The Evolving Metropolis
2019 IABSE Congress
New York City

IABSE 90 YEARS

Energy-Based Robustness Measure for Deteriorating Structures

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1 Abstract

An approach to robustness assessment of structural systems undergoing continuous damage is presented. Damage is described by means of a dimensionless index associated with prescribed patterns of cross-sectional deterioration and computed through a weighted average over the structural volume based on strain energy. The variation of a performance indicator associated with deformation modes and load participation factors is related to the amount of damage to obtain a dimensionless measure of structural robustness. The proposed approach is applied to structural robustness assessment of an arch bridge under continuous deterioration.

Keywords: Structural Robustness; Aging; Deterioration; Bridges.

2 Introduction

Structural robustness and design procedures aimed at avoiding disproportionate failure and progressive collapse gained increasing attention over the last few decades [10]. However, the concept of robust structures, or damage-tolerant structures, is still an issue of controversy since there are no well established and generally accepted criteria for a consistent definition and a quantitative measure of structural robustness [14]. This is also reflected by a lack of quantitative design criteria in design codes and standards. Moreover, robustness evaluations are usually related to sudden damage provoked by accidental actions, such as explosions or impacts [11]. However, damage could also arise slowly in time over the life-cycle of structures due to aging and deterioration processes [7]. This is particularly important for bridges, for which the structural members are directly exposed to environmental aggressiveness. Notable events of bridge collapses due to deterioration processes and related phenomena, such as corrosion and fatigue, include for example the Silver Bridge in 1967 [2], and the Mianus River Bridge in 1983 [13].

Structural systems under continuous damage have been investigated to identify suitable measures of structural robustness [8]. A significant effort has been also made to explicitly include the time factor in a lifetime scale to formulate a time-variant measure of robustness [4], [6]. This paper presents further developments along these research lines on robustness assessment of deteriorating structural systems. Damage is described at the member level by means of a dimensionless index associated with prescribed patterns of cross-sectional deterioration. At the system level, the amount of

https://doi.org/10.2749/newyork.2019.2547
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