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A review on environmental and economic potential of robotic construction in actual scale driven by structural optimization

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Abstract

The application of robotic construction techniques in real scale structures is an emerging direction of technological development, which is rapidly growing nowadays with various examples coming to the fore. Studies have shown that their application in complex design solutions is advantageous as regard their economic aspect in comparison with conventional construction processes, whose cost increases exponentially depending on the design complexity [1; 2]. Apart from this, other advantages include their ability to reduce errors during construction, to minimize material waste and to eliminate the use of formworks, which are evidence of their sustainable potentiality in the construction industry. Also, their environmental impact is considerably reduced when structural optimization, e.g. topology optimization, is applied during the design stage aiming at material reduction and cost minimization.

Within this frame, a number of topologically optimized designs have been implemented in actual scale using conventional construction methods [3], however fewer cases appear to apply robotic construction techniques, e.g. robotic 3D printing or adaptive formwork casting, which might have decisive involvement in the seamless process from design to fabrication of structures. In most examples, emphasis is given on small or medium scales, mainly towards the investigation of constraints that arise during the transfer of information from complex design to physical realization. On the other hand, research on robotic 3D printing focuses on technology readiness or materials buildability through simply examples without taking into consideration the sustainable aspect of the process involved. Thus, examples on robotic construction in actual scale, with an emphasis on their sustainability driven by topology optimization principles, appear fragmented and not systematically analyzed in their full extend.

This paper reviews on relevant works on this research direction with emphasis on robotic construction processes and particularly on 3D printing and adaptive casting, together with their influence that can bring to the building industry in terms of their environmental impact and cost, taking into account structural optimization as medium to reduce required materials. Simultaneously, recent developments in this area of research, currently undertaken in our research laboratory are discussed. The aim is to discuss and draw conclusions, formulating at the same time a theoretical framework for understanding and applying automation and robotic techniques in the construction industry based on their sustainable potential.

References

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