Response surface method strategies coupled with NLFEA for structural reliability analysis of prestressed bridges

Silvia J. Sarmiento Nova, Jaime Gonzalez-Libreros

Luleå University of Technology, Luleå, Sweden

Gabriel Sas

SINTEF Narvik AS, Rombaksveien E6-47, N-8517 Narvik, Norway

Luleå University of Technology, Luleå, Sweden

Rafael A. Sanabria Díaz, Maria C. A. Texeira da Silva, Leandro M. Trautwein

University of Campinas, Campinas, Brazil

Contact: silvia.sarmiento@ltu.se

Abstract

The Response Surface Method (RSM) has become an essential tool to solve structural reliability problems due to its accuracy, efficacy, and facility for coupling with Nonlinear Finite Element Analysis (NLFEA). In this paper, some strategies to improve the RSM efficacy without compromising its accuracy are tested. Initially, each strategy is implemented to assess the safety level of a highly nonlinear explicit limit state function. The strategy with the best results is then identified and used to carry out a reliability analysis of a prestressed concrete bridge, considering the nonlinear material behavior through NLFEA simulation. The calculated value of β is compared with the target value established in Eurocode for ULS. The results showed how RSM can be a practical methodology and how the improvements presented can reduce the computational cost of a traditional RSM giving a good alternative to simulation methods such as Monte Carlo.

Keywords: Structural reliability; Response surface method; Prestressed concrete; Nonlinear analysis; Bridge.

1 Introduction

The necessity of assessing the structural safety level for both design and monitoring stages has highlighted the importance of implementing reliability analysis. When predicting structural capacity, there are inherent uncertainties that a deterministic approach is unable to consider. Some of the uncertainties can be found in the material properties, geometry, and loads. Therefore, probabilistic analyses are usually implemented to take into account those uncertainties. Several methods to quantify the reliability of the structures have been developed and implemented, such as the Monte Carlo simulations (MCS), the First and Second Order Reliability Methods (FORM, SORM), and the Latin Hypercube Sampling (LHS), which are widely used because of their simplicity and

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