Experimental Study on Activation Performance of Fe-Based Shape Memory Alloy for Strengthening Steel Bridge

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Abstract

To reveal the effect on heat transfer and the distribution of temperature in Fe-SMA during its activation, a series of tests was performed on Fe-SMA strips in this paper. The mechanical properties of Fe-SMA were preferentially studied by uniaxial tensile test, and the activation performance of Fe-SMA strips was investigated by independently designed set-up, in which the temperature can be monitored by eight K-type thermocouples. The test results reveal that the heat-transfer effect of activation in Fe-SMA strips was dramatical with different spacing and transfer time. Furthermore, a theoretical predication equation was proposed to obtain the peak temperature at any point of the structural member, which serves for deciding the adhesive type and the bonding length of adhesive bonding joint for Fe-SMA reinforcement. This paper offers basic material properties and activation performance of Fe-SMA, which can be employed for further numerical study and theoretical study on the smart reinforcement of steel bridges via Fe-SMA.

Keywords: Fe-SMA; steel bridge; strengthening; activation; mechanical property; recovery stress; temperature distribution.

1 Introduction

With the in influence of chloride ion-induced corrosion[1] and the increase in repeated traffic loads[2], numerous steel bridges are threatened by racking, aging and insufficient load-bearing capacity. Degraded structures need to be strengthened or repaired to prolong the service life and reduce maintenance costs[3].

Shape memory alloy (SMA) has been applied to bridge strengthening for its shape memory effect which is controlled by transformation of two basic phases, austenite and martensite[4-6]. The so-called shape memory effect refers to the stress-induced deformation of SMA can completely or partially restored under heating[7-8]. If the recovery strain is limited, a considerable recovery stress is generated, which can be applied for structural reinforcement as a prestress.

The nickel-titanium based SMA(NiTi-SMA) and iron based SMA(Fe-SMA) are the commonly used alloys for bridge engineering. NiTi-SMA is often used as dumping or connection for stable shape memory effect and superelasticity[9-10]. Recently, it has been applied in local reinforcement of steel structures as hybrid composite patches with CFRP sheet[11-12]. However, the high cost and low elastic modulus have obstructed its application[13].

Alternatively, Fe-SMA, featuring low-cost, wide transformation hysteresis, and excellent mechanical performance, have been widely studied[14]. Fe-SMA was firstly successfully applied by Soroushian et al.[15] to strengthen a concrete T-beam bridge. Dong et al.[16-17] developed a new

https://doi.org/10.2749/nanjing.2022.1551