



# Deep reinforcement learning algorithm based optimization method for the multiple storey braced steel frame structure under global stiffness constraints

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## Abstract

In the process of multiple storey braced steel frame structure design in the real world, after the completion of structural topology design, it is necessary to calculate the cross-section size of the member. The cross-section of the member not only affects the index of the member itself, but also changes the global stiffness of the structure, thus affecting the global index of the structure. The adjustment of the cross-section of the member needs to consider the influence of its own index and the global indices. Designers need a lot of repeated calculations to optimize member cross-section. This paper studies the use of artificial intelligence to replace manual cross-section optimization. The training method of the agent adopts the PPO algorithm in reinforcement learning, and created a structural generator which randomly generates various structural schemes of the plane layout to interact with the agent, so that the agent can accumulate optimization experience and improve optimization ability in continuous trial and error. The training goal of the agent is to complete the adjustment of the cross-section with the least volume of material and the least of computation that satisfy constraints. Compared with manual optimization, agent optimization saves more than 95 % of time.

**Keywords:** Global Stiffness Constraints, Member cross-section, Reinforcement Learning, Deep Learning

## 1 Introduction

The design process of multiple storey braced steel frame structure in the real world is generally divided into two stages. In the first stage, designers need to complete structural topology design, including beam and column layout, arrangement of brace. The second stage is to select the cross-section of the members based on the existing structural topology, which needs to meet the global constraints of the structure and the constraints at the member level. Constraints

can be divided into driven constraints[1], control driven constraints are crucial for structural optimization, in this study only considers the storey drift, member constraints generally includes stress ratio, stability, deformation, etc. When select member cross-section in the second stage, both of these constraints need to be met simultaneously.

The modification of member cross-sectional dimensions not only affects its own indices, but also affects the global indices of the structure. When designing structures in real life, the