the faults in a structure, and it is necessary to seek new techniques to ensure greater precision in inspections.

Using advanced techniques and with greater precision in inspections, it is possible to detail the real conditions of the structure and the need for repairs.

Infrared thermography is a promising technique that is based on the visualization of infrared radiation emitted with intensity proportional to the temperature, being a non-destructive technique. Through this technique, it is possible to identify where the temperature is altered in relation to a pre-established pattern. The thermography technique is based on the measurement of electromagnetic radiation transmitted at a temperature above 0°C [7].

An indication of the existence of problems in civil construction is the temperature variation from 1°C to 2°C. Starting at 4°C, it is possible to affirm the existence of an abnormality in the system under analysis [8-9].

Cracks are better identified during the day, as there is a reduction in surface temperature in this region, with the evaporation of water. Likewise, in the period of positive heat flow, the presence of moisture in masonry and concrete structures is easily identifiable due to capillarity [10].

The manifestation of cracks is an indication that the structure loses its durability and the level of safety, compromising its use both in reducing its useful life and impairing its functioning and aesthetics, which may cause the corrosion of the reinforcements when they are in contact with aggressive environment [11].

In view of the above and the real need to use new techniques to increase the safety and useful life of structures, this article aims to identify pathological manifestations on a bridge using infrared thermography.

II. METHODOLOGY

To carry out the research, an infrared camera (termovisor) FLIR T440 was used. The camera's customizable calibration parameters consist of emissivity, ambient temperature, reflected temperature, relative humidity and distance to the object. The main technical specifications of the equipment are shown in table 1.

Table 1: Specification of the infrared camera.

Specification	-
IR Resolution	320 X 240 pixels
Digital Camera Resolution	7,6 Mp
Heat sensitivity	< 0,045°C a 30°C
Precision	+ - 2°C ou + - 2% of reading
Temperature range	- 20°C to 1200°C
Field of vision	25°
Focus	Manual/Automatic
Color display	3,5” (320 x 240)
Frame Rate	60 Hz
File format (Thermogram)	Radiometric JPG

A qualitative study was carried out with the help of a thermal camera on a bridge located in the city of Brasilia, Federal District, Brazil. The inspection was carried out in the morning to identify temperature gradients in different regions of the bridge. The standard emissivity of the concrete (ε=0.95), ambient temperature (25°C) and relative air humidity (70%) configured in the equipment were used as parameters, in addition to the measurement distance set at 6 meters in all analyzes. During the inspection, the climatic conditions were stable, with no rain and no wind.

III. RESULTS AND DISCUSSION

The Fig. 1 shows photos taken with the thermographic camera on the sides of the bridge.

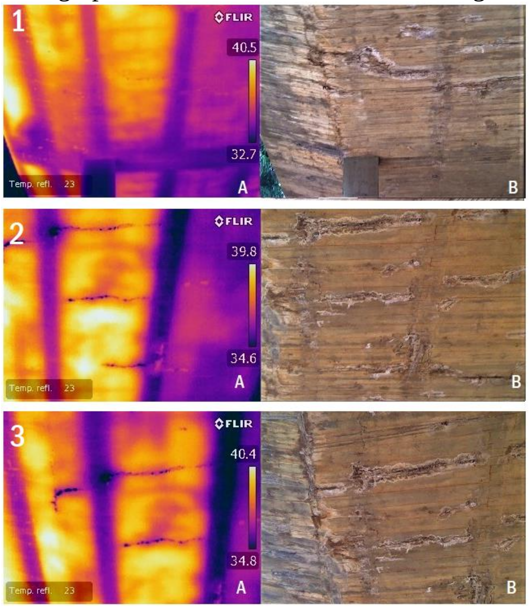

Figure 1: A) Thermographic photo of the sides of the bridge; B) Original photo of the sides of the bridge.

Through infrared thermography, it was possible to observe that in some of these regions the flaws may be evolving to greater damage to the structure, evidenced by the different coloring obtained in the thermogram. It is also possible to observe, through the images, points that show signs of carbonation.

Where the purple colors are most evident, they are very flawed areas subject to imminent displacement of the concrete. One of the causes of this displacement is the failure to maintain the bridge.

The corrosion found in the system is an evolutionary process, that is, over time it gets worse. In order to guarantee structural security, security measures cannot be taken too late.

Fig. 2 shows pictures taken with the thermographic camera from the center of the bridge. It is possible to observe the presence of cracks and cracks with moisture due to the darker colors in the thermographic photos.

Through the cracks, water (H_2O) enters the concrete structure, along with carbon dioxide (CO_2). When the frame comes into contact with these two elements, the corrosion process begins. When reinforcement corrodes, it expands within the concrete structure. With the expansion of reinforcement, the concrete structure cracks and consequently generates the detachment of pieces of concrete.

Anomalies compromise the building's durability. If they are not treated as a matter of urgency, they may compromise the stability of the structure, affecting the safety of the construction and generating risks to the integrity of the users. When the reinforcement loses section, it no longer supports the efforts initially planned in the project.

The concrete debonding (disaggregation) is the physical separation of it into slices, so that the structure ends up losing its capacity resistant to efforts in the disaggregated region.

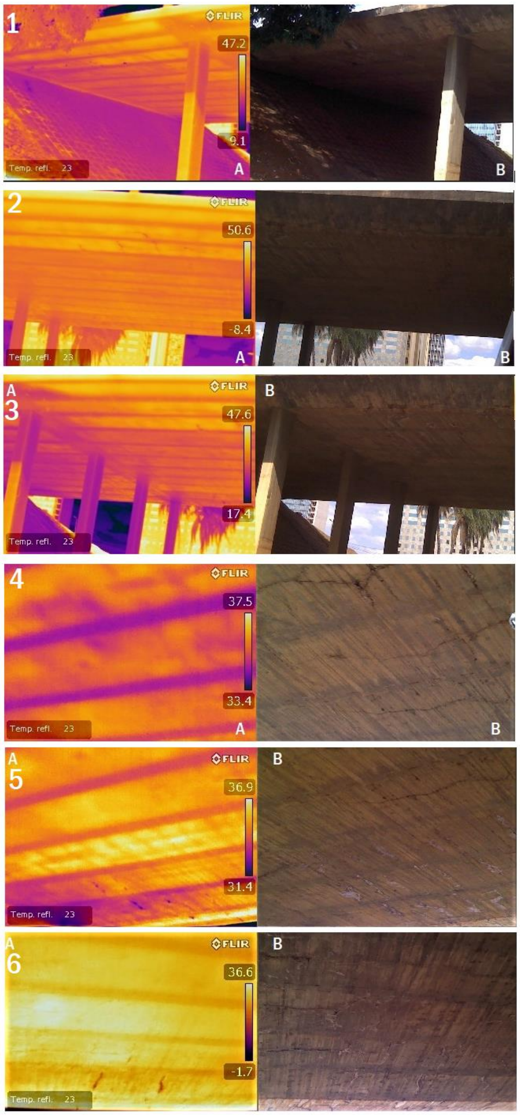

Figure 2: A) Thermographic photo of the center of the bridge; B) Original photo of the center of the bridge.

The Fig. 3 shows photos taken with the thermal camera of the end of the bridge.

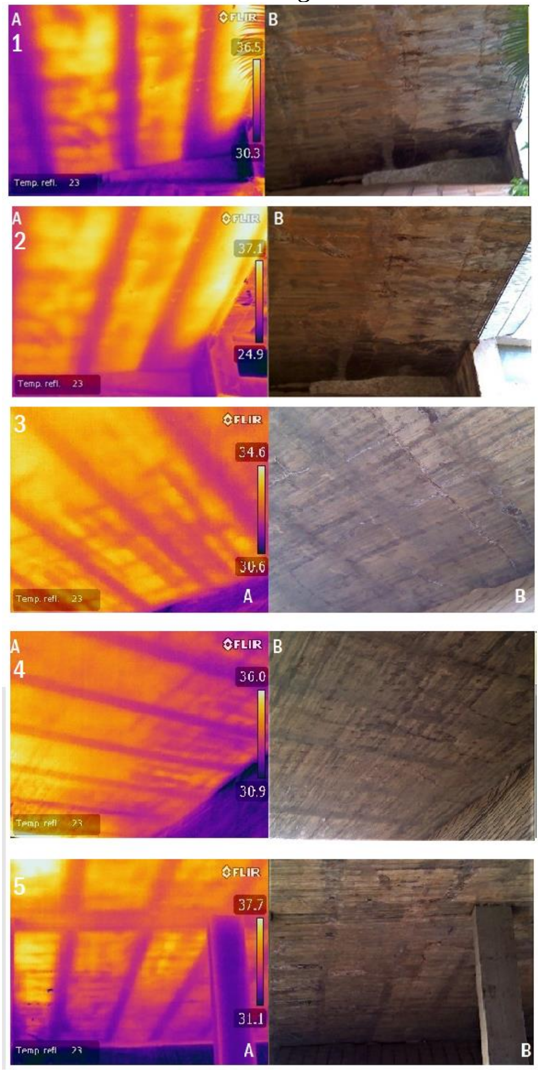

Figure 3: A) Thermographic photo of the end of the bridge; B) Original photo of the end of the bridge.

It is possible to observe in Fig. 3 an advanced state of reinforcement corrosion along the bridge, in areas that have moisture and infiltrations, causing concrete to crack.

Fig. 4 presents photos taken with the thermographic camera of the bridge pillars. It can be seen that the bridge has no water seeping on its pillars. Analyzing the thermographic photos, the pillars do not show color variation in the thermography images, but a constant color in the incidence of heat, i.e., they do not have cracks with percolation of fluid along their structure.

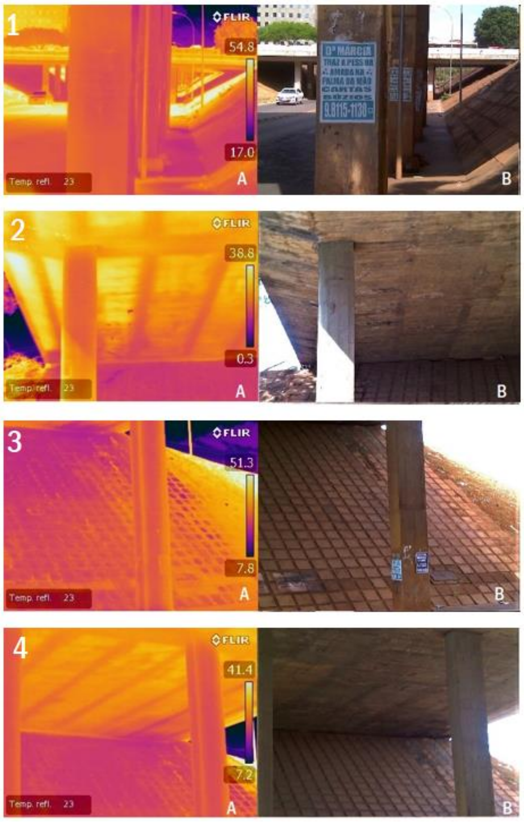

Figure 4: A) Thermographic photo of the bridge pillars; B) Original photo of the bridge pillars.

Considering the refraction of the positive and negative heat observed in the inspections carried out in the morning, it was possible to point out the existence of humidity in the verified regions, which was confirmed through visual inspection. In the presence of cracks, it was possible to detect the existence of moisture inside them.

IV. CONCLUSION

Through this research, it was possible to conclude that the infrared thermography technique is efficient for the inspection of bridges. Through the variation of heat in certain visible areas, it was possible to identify cracks with the presence of water, in which the existence of efflorescences, carbonation, corrosion of the steel in the reinforcement and concrete detachment.

The ability to analyze technical anomalies linked to pathologies through infrared thermography facilitates the inspection process and allows the areas that should pay greater attention to careful investigations to be characterized. On the other hand, erroneous conclusions can be taken the inspections, external interferences and environmental conditions in which images are obtained. In order for this not to happen, the experience with the use of the equipment, the theoretical background and the characteristics of the pathological manifestations are of paramount importance to obtain adequate subsidies for its interpretation, making it possible to correctly point out its characteristics with the presented pathologies.

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