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Repair of Delaminated Composite Beams Using FRP Jackets under Fatigue Loading Conditions

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Abstract

Delamination of the composite structural members is one of the prevalent damage modes which can grow among the layers of composite materials and decreases the performance of the member considerably. In this paper, an existing delaminated region will be assigned for two type composite beams and propagation of the predefined delamination will be examined during the fatigue loading. The delamination growth in the components was characterized for the defective beams in comparison with the perfect models. Then using FRP jackets, the delaminated region was wrapped regarding the predefined configuration of the composite jacket. Then influence of the applied repair on the increase of fatigue delamination growth life was presented in comparison with the un-repaired models. Delamination propagation of the models was performed using MVCCT. These results provided useful guidelines for design engineers to apply the proposed repair technique for delaminated members under various fatigue loading conditions.

Keywords: Delamination, Repair, Composite beam, FRP jacket, Fatigue loading.

1. Introduction

Nowadays, composite materials are used for fabrication of various structural components in various industries such as mechanical machines, automobiles, naval and aeronautic vehicles and civil constructions that these applications are widen regarding the useful characteristics of composite materials. For utilization of composite materials as structural elements, their strength, stiffness and various probable damage aspects under loads must be considered to prevent form failure of member by employing design provisions. As the popular failure modes of the composites are matrix cracking, delamination, fiber/matrix debonding and fiber breakage. Each one of these modes in the composite occurs due to different conditions and also, a compound failure mode may appear in a composite member in following the initial damage. In present paper, delamination phenomenon of the composite beams has been investigated in progressive conditions and a repair technique has been proposed for increase the service life of structure.

As review of the delamination research in the literature, Liu et al. [1] using virtual delamination closure technique studied post-buckling of delaminated beams by finite element analysis in 2-D and 3-D models for various layup methods of the composite. Shen et al. [2] numerically observed delamination growth in composite laminate of a plate including of a circular hole under compression loading by taking account the strain energy release rates in the delamination front and they predicted the contour of delaminated area with increase of the load. Chen et al. [3] investigated dynamic behavior of a composite plate considering progressive failure process for pre-assigned delamination in the plate. They utilized a generalized orthogonal damping model for delamination study and employed virtual interface linear spring elements for their model to ovoid penetration and overlap phenomenon between the upper and lower sub-laminates at the delamination region. Grassi and Zhang [4] through finite element analyses on their cantilever beam models, examined mode I delamination by introducing an interlayer delamination front in the beam increasing the load observed delamination growth in the model. Then using Z-fiber technique improved the delamination growth resistance and introduced this method as a successful repair to arrest the delamination extension. Li et al. [5] studied a through thickness repair technique for delaminated composite laminates. They drilled some holes on the delaminated region of the specimens and bonded pins into these holes which were effective for restoring the compression strength of the member. Fan et al. [6] experimentally studied the delamination development in the composite beams under three-point bending. Then based on two analytical approaches they predicted delamination development compared to experimental data. Blanco et al. [7] used MMELS