# Load Bearing Behavior of 3D Printed Prestressed Segmental Concrete Girders

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## Abstract

This research discusses the load-bearing behavior of prefabricated girder segments produced by a concrete 3D printing technology. The segments are joined together with grout and are prestressed to form load bearing bending members. Various hollow segments are printed individually where intended cold joints were created. Before continuing the printing process, different joint reinforcements were installed at the cold joints to improve the shear force transmission between the segments. The focus of this research was to observe the segment joints as well as the reinforced cold joints within a segment when high shear stresses are applied. The specimens were observed in a 3-point bending test. The deflection, cracking and failure behavior is evaluated and described in detail based on each specimen's test results and compared to the numerical and analytical results.

**Keywords:** Concrete 3D printing, bending members, prestressing, segmental girder, bending test.

## 1 Introduction

Additive manufacturing technologies, often known as 3D printing, are already being used in various industries and are helping to open up completely new production possibilities. This manufacturing method enables cost- and material-efficient production of e.g. prototypes, individualized one-offs or small series without having to provide or produce molds, formwork or other special tools. 3D printing is already used very successfully in industrial processes (mechanical engineering, toolmaking etc.) outside the construction industry. This makes it possible to economically produce parts and components with deviations from common standards or geometries [1]. Currently, there are also numerous international R&D and pilot projects dealing with the use of 3D printing in structural concrete engineering [2], [3]. The developments, some of which are running in parallel, have resulted in numerous approaches to solutions, which can be fundamentally differentiated into technologies for the prefabrication of components or systems for construction site production. Common research goals of the individual projects can often be found in the basic concept of a particular technology:

- reduction of manual labor,
- increase in material efficiency,
- waste avoidance or
- improvement of customizability.

Especially, the fact that the production of concrete - primarily the production of the contained cement - results in a high proportion of climate-impacting gas emissions makes targeted material use desirable. According to studies, this accounts for at least 8% of global $CO_2$ emissions [4]. Nevertheless, the demand for concrete has been increasing exponentially for several decades due to its cost-effectiveness and broad applicability. If any ecological aspects are included in the considerations, concrete should be used more


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