Determination of minimum CFRP pre-stress levels for fatigue crack prevention in retro-fitted metallic beams

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Abstract
The majority of fatigue strengthening studies focus on reducing propagation rates of existing cracks, ignoring the crack initiation stage. Many existing metallic bridge members however do not contain existing cracks, but rather are nearing their design fatigue life wherein crack initiation is approaching. Traditional bonded carbon fiber reinforced polymer (CFRP) retrofit methods focus on crack arrest rather than initiation prevention. Limited research exists on the prevention of crack initiation using CFRP materials. In this paper, modified constant life diagrams (CLDs) are used to determine the optimum level of CFRP pre-stress required to indefinitely extend the fatigue life of existing metallic beams. To validate the proposed method, a pre-stressed un-bonded CFRP reinforcement system is introduced and tested on four metallic beams. The proposed un-bonded CFRP system is advantageous over traditional bonded CFRP systems as it can be applied to rough or obstructed surfaces (surfaces containing rivet heads or corrosion pitting for example). Additionally, the new un-bonded CFRP system offers a fast on-site installation (no glue and surface preparation are required) and an adaptive pre-stress level. Experimental results show that strengthening using pre-stressed CFRP plates are capable of shifting the working stresses from a finite fatigue-life zone to an infinite fatigue-life zone preventing crack initiation.

Keywords: Fatigue crack; metal; constant life diagrams; CFRP; strengthening; pre-stress