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Abstract

Introduction to a New Extrusion-Based Technology for the Regeneration of Existing Tunnels †

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Additive Manufacturing (AM) is process in which a three-dimensional component is produced by the consecutive addition of material. This technology, applied on a large scale to cementitious materials, is known as 3D Concrete Printing (3DCP). Among the new technologies driving the fourth industrial revolution in the construction industry, 3D Concrete Printing (3DCP) is playing a key role. The typical process is carried out through robotic arms or gantries equipped with nozzles, similarly to contour crafting in other industries, where the printed object is obtained through the multiple deposition of layers. Although 3DCP is appealing when applied to specific items, as complex architectural shapes, the structural behavior and geometrical size are limitations that are difficult to overcome. Upscaling the extrusion process to full scale infrastructure applications through introducing a new concept of ultrafast and adaptable slip forming is the key to accessing different domains of the industry, where the increase in productivity results in social, economic and environmental benefits that are not comparable to the niche to which 3DCP is confined. As a matter of fact, the process of maintaining existing infrastructures is a very critical topic in most of the industrialized countries worldwide. It is commonly recognized by the main players operating in the industry (professional engineers, owners, construction companies, etc.) that, despite for new constructions, the methodologies are quite evolved (i.e., development of the tunnel boring machines), in the maintenance area there is complete lack of technologies, making it still impossible to industrialize the operations. This paper will present the Extruded Tunnel Lining Regeneration (ETLR) technology developed by HINFRA, which can automatically regenerate the lining of existing damaged tunnels directly at the site. The ETRL processing train is a machine consisting of several modular units, each solving a specific function. The increasing industrialization of operations, typically the demolition of the existing lining, the surface preparation and the new lining phases, combined with the performances of the advanced concrete, allow for targeting better productivity rates than those achieved with the traditional methods in the industry. This is made possible by the development of an extrudable eco-friendly Fiber-Reinforced Concrete (FRC) characterized by high early-age compressive strength and a fast setting time, which is the other key aspect of the innovative technology implemented by HINFRA. "Tailored" technological issues, including, e.g., the experimental determination of the friction between the extrudable mixes and formworks, will be discussed, together with a design validation related to a FRC tunnel lining, whose use could further exploit, through the significant reduction in ordinary reinforcement, the potential of 3DCP.

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