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Non-deterministic Approach for Reliability Evaluation of Steel Portal Frame

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Abstract

In recent years, more researches on structural reliability theory and methods have been carried out. In this study, a portal steel frame is considered. The reliability analysis for the frame is represented by the probability of failure, P_f, and the reliability index, β, that can be predicted based on the failure of the girders and columns. The probability of failure can be estimated dependent on the probability density function of two random variables, namely Capacity R, and Demand Q. The Monte Carlo simulation approach has been employed to consider the uncertainty the parameters of R, and Q. Matlab functions have been adopted to generate pseudo-random number for considered parameters. Although the Monte Carlo method is active and is widely used in reliability research, it has a disadvantage which represented by the requirement of large sample sizes to estimate the small probabilities of failure. This is leading to computational cost and time. Therefore, an Approximated Monte Carlo simulation method has been adopted for this issue. In this study, four performances have been considered include the serviceability deflection limit state, ultimate limit state for girder, ultimate limit state for the columns, and elastic stability. As the portal frame is a statically indeterminate structure, therefore bending moments, and axial forces cannot be determined based on static alone. A finite element parametric model has been prepared using Abaqus to deal with this aspect. The statistical analysis for the results samples show that all response data have lognormal distribution except of elastic critical buckling load which has a normal distribution.

Keywords: Reliability Analysis; Monte Carlo Method; Matlab; Abaqus.

1. Introduction

The design of engineering structures is usually associated with a significant level of uncertainties due to limited information in the process of estimating the structural parameters. The impact of uncertainties needs to be quantified and propagated to obtain the reliability of a structural system Morio and Balesdent (2016) [1]. In practice, most engineering design of structures are based on deterministic parameters and often do not consider the variations in the material properties and the geometry of the structure. Ebenuwa and Tee (2019) stated that the determination of structural performance based on the deterministic model is undoubtedly a simplification because physical measurement always shows variability and randomness [2].

In many circumstances, it is impossible to describe the response of structural systems mathematically because of these uncertainties. Even after finding a mathematical model to predict the behavior of the system, there is no closed form solution for solving the equation. In such cases, simulation is one of the most applicable techniques to acquire the required information. Simulation is a special technique to approximate the quantities that are difficult to obtain

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