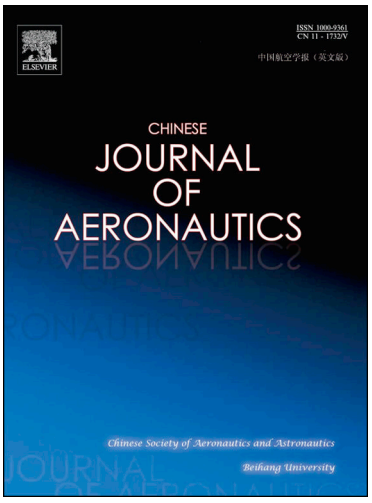
Accepted Manuscript



Full Length Article

A new structural reliability index based on uncertainty theory

Pidong Wang, Jianguo Zhang, Hao Zhai, Jiwei Qiu

PII: S1000-9361(17)30103-6
DOI: http://dx.doi.org/10.1016/j.cja.2017.04.008
Reference: CJA 840

To appear in: *Chinese Journal of Aeronautics*

Received Date: 1 June 2016
Revised Date: 11 April 2017
Accepted Date: 11 April 2017

Please cite this article as: P. Wang, J. Zhang, H. Zhai, J. Qiu, A new structural reliability index based on uncertainty theory, *Chinese Journal of Aeronautics* (2017), doi: http://dx.doi.org/10.1016/j.cja.2017.04.008

Chinese Journal of Aeronautics 28 (2015) xx-xx

Contents lists available at ScienceDirect

Chinese Journal of Aeronautics

journal homepage: www.elsevier.com/locate/cja

A new structural reliability index based on uncertainty theory

Pidong WANG [a,b], Jianguo ZHANG [a,b*], Hao ZHAI [a,b], Jiwei QIU [a,b]

[a]*School of Reliability and Systems Engineering, Beihang University, Beijing 100083, China*

[b]*Science and Technology on Reliability and Environment Engineering Laboratory, Beihang University, Beijing 100083, China*

Abstract

The classical probabilistic reliability theory and fuzzy reliability theory cannot directly measure the uncertainty of structural reliability with uncertain variables, i.e., subjective random and fuzzy variables. In order to simultaneously satisfy the duality of randomness and subadditivity of fuzziness in the reliability problem, a new quantification method for the reliability of structures is presented based on uncertainty theory, and an uncertainty-theory-based perspective of classical Cornell reliability index is explored. In this paper, by introducing the uncertainty theory, we adopt the uncertain measure to quantify the reliability of structures for the subjective probability or fuzzy variables, instead of probabilistic and possibilistic measures. We utilize uncertain variables to uniformly represent the subjective random and fuzzy parameters, based on which we derive solutions to analyze the uncertainty reliability of structures with uncertainty distributions. Moreover, we propose the Cornell uncertainty reliability index based on the uncertain expected value and variance. Experimental results on three numerical applications demonstrate the validity of the proposed method.

Keywords: Structural reliability; Reliability index; Uncertain measure; Uncertain variable; Belief degree

*Corresponding author. *E-mail address:* wpd-pizi@163.com (P. D. Wang); zjg@buaa.edu.cn (J. G. Zhang)

1. Introduction[1]

Reliability analysis has been a hot research topic in recent years, as the influences of uncertainty arising on loads, material properties, dimensions, and geometries become more and more profound [1]. This topic has a wide range of applications in the design and analysis of structural systems for aerospace vehicles, civil engineering, and manufacturing industry [2].

Probability theory is one of the most classical and prevailing tools in dealing with uncertain variables, which has been widely used to estimate structural reliability and safety by calculating the probability of failure and the reliability index β [2-5], and a lot of probabilistic reliability methods have been proposed in literature such as the first-order method [2, 5, 6], the second-order method [2, 6], the response surface method [7, 8], and the numerical sampling simulation method [7, 9].

However, in practical structural engineering, beside randomness which can be modelled by probabilistic theory with Probability Distribution Functions (PDFs) [3, 9, 10] we encounter epistemic uncertainty [3, 10], caused by things such as loss of information, limited knowledge, and inevitable man-made mistakes [3, 11, 12]. It cannot be well explained by randomness and probabilistic models. Although, for uncertain problems in structural engineering, a random variable is always employed to represent a kind of subject probability, which is conducted by experts' judgments (subjective interpretation) [10], the uncertainty of this variable is actually fuzziness from experts' judgements[3]. In this sense,