第Ⅰ部門　Temperature characteristics of steel bridges caused by solar radiation in Taiwan

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1. Introduction

Temperature change caused by solar radiation is a kind of short-term change, which is nonuniform in structure. Temperature stress caused by such kind of short-term floating value may cause component damage or even destruction, which buries an unpredictable risk for bridge safety[1]. Color of the bridges is an apparent factor that may cause different degrees of absorption to the sunlight.

Then, this study investigates the influence of solar radiation on the temperature of bridges and the difference of temperature variations among steel plates painted different colors under sunlight through two parts of field tests in Taiwan.

2. Research subjects

In the first test, to monitor the characteristics of temperature, a bridge with a span of 137m and width of 15m is selected as the target of measurement.

Fig.1 New Jiangbei Bridge Fig.2 Location of the bridge

The bridge painted white is called New Jiangbei Bridge(Fig.1), which is located in Xizhi District, New Taipei City. It goes across Keelung River and presents a general north-south trend(Fig.2).

For the second test, steel samples whose size is 75mm×150mm but painted in original, black, brown, red, blue, green, grey and white were placed horizontally and exposed to sunlight to measure temperature changes over the course of a day[2](Fig.3).

Fig.3 Steel samples

4. Measurement equipment and method

The surface temperature of the bridge structure was measured by infrared thermal camera(Fig.4). The UV level and solar irradiance were measured by 3 in 1 Illumination-Solar-UVA Meter(Fig.5). The environmental temperature, solar angle and azimuth angle were measured by a solar tester(Fig.6).

Fig.4 Thermal camera Fig.5 3 in 1 Meter Fig.6 Solar tester

Measurements were conducted to observe the surface temperature of the target bridge in November and December, 2018. The time of measurement was 9:30a.m. to 4:30p.m., depending on the specific conditions. The measurement interval was one hour.

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Seven measuring points (Fig.7) were set around and on the bridge to ensure that different structural components under direct sunlight and in the shadow were all measured.

For steel specimens, use a handheld data logger to measure the temperature. The measurement time is the same as the first part.

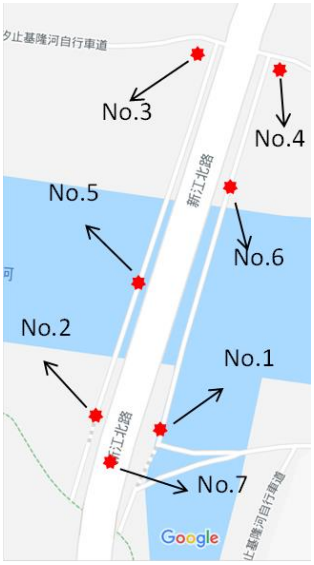

Fig.7 Location of measuring points

5. Result

According to infrared images, the difference in temperature distribution between components under direct sunlight and in shadow is able to be observed. In sunny days, the surface temperature of the bridge reaches its peak from 12:30 to 14:00.

Among all of the components, the highest temperature occurs on the upper surface of arch rib and diagonal bracing, which is about 38.6℃ (Fig.8). The maximum temperature difference of all the components occurs at the upper surface of the arch rib and the lower surface of the girder, which is about 14℃.

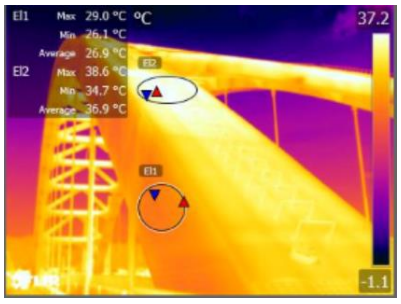

Fig.8 Thermal image of the arch rib

In a comparison test with another bridge next to the target bridge, the temperature of the bridge which is painted blue peaked at 40.2℃, and the maximum temperature difference of all components is 23℃, which is larger than that of the target one.

Table1 two groups of typical statistics of temperature

Date		Nov.21st	Dec.3rd
Time		1.30p.m.	12.00p.m.
Air Temperature		25.3℃	28.2℃
Weather		Cloudy	Sunny
Color	Original	33.4℃	54.6℃
	Black	33.6℃	54.9℃
	Brown	32.9℃	49.2℃
	Red	30.9℃	45.2℃
	Blue	31.8℃	45.9℃
	Green	30.9℃	51.3℃
	Grey	31.6℃	49.3℃
	White	29.2℃	36.6℃

For the experiment of steel specimens, as we can see from Table1, the direct sunlight has an obvious influence on the temperature on the steel sheets. The darker the color is, the more evident the result would be. If there is no direct sunlight, even it is still bright, the difference of temperature of steel sheets of all the colors is not very clear. The maximum of temperature difference is 18.3℃.

6. Conclusion

According to the measurement, the surface temperature rises under direct sunlight, which leads to a noticeable temperature difference between components. Besides, direct sunlight has an obvious influence on the temperature on the steel specimens and the temperature variation between different colors is huge.

Reference

1. Duan Fei: Research on the sunshine temperature field and temperature effects on long-span steel bridges[D], Southwest Jiaotong University, 2010.
2. 谷口望: 鋼橋の表面色の違いによる日射温度影響について，FCM に着目した橋梁の維持管理に関する講習会 （土木学会関西支部）, 2015