Chapter 16
Predicting and Monitoring the Failure of Steel Structures Using Artificial Neural Networks

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ABSTRACT

Artificial neural networks (ANN) have emerged as powerful tool to compute, assess, predict and understand the structural system behavior subjected to combination of complex input variables such as mechanical loads, extreme environmental conditions, seismic conditions etc. The existing experimental and simulation methods may not completely predict the structure response under combination of different input variables. In this context, assessing the failure of the steel structures by using ANN techniques ease the efforts of engineers in structure health monitoring. Compared with the available traditional methods, using ANN enables to assess the failure of the structures with more accuracy and reliability. The present chapter provides a

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summary of using ANNs in predicting different failures usually observed in steel structures. Additionally, the challenges and future perspectives are also discussed.

1. INTRODUCTION

Using steel structures in the construction of buildings, skyscrapers and bridges is essential in the modern engineering and infrastructure development. The steel structures are prone to different mechanical and environmental conditions and the produced stresses may lead to the structure failure. The performance of the steel structures depends on several factors including loading conditions, fatigue, corrosion, defects in material, environmental conditions, temperature changes and seismic conditions. Therefore, it is essential to predict the steel structural failures in order to monitor the service life of the structures and to reduce the maintenance costs. The safety of the structure during functioning is important factor in the structure health monitoring. Traditional methods fail to comprehensively predict the effect of real time conditions on the failure of the steel structures (Kanvinde, A., 2017). Visual inspections, numerical modeling studies, and empirical calculations have limitations to predict the structure performance due to the complexity when multiple influencing factors are combined together.

Recently the application of artificial intelligence (AI) and machine learning (ML) in analytical and maintenance applications is gaining attention and opened new opportunities (Yuvaperiyasamy et al. 2024, Dhinakarraj et al. 2024). In this context, Artificial Neural Networks (ANNs) have become popular to predict the failure of steel structures and to precisely assess the failure modes which help to take necessary precautionary measured to mitigate the structures failure. ANNs can be useful to assess the effect of complex interactions of the parameters on the outcome of any system with no need of explicit mathematical model. ANN structure contains input layer, hidden layers and output layer (Senthilkumar et al. 2014). The input layer contains the neurons that bring the information to the system. The hidden layers process the input information using different functions and the output layer provides the information from the system (Ragupathy et al. 2021). The output layer can have one or more nodes depending on the type of ANN system. ANNs are especially useful in predictive maintenance and structural health monitoring (SHM) applications because of their ability to process massive datasets from a variety of sources, including sensors implanted in structures, historical performance data, and environmental variables (Murotzhonovich, T. S., 2023).

Over the past decade, a significant research has been carried out on the use of ANNs to predict the failure of steel structures. Using ANN offers several benefits including processing of different types of data, flexibility and combining multiple

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