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# A review of "3D concrete printing": Materials and process characterization, economic considerations and environmental sustainability

Ghafur H. Ahmed

*Department of Highway & Bridge Engineering, Technical Engineering College, Erbil Polytechnic University, Erbil, 44001, Kurdistan Region, Iraq*

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ABSTRACT

3D printing of cementitious materials or concrete (3DCP) has developed unbelievably in past 10 years and has the potential to revolutionize the concrete industry completely in the couple of incoming decades. Compared to cast concrete, 3DCP technology has a high customizability of architectural and structural design; can reduce material consumption, minimize material waste, decrease construction time from months or days to hours; can improve sustainability, environmental impact and resolve residential crises through providing $10,000 homes. In this article, a comprehensive review for 3D printing of various materials, techniques and trending applications has been carried out. The materials used for 3DCP, mix design principles and printing process parameters has been overviewed. The factors influencing flowability, extrudability, buildability of various mixes; microstructure and mechanical properties of the hardened concrete; and improvement techniques has been discussed. An important part of this review is provided to highlight the cost of 3D printed houses compared with traditional alternatives, and environmental sustainability of 3DCP and its compatibility with international plans for climate change and minimizing the energy usage. Finally, some to-date challenges are discussed, with conclusions that also identifies the needed research and state of the art for this incredible technology. Overall, this review presents the finding of the mentioned topics through exploring 396 of the latest published articles especially focusing on last three years.

## 1. Introduction

3D printing construction technology was an amazing breakthrough in the past decade and potentially can revolutionize the construction industry, resolve residential crises, serve the green house, and brings in sustainability benefits, such as increased resource efficiency, improved construction productivity, compensates for shortages of skilled labors, and building of complex shaped structures without formworks. Additive manufacturing with cementitious materials or real concrete, commonly refers to as 3D concrete printing (3DCP) or 3D printed concrete (3DPC). This promising construction technique regarded as a modern technology which can transform the planned digital construction data to the automated production on the construction site using robotic assistant [1–5]. In traditional construction, concrete shaping is usually done by a false works, or formworks that made of plywood, steel, aluminum, etc., which shall be designed to resist the gravity load and the lateral pressure of placed material. The formwork normally comprises up to one-half of construction cost, and this ratio could potentially increase to 80–90% if the formwork is not reusable or standardized [6–8]. This contradictory phenomenon restricts the development and optimization of traditional concrete construction, as the conventional

*E-mail address:* ghafur.ahmed@epu.edu.iq.

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