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FATIGUE PROPERTIES OF 3D WELDED THIN STRUCTURES

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ABSTRACT

Additive manufacturing technology has matured enough to produce real industrial components. A newer method of 3D printing is the deposition of molten metal beads using a MIG weld torch. This involves a 3D printer equipped with a MIG torch layering the metals in desired shapes. It allows the fabrication of components made of MIG weld wires, currently available from various elements including Cu, Al, steel and alloys. Some of these structures made by 3D welding will have applications in critical load bearing conditions. The reliability of such components will be vital in applications where human lives are at stake. Tensile tests are conducted to verify the required strength of the fabricated parts which will undergo monotonic loading; however, fatigue tests are required for cases where cyclic loading will take place. Conventional tensile and fatigue testing requires macro-scale samples. With MIG welding, it is possible to make thin-walled structures. Fatigue testing on samples extracted from thin walls is made possible by microtesting. This study is focused on the mechanical properties of 3D welded structures made from MIG welding wires. Our earlier results showed orientation dependence of mechanical properties in 3D welded structures. They also showed the effect of substrates in expression of the orientation dependence. Welding on metal substrate produces weld beads that are harder at the substrate interfacial area. However, for structures welded on ceramics, the opposite is true. They exhibit a softer substrate interfacial area and a relatively harder top. Our newer results show fatigue properties of structures made by 3D welding. Microsamples measuring 0.2 mm x 0.2 mm x 1.0 mm were extracted from metal beads using a CNC mill along with an EDM. The contours of the samples were machined by milling and the back side was cut by electro discharge machining. Specimens were then polished to the desired size and mounted in the grippers of an E1000 Instron load frame. WaveMatrix® application software from Instron was used to control the machine and to obtain testing data. Fatigue tests were performed, and life cycles were determined for various stress levels up to over 5 million cycles. The preliminary results of tensile tests of these samples show strength levels that are comparable to those of parent metal, in the range of 600-950MPa. Results of fatigue tests show high fatigue lives associated with relatively high stresses. The preliminary results will be presented and the implications of the use of 3D welded rebar in 3D printing of reinforced concrete structures will be discussed.

INTRODUCTION

Originating as a prototype fabrication technique, 3D printing is now used to create production-quality industrial parts that are produced in small quantities. This is especially true for metallic aerospace components that require quick turnaround while maintaining high precision. Laser melting of metal powders, in contrast to powder binding/sintering produces near-finished parts that require no further sintering. Surface melting of metal particles, as performed in the sintering process, will leave voids and flaws behind that may later act as sites for crack initiation. The residual porosity can often weaken a metal and degrade its mechanical properties [1, 3].