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INERTIAL AND RATE EFFECTS IN THE DYNAMIC INTERFACIAL FRACTURE OF BEAMS STRENGTHENED WITH FRP

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Interfacial fracture, debonding, and delamination are failure mechanisms that critically affect almost any form of layered or adhesively bonded structure. In beams that are strengthened with externally bonded layers of fiber reinforced polymer (FRP) composite materials, the interfacial fracture commonly defines the failure mechanism of the entire element. The vast experimental work on layered structures has shown that in most cases, the debonding phenomenon is brittle, rapid, and unstable. These observations, which were reported under dynamic loading [1,2] as well as under static ones, e.g. [3], and is crack propagation analyses [4] directly draw the attention to the dynamic, inertial, and rate dependent aspects of the interfacial problem. As such, they define the interfacial fracture phenomenon as dynamic by nature [5-7].

The rapid propagation of the interfacial fracture, the dynamic change of the structural configuration, and, at the same time, the time dependent response of the entire structural system places the physical problem in the dynamic field. Correspondingly, it defines a range of analytical, computational, and even experimental challenges that still have to be faced. The handling of the interfacial debonding fracture in its realistic dynamic environment gives rise to many questions. The fundamental ones refer to the impact of the evolution of inertial effects on the nucleation, initiation, and growth of the interfacial fracture mechanism [5,6]. Refined questions refer to the impact of the loading and the response rates on these process and, particularly, to the impact on the rate effects on the behavior of the fracturing interface [8,9]. Another spectrum of questions refers to the effect of the elastic or mechanical properties of that debonding interface on the response of the beam. This aspect is particularly relevant to the phase in which the interfacial fracture nucleates as well as to the stability of the propagation of the interfacial process.

In this presentation, the challenge of describing and quantifying the dynamics of the interfacial debonding fracture phenomenon in beams that are strengthened with composite materials is faced. The study adopts an analytical-numerical approach and the handling of the problem is based on a refined high order dynamic model. The model aims to provide the structural analysis with the refined resolution required for detecting the dynamic nucleation and growth of the interfacial fracture at the two distinct interfaces of the adhesive layer [6,10]. At the same time, it aims to provide an analytical-computational platform that can accommodate various inertial and rate dependent interfacial effects. To achieve this modeling resolution, the analysis combines a dynamic high order theory, cohesive interfaces, and consideration of various aspects of the inertial and rate dependent effects involved with the dynamic phenomenon. Emphasis is placed on the latter aspect as well as on its analytical and numerical modeling. The impact of the loading and response rates on the nucleation and dynamic propagation of the interfacial phenomena and their impact on the dynamic stability of the process will be discussed. Based on this discussion, the consequences of the dynamic phenomena in terms of the structural functionality, safety, and resilience will also be addressed. The presentation will close with concluding observations on the place of the dynamic aspects in the general context of the modern strengthening technique as well as in the broader context of interfacial fracture in layered structures.

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