Chapter 11
An Artificial Neural Network With a Metaheuristic Basis for Plastic Limit Frames Analysis

R. Selvapriya
https://orcid.org/0000-0003-1185-2228
Muthayammal Engineering College, India

M. Gopinath
Muthayammal Engineering College, India

D. Velmurugan
https://orcid.org/0000-0002-5392-3461
Muthayammal Engineering College, India

P. Tamilchelvan
Muthayammal College of Engineering, India

ABSTRACT

The plastic limit analysis of structures has several benefits, but it also has certain disadvantages, such high computing costs. In the past twenty years, plastic limit analysis has performed better thanks to metaheuristic algorithms, particularly when it comes to structural issues. Graph theoretical techniques have also significantly reduced the process's processing time. But until recently, the iterative process and its proportional computer memory and time have proven difficult. In order to quickly

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ascertain the collapse load factors of two-dimensional frames, a metaheuristic-based artificial neural network (ANN), which falls under the category of supervised machine learning techniques, has been utilized in this work. The numerical examples show that the accuracy and performance of the suggested method are adequate.

INTRODUCTION

Plastic analysis (PA) is a potent structural analysis technique, particularly for ductile materials. The maximum and minimal principles serve as the foundation for nearly all analytical techniques used in PA (Baker et al., 1961). The majority of minimum principal techniques Combining elementary mechanisms is a common one. Neal and Symonds devised this technique initially (Neal & Symonds, 1950; Neal & Symonds, 1952a; Neal & Symonds, 1952b). Thanks to the work of Charnes and Greenberg (1951), the PA problem involving rigid-jointed frames began to be solved in 1951. Their principal tool was linear programming (LP).

Heyman (1960) looked at the minimum weight of two-dimensional rectangular frames under various loading scenarios using elementary plastic theory. The Foulkes Theory served as the main theory in his investigation. Watwood (1979), Baker and Heyman (1969), Jennings (1983), Thierauf (1978), Horne (1953), and Gorman (1981) are all credited with contributing to further advancements in this discipline.

Although the integration of elementary processes has its merits, there are several disadvantages to this approach. Its shortcomings make it unsuitable as a regular analysis tool. Among these disadvantages, the large number of processes that must be integrated in order to evaluate the collapse load factor places a heavy computational burden on the problem solver in terms of both time and memory. Thus, certain innovative methods—like graph theory—and cutting-edge algorithms—like metaheuristics—have been applied in this way. Graph theoretical notions have been applied for the first time to the flexibility study of structures by Kaveh (1976). He has thereby enhanced cycle basis in flexibility analysis to enable a precise and effective structural analysis. Mokhtarzadeh and Kaveh (1999) proposed an effective graph theoretical method for the best plastic analysis and frame design using this innovative methodology. The evolutionary approach was used by Kaveh and Khanlari (2004) to determine the planar frame collapse load factor. Genetic algorithms have been used by Kaveh and Rahami (2006) for structural analysis employing the force approach. A comparison study between various metaheuristic methods for the plastic analysis of braced frames was reported by Palizi and Saedi Darayan (2020). Greco et al. (2019) have presented an automatic approach for evaluating the plastic collapse conditions of planar frames. Using the Rankine-Merchant-Wood method, Smail and Laid (2021) presented a second-order analysis of flat steel structures.