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Investigating the Flexural Performance of Steel Fibers–Reinforced Lightweight Aggregate Concrete Hollow RC Beams With Low Reinforcement Ratios

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ABSTRACT

The structural consequences of sectional hollowness under low reinforcement ratios are still not fully understood, despite the fact that lightweight aggregate concrete hollow beams present an appealing way to reduce self-weight and material consumption. The flexural response of lightweight aggregate reinforced concrete beams (LWARCB) with a 75-mm longitudinal hollow core and low reinforcement ratios is investigated in this work. Natural gravel was substituted with 60% lightweight expanded clay aggregate (LECA, 4–10 mm) to create structural lightweight concrete with a compressive strength of 30.77 MPa. Four-point bending tests were conducted on nine beams ($200 \times 250 \times 1500$ mm), including solid, hollow, and steel-fiber–reinforced specimens. The ultimate load capacity of beams with normal and low reinforcement ratios decreased by 5.41% and 8.7%, respectively, when a longitudinal hollow core was introduced. This reduction was accompanied by increased midspan deflection and crack width, indicating a corresponding loss in flexural stiffness. The outcomes revealed that the stiffness and strength loss attributed to the hollow core were significantly reduced by adding 0.5%–1.5% hooked-end steel fibers. The most notable increases were observed in beams with 1.5% fibers, which successfully mitigated the adverse effect of low reinforcement ratios by yielding higher cracking loads, enhanced flexural capacity, and more stable postcracking response. The study showed that the structural efficiency of hollow LWARCB can be restored and improved with the right amount of fiber.

1 | Introduction

The high density of normal reinforced concrete constructions induces a relatively high self-weight, which significantly adds to the overall dead load. In current structural design, mitigation of self-weight is now crucial, especially for long-span or multistory systems [1]. Lightweight aggregate concrete, which reduces structural mass without a loss in necessary strength requirements, is one effective approach [2–4]. In addition to reducing self-weight, longitudinal hollow cores within beams create internal voids that are appropriate for HVAC, plumbing, and electrical installations. Thus, these hollow-core beams can improve the structural and functional efficiency of load-bearing systems [5–7].

In order to maximize the merits of both materials, recent evolution in material technology has focused on combining LWAC with fiber-reinforced concrete (FRC) [2]. Although FRC improves tensile strength, crack resistance, and ductility, LWAC lowers the dead load. Hooked-end steel fibers (HESF) have been notably effective in enhancing flexural toughness and postcracking efficiency among different fiber types. They can