Accepted Manuscript

Pressure-sensitive bond fatigue model with damage evolution driven by cumulative slip: thermodynamic formulation and applications to steel- and FRP-concrete bond

Abedulgader Baktheer, Rostislav Chudoba

PII: S0142-1123(18)30158-0
DOI: https://doi.org/10.1016/j.ijfatigue.2018.04.020
Reference: JIJF 4659

To appear in: *International Journal of Fatigue*

Received Date: 9 January 2018
Accepted Date: 19 April 2018

Please cite this article as: Baktheer, A., Chudoba, R., Pressure-sensitive bond fatigue model with damage evolution driven by cumulative slip: thermodynamic formulation and applications to steel- and FRP-concrete bond, *International Journal of Fatigue* (2018), doi: https://doi.org/10.1016/j.ijfatigue.2018.04.020

Pressure-sensitive bond fatigue model with damage evolution driven by cumulative slip: thermodynamic formulation and applications to steel- and FRP-concrete bond

Abedulgader Baktheer, Rostislav Chudoba

Institute of Structural Concrete, RWTH Aachen University

Mies-van-der-Rohe-Straße 1 , 52074 Aachen , Germany

Abstract

In this paper we introduce a thermodynamically consistent bond-interface pressure-sensitive damage model with cumulative sliding strain measure as a fundamental source of fatigue damage. The modeling approach provides a clear physical interpretation of the dissipative mechanisms governing the propagation of fatigue damage within the concrete-steel/FRP interface so that it is possible to reproduce both the monotonic and the cyclic behavior of the bond with a consistent set of material parameters. The model has been applied for simulation of the degradation process in the bond between concrete and reinforcement bars and between concrete and FRP sheets under pullout fatigue loading. The paper presents numerical studies of the fatigue pullout behavior with detailed analysis of the damage propagation during loading and unloading stages, and at different levels of imposed lateral pressure. To validate the ability of the model, simulations of pullout tests published in the literature have been conducted.

Keywords: Interface, Debonding, Fatigue modelling, Damage accumulation, Composite structures

1. Introduction

An increased interest in detailed description and characterization of fatigue behavior of reinforced concrete (RC) members has developed during the last decade due to the enhanced requirements on the fatigue resistance of structures exposed to up to 10^7 number of cycles, e.g. wind turbine towers or bridges. The behavior of RC members subjected to fatigue loading can only be appropriately described if the local degradation processes affecting the bond strength under fatigue loading are captured. It significantly affects the structural deformation, the width and distribution of the cracks in the RC members and, certainly, the ultimate failure.

In parallel, new types of non-metallic reinforcement and strengthening materials have been developed in recent decades. For rehabilitation and strengthening of the existing RC structures subjected to fatigue loading, e.g. bridges, the fiber reinforced polymers (FRP) have become widely used. The bond behavior between the concrete surface and the FRP plays a crucial role for determining the achieved level of strengthening [1, 2, 3]. Realistic models of the bond behavior play the crucial role in the reliable design of the FRP-strengthened structures [4]. Therefore, theoretical characterization of the bond fatigue behavior in a broad range of concrete composites represents an important and challenging task that has attracted attention of researchers during the past decades as documented by our brief survey of existing modeling approaches.

Email address: `Abaktheer@imb.rwth-aachen.de; tel: +492418026830` (Abedulgader Baktheer)