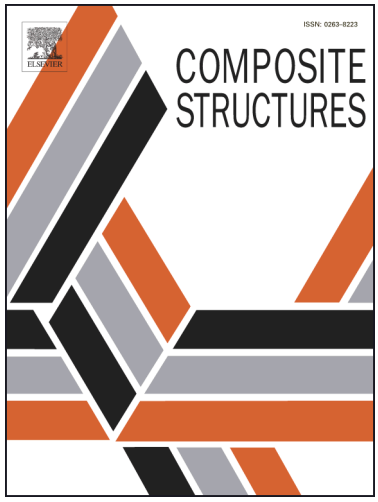
Accepted Manuscript



Progressive damage analysis of a rate-dependent hybrid composite beam

Giovanni Belingardi, Hadi Mehdipour, Enrico Mangino, Brunetto Martorana

PII: S0263-8223(16)31194-1
DOI: http://dx.doi.org/10.1016/j.compstruct.2016.07.055
Reference: COST 7655

To appear in: *Composite Structures*

Received Date: 14 July 2016
Accepted Date: 21 July 2016

Please cite this article as: Belingardi, G., Mehdipour, H., Mangino, E., Martorana, B., Progressive damage analysis of a rate-dependent hybrid composite beam, *Composite Structures* (2016), doi: http://dx.doi.org/10.1016/j.compstruct.2016.07.055

This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

ACCEPTED MANUSCRIPT

Progressive damage analysis of a rate-dependent hybrid composite beam

Giovanni Belingardi[1], Hadi Mehdipour[1] , Enrico Mangino[2] , Brunetto Martorana[2]

[1] *Department of Mechanical and Aerospace Engineering, Politecnico di Torino, Corso Duca degli Abruzzi- 24, Torino, Italy*
[2] *Group Material Lab., Centro Ricerche Fiat, strada Torino 50, 10043 Orbassano (TO), Italy*

Abstract

A hybrid beam combined of a molded woven fabric beam and over injected or compressive molded short fiber composite material, are manufactured and three point bending tests with different loading rates and two different boundary conditions are performed. Since the experimental results demonstrate a rate dependent behavior of the beam, then to predict its mechanical behavior under different loading velocities two strain rate sensitive progressive damage models have been developed based on Continuum Damage Mechanics approach. For internal reinforcing constituent of the beam which dominated by matrix, the matrix failure index of Hashin-Rotem's failure criterion was chosen and for outer part which governed by fibers the maximum stress theory is considered as damage initiation indicator. For both models Lapczyk-Hurtado's approach is followed to capture damage propagation. To account for rate-dependent material properties, where is needed, equations derived from a logarithmic formula, are utilized. The models is applied on the commercial finite element software of ABAQUS using user-written subroutine based on explicit numerical method. The numerical results are verified by the bending tests and it is shown that the numerical results of the proposed models have shown better agreement with experimental results of compressive molding technology than back injected one.

Keywords: Continuum damage mechanics, Progressive damage, Fabric thermoplastic sheet, Short fiber composite, ABAQUS subroutine

Introduction

One of the main obstacles that vehicle companies are facing is the reduction of the vehicle weight without sacrificing their safety, reliability, durability and riding performances. The substitution of new materials and modern manufacturing technologies, such as hybrid composite materials, for classic approaches and materials, such as fully made metallic components, is one of the main trends to achieve relevant weight reduction. Introduction of complicated hybrid composite materials leads us to going through relatively immature field of mechanics of material. To deal with these new generations of components and materials, researchers have been searching for accurate sorts of analytical and numerical procedures to predict their mechanical responses under different loading and boundary conditions.

Continuum Damage Mechanics (CDM) approach deals with material damage based on stiffness component degradation[1].Also, CDM method which incorporates damage in the material response functions might be introduced as a set of internal vector field variables [2]. To define a damage model based on CDM approach, a constitutive model including damage variables must be presented. Generally, a constitutive model relates stresses to strains components using a fourth order stiffness tensor. To incorporate damage variables in constitutive equations, a reasonable way is redefining the stiffness tensor by implementing damage variables. The redefined stiffness tensor called degraded stiffness tensor. To achieve a physical base damage model and extract the constitutive equations, thermodynamic laws are considered which needs to define Helmholtz free energy [3]. To detect a specific damage mode activation a failure criterion, which represent the damage surface in stress or strain space, must be defined. The damage envelope might be in separated form such as Hashin-Rotem criterion for unidirectional composite plies[4]. In this type of failure criterion for each modes of damage, in longitudinal and transverse direction and under compression and tension, damage surfaces defined by different formulas. Later, Puck and Schurman based on Hashin and Rotem's hypothesis formulated another separated form of failure criterion which deals with inter-fiber failures and has a capability of detection of crack direction [5]. Even though based on World Wide Failure Exercise (WWFE) [6] Puck's failure theory showed the best agreement with experimental results, but there are some non-physically based parameters in this theory which make its application hard for users. To overcome this difficulty, Davila and Camanho developed a failure criterion based on Hashin and Puck theories, where no nonphysical parameters are needed[7]. Formerly, Chang and Chang suggested a separated form of failure criterion for notched laminated composites with consideration of material nonlinearity [8]. In addition to the separated type of failure criteria, one can implement an integrated type in CDM which are mostly the generalized form of Hill's criterion for orthotropic materials [9].

Download English Version:

https://daneshyari.com/en/article/6705113

Download Persian Version:

https://daneshyari.com/article/6705113

Daneshyari.com