Thermal Simulation on the Flat Steel Box Girder of the Maputo Bridge under Solar Radiation

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Abstract

Bridges may undergo significant temperature variation under the combined influence of solar radiation and daily ambient temperature. In some circumstances, thermal stresses due to temperature gradient or external constraint can be significant in comparison to dead or live load stresses. This paper investigates the solar temperature distribution and effect on the Maputo Bridge, a super-long suspension bridge in Mozambique. Thermal finite element model is established considering the local seasonal and daily variation of solar radiation and ambient temperature. Then the temperature distribution of the outer plates of the girder is extracted to quantify the temperature effect. Parametric analysis is also carried out to identify the key parameters. It is found that the modelling details have minor influences, whereas a smaller film coefficient and thinner asphalt pavement tend to enlarge the temperature gradient. By comparing the simulated temperature distribution with the thermal gradient load in the codes, it's found that the temperature distribution in the studied flat steel box girder doesn't follow any thermal gradient load in the current bridge codes and therefore a novel thermal gradient load is suggested.

Keywords: Maputo Bridge; thermal simulation; solar radiation; flat steel box girder; temperature effect

1 Introduction

Bridges are continuously exposed to varying ambient temperature and solar radiation. The heat transfer from surrounding environment induces not only temperature variation but also structural deformation and thermal stresses. It has been observed that bridge movement is dominated by daily and seasonal temperature variation [1]. For steel bridges, temperature variation can induce significant thermal stresses that are comparable to the stresses induced by dead and live loads [2].

Thermal behaviour caused by environmental parameters such as solar radiation, air temperature, and wind speed depends highly on the bridge's shape and local meteorology; hence using the thermal load in bridge codes without careful examination may lead to unsafety. Since temperature field measurements are unavailable for bridges in general, numerical simulation is necessary to get a quantitative understanding of a bridge's transient temperature field. Among the thermal simulation works [3-7], the heat transfer finite element (FE) method is most preferred for accurately modelling the changing direction of solar radiation and shading effect.

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