

# Adaptive Prestressed Structures realized by utilization of Artificial Intelligence Techniques

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## Abstract

Safety, economy and aesthetics are principal criteria for structural design. Involved contradictions between rising design demands and increasing influences provoke new challenges in the field of engineering and therefor innovative strategies and construction techniques. The conventional passive design principle of prestressed concrete is significantly improved by equipping the structure with appropriate control processes. Adaptive Prestressing is characterized by an active self-adjustment of the construction featuring various potentials. Benefits are verified by previous projects covering self-adjusting prestressed structures. A new implementation approach is based on application of AI-techniques like Fuzzy Logic, expert knowledge and machine learning. By means of experiments on two different prototypes the developed system's applicability is verified and potential of Adaptive Prestressing is emphasized.

**Keywords:** Adaptive Prestressing; self-optimization; Fuzzy control; adaptive control; structural optimization; artificial intelligence; machine learning; adaptive structures.

## 1 Introduction

Consideration of prospective influences on constructions often leads to a conflict between economic efficiency and design requirements. Thereby classical "passive" design and strengthening methods frequently involve a disproportionate high effort [1, 2]. The contradictory demands from design aspects and load increases result in new challenges in the field of engineering and the necessity of innovative strategies and construction techniques [1, 3, 4]. The natural biologic principle of active self-adjustment (adaptation) is transferred to constructions by reactive control of structural responses utilizing appropriate control procedures. Enabled adjustments to the load situation allow these adaptive structures to reduce or avoid critical conditions. The conventional passive design principle of

prestressed concrete is significantly improved by equipping the structure with appropriate control processes. Adaptive Prestressing is characterized by an active self-adjustment of the construction featuring various potentials. By real-time optimization of the structural responses a homogenization of stresses, a minimization of deflections as well as an increase of the load carrying capacity are realized. Consequently, enhancements in performance, capacity, durability, cost efficiency and sustainability of architectures are achieved [5]. These benefits were verified by previous projects with respective realization methodologies for self-adjusting prestressed structures [6]. A new implementation approach is based on the application of artificial intelligence techniques like Fuzzy Logic, expert knowledge and machine learning [7]. In the context of feasibility studies an adaptive prestressing system was developed [1]. Various