Proceedings of the ASME 2022 International Engineering Congress & Exposition
IMECE2022
October 30 to November 3, 2022, Columbus, OH

IMECE2022-94651

ON THE MICROMECHANICAL PROPERTIES OF CONVENTIONAL & 3D-PRINTED REBAR

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ABSTRACT

This study is focused on the micromechanical properties of conventional rebar and how they could be used for comparison with the 3D printed rebar fatigue tensile and fatigue properties. Current trends in additive manufacturing hint at the eventual use of 3D printing in the construction of homes and office buildings. Nowadays, 3D printing of homes is being achieved on an experimental basis by depositing extruded concrete in layers up to the ceiling to make walls, and then building a roof on top of the walls by conventional methods. This practice is not suitable to make bridges, multistory office buildings or structures that substantially experience tensile stresses. It is necessary to incorporate steel rebar in otherwise easily printed concrete structures. One way to achieve this is direct welding of steel into concrete by mounting a welder gun on to the 3D printing head and conducting 3D welding of the rebar. This has been accomplished and mild steel weldments have been 3D welded onto concrete. To make it acceptable for construction, the reliability of such printed rebar must be investigated. Early results of microscale tensile and fatigue testing on steel weldments made by additive manufacturing show desirable mechanical properties. However, the comparison has been made with macroscale tensile and fatigue properties of conventional rebar. To ascertain the reliability of 3D printed rebar welded onto concrete, it is essential to conduct a comparison with the micromechanical properties of conventional mild steel rebar. To achieve this, micro-specimens were machined off thick and thin conventional rebar in various orientations including along and across the longitudinal axis of the rebar and at different depths from the surface to investigate their micromechanical properties. Dog-bone shaped specimens 1000-micron in gage length with square gage cross sections measuring 200-micron x 200-micron were extracted from the surface as well as from the center of thick and thin rebar rods using a HAAS CNC. Samples were polished to a mirror finish and then tested in an Instron Electropulse E1000 load frame equipped with microgrippers that allowed monotonic and cyclic loading of the samples at a frequency of 50Hz. The results of micromechanical testing obtained from conventional rebar are compared with the those obtained from testing micro-specimens machined from mild steel weldments deposited by 3D welding on ceramics. The results demonstrate the reliability of mild streel rebar printed by 3D welding onto concrete. The implications of the findings on the use of additive manufacturing in 3D printing reinforced concrete and how it will impact the construction industry are discussed.

Keywords: Microtesting, Microfatigue, 3D welding, reliability, reinforced concrete, conventional rebar.

INTRODUCTION

Additive manufacturing methods currently investigated for building homes include material extrusion, directed energy deposition, and particle bed processes. Selective cement paste