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The Temperature Effect to the Concrete Due to the Single Strike of High Electric Current

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Abstract. The protection against lightning had been increasingly used in the building to protect the building from the direct lightning impact. One of the methods is to embed the lightning protection cable in the concrete structure. The objective of this research is to investigate any changes of temperature during the lightning strike, which the lightning strike were stimulated by high electric current equipment. The high electric current were provided by high current equipment model Haefely P90.1 and flowed into the concrete cube. There are two method used in this research, by using Thermal Imager Camera Model FLUKE Ti20 to monitor the surface temperature and fiber thermocouple with Data logger model DATATAKER T80 to monitor the temperature in the concrete cube. As the result there are no drastically changes in temperature in both methods. The changes are very small and can be negliable. This is due to the duration of the high electric current strike is too short and not caused any changes in the temperature.

INTRODUCTION

Lightning is natural phenomena that cannot be prevented. The protection against lightning had been increasingly used in the building to protect the building from the direct lightning impact. This lightning can be one of natural cause of injuries to human or damage of the electrical equipment [1]. Malaysia including as country with highest thunderstorm days in the world [2]. It is recorded the country around the equotar received higher number of lightning activity including Africa, Sourthern Asia and South America. Therefore, lightning protection system was created in 20th century to reduce the damage of equipment, fire on structure or the safety of human life from direct lightning strikes [3]. Even though the occurrence of lightning cannot be prevent, the lightning protection system can provide a specific location for the lightning strike on the building by using air termination rods and provide the safe path on the electricity current from the lightning to be smoothly discharge to the earth [4]. As the overall function of the lightning protection system can be classified into several function such as provide the proper point for intercept the lightning strike and path for lightning lightning current to earth, to dissipate current into the earth and lastly to create an equipotential bond to prevent hazardous potential differences between LPS, structure and internal elements/circuits [5]. For the protection system concelaed in the concrete, the conductor cable were bind in the reinforcement bars before the concreting process and finally the cable were transfer the electricity current into the ground [6]. The objective of this research is to investigate any changes of temperature during the lightning strike to the concrete structures.

MATERIALS AND METHODS

Concrete Cube

The concrete were casted into mold size 150 x 150 x 150 mm. The grade of the concrete is G20 and the specimens were left for 24 hour for drying process and curing process was done for 28 days [7]. Four thermocouples were casted together in the mold at the location as shown in Figure 1 (a). The location of reinforcement bars and the Thermocouple 1 (T1) is 2 cm, Thermocouple 2 (T2) 2 cm and 3 cm for Thermocouple 3 (T3), Thermocouple 4 (T4) as shown in Figure 1 (b).

Figure 1 (a): Thermocouple casted into Concrete

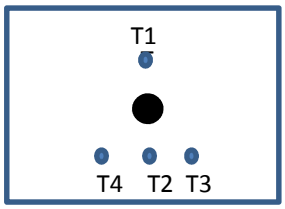

Figure 1 (b) : Location of thermocouple

High Current Test

The equipment used to provide the high electric current is the P-Surge model Haefely P90.1. And the concrete cube is connected with incoming current from the Haefely equipment and the others part is dissipate into ground. The high electric current used in this research is single strike current 12 kA, as stated in Specification For Lightning Protection System for Structures in Malaysia (L-S9) Revision 1 [8] the minimum current for lightning is 1.5 kA.

Temperature Test

The temperature tests have been done by collecting data for surface temperature and inside concrete temperature. Thermal Imager Camera model FLUKE Ti20 used to take the surface temperature before and after the electric current strike. For the temperature inside concrete, the thermocouples have been connected to the data logger model DATATAKER DT80 to collect the temperature data and the data can be monitored at computer.

RESULTS AND DISCUSSION

Surface Temperature

From Figure 2, it is shown that the result of surface temperature before the electric current strike and Figure 3 after he strike. From the result, the initial surface temperature surface in between lightning cable, reinforcement and concrete is in the range 20 °C until 21 °C. And the result after the strike is in the range of 21 °C until 22 °C. The increment recorded around 1 °C. However this minor increment is not because the strike, the 1 °C increment is due to the time exposure of the concrete surface during the duration to set-up of the test which resulted of the increment of the surface temperature. From the surface temperature test, it can be clarify that the temperature changes because of the strike is almost zero or cannot be measured because of the event of current strike is too short.

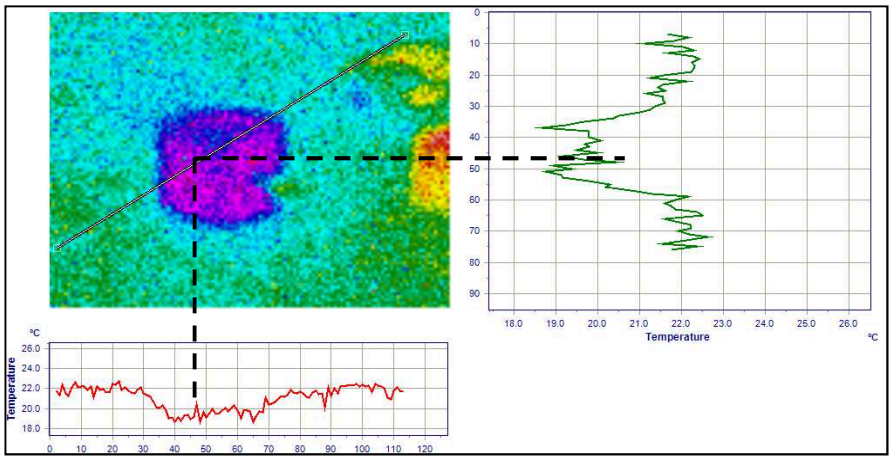

Figure 2 : Surface Temperature before high current strike

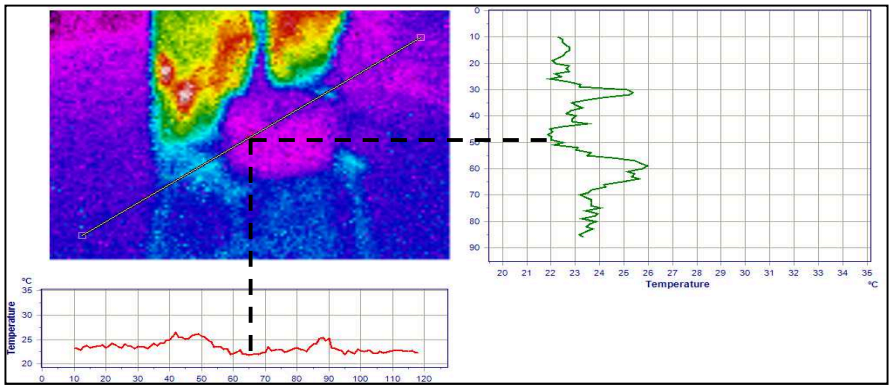

Figure 3 : Surface Temperature after high current strike

Inside Concrete Temperature

As the result from the thermocouples collected from the data logger are shown in Figure 4, 5 and 6. However the result for the thermocouple number 4 is invalid due to technical problem. The data logger has been set-up to collect the temperature data in the minimum time, in 0.2 second interval time. The electric current strike is set to occur after 4 second, so that any changes of temperature can be monitor after that time. The lines for the 4 second had been plotted in the graph for differentiate before and after electric current strike. For the individual Thermocouples record in Figure 4 for Thermocouple 1, Figure 5 for Thermocouple 2 and Figure 6 for Thermocouple 3, the initial temperature recorded is around 28.22 -28.3 °C and show increased pattern until 4 second. After the strike at 4 second, there are no sudden increments of temperature; the temperature is remaining in the same pattern, with the very small increment of temperature.

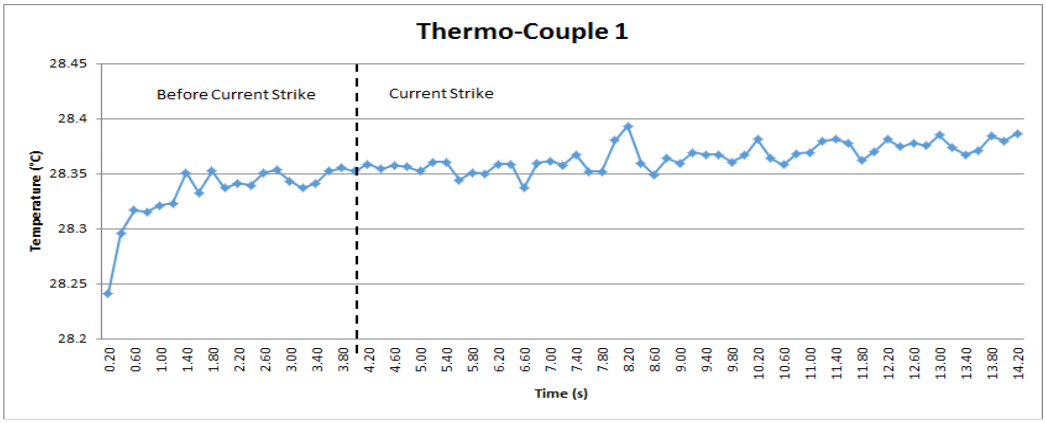

Figure 4 : Changes in Temperature for Thermocouple 1

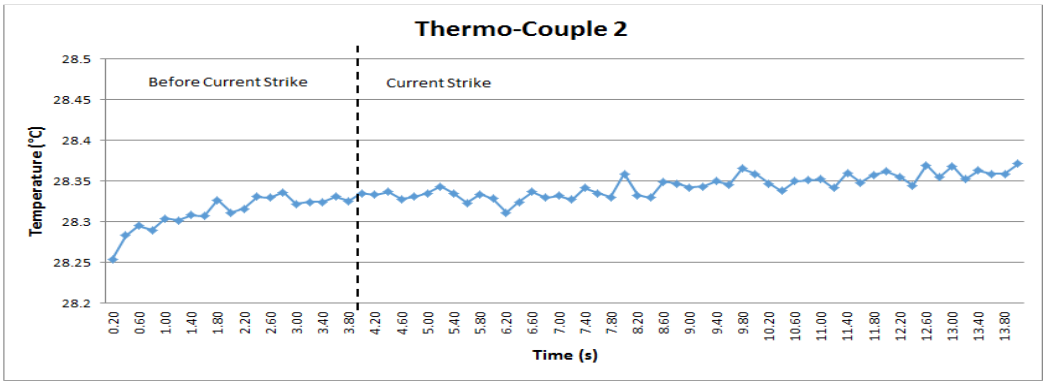

Figure 5: Changes in Temperature for Thermocouple 2

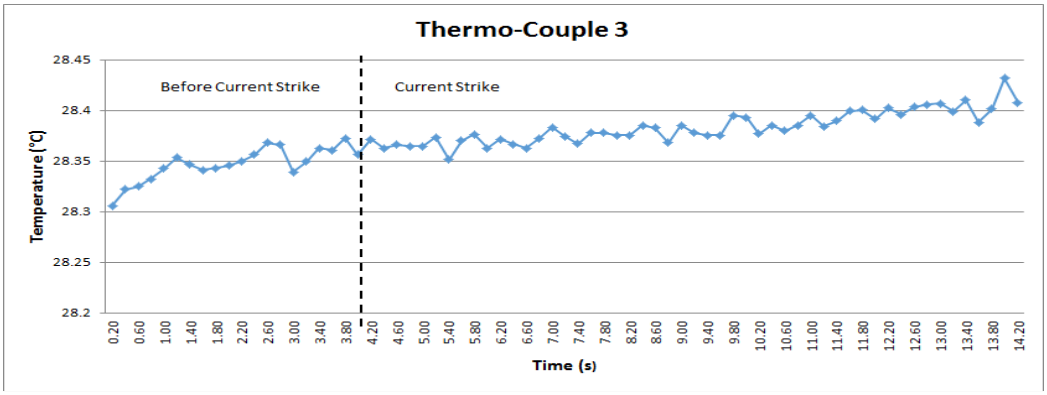

Figure 6: Changes in Temperature for Thermocouple 3

For the result of all thermocouples in Figure 7, its show the similar pattern which is there are no drastically changes in the temperature at 4 second, the temperature remain with the same pattern without causes any effect from the electric current flow. Comparing the pattern between Thermocouples, is shown slightly difference between the patterns. The thermocouples 2 has the lowest reading as this is due to the location of the thermocouple is in the middle of the cube and placed at the bottom part. For the thermocouple 1 and 3, almost similar pattern was plotted in the graph for both result, this is due to the location of the both thermocouples where located near the surface at the top and edge of the concrete cube.

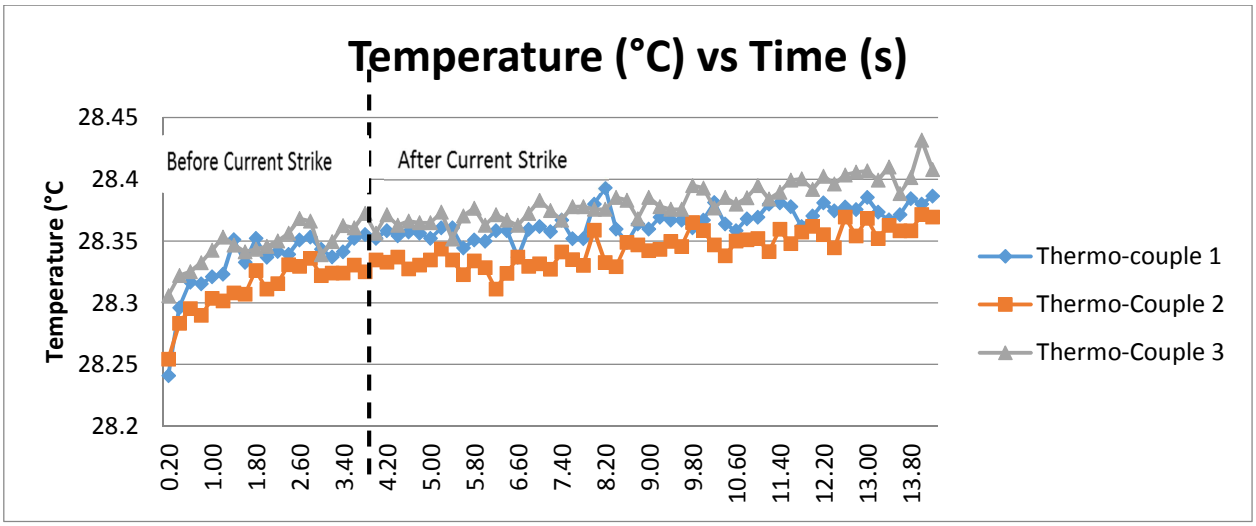

Figure 7: Comparison between the Temperatures for the Thermocouples

CONCLUSION

This study shows the effect of temperature in the concrete due to high current impact. As conclusion from this study, it can be conclude that there are no changes of the temperature captured by the Thermal imager camera, this may be due to the camera was operate manually and the timing to capture the effect of high current is not exactly on the right time. As for the inside temperature, it can be verified that there are no changes of the temperature as the data logger was set to collect the data after 4 second, and no drastic changes of temperature was recorded. The changes are very small and can be negliable. The small changing is due to the increasing of the temperature for the concrete that exposed at open space.

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