Design and testing of 3D-printed lightweight staircase with reduced materials

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Three-dimensional concrete printing (3DCP) is often employed to fabricate buildings or construction components in sophisticated geometries without the need for formwork. This complex structure design also allows hollow sections which reduce the structure's self-weight. This study explores the potential of 3DCP in manufacturing of a lightweight prefabricated staircase and evaluates its structural performance. The staircase is designed using computer-aided design (CAD), fabricated by 3DCP, tested according to the Australian Standard (AS) and validated with finite-element analysis (FEA). The CAD provides a pathway for the parametric design of the staircase through a script, which accelerates the design process. The fabrication of a 3-riser staircase took 19 minutes and is free to move after 24 hours. Around 58% of material saving is achieved through the hollow design. The experiment testing indicates that the final deflection of the first tread, second tread, and mid-span is 0.078mm, 0.076mm and 0.040mm, respectively. The FEA shows a similar trend of change in deflection under the same loading conditions as the experiment. The deflection results from the analysis are considerably less than the maximum acceptable deflection of 7.47mm, proving that the printed staircase complies with AS 1657-2018 - Fixed platforms, walkways, stairways and ladders.