GROW/HARVEST CALL FOR PROPOSALS 2022

4. THE 3D PRINTING CHALLENGE FOR THE CONSTRUCTION SECTOR

Additive manufacturing[1] (AM) technologies have been identified among the most innovative manufacturing solutions of the last decade, as one of the most promising production technologies at global level. They are considered to empower the transition from mass production to "mass customization" in several leading sectors.

The adoption of AM technologies by the European industry can reduce the negative environmental impact of manufacturing, based on its capability to process only the material which constitutes a specific element and to avoid the generation of waste in the form of chips (e.g., substracting technologies like CNC milling). AM technologies allow as well the creation of efficient designs as it permits designers to put material only where needed. Moreover, freeform fabrication is expected to provide energy-efficient tooling to industries working on injection moulds.

Unlike conventional fabrication processes, AM substantially reduce the interface between machines and workers since machines operate most of the time autonomously. For instance, the global introduction of AM in production chains will shift workers tasks from assembly operations to support, inspect and control tasks reducing the potential risks of accidents at the work place. Moreover, once the AM technologies are widely implanted in factories as a standard manufacturing process, new venues for shifting from mass-customization towards the mass-production of customized products will be opened, enhancing our quality of life.

Additive Manufacturing and the built environment

The European Additive Manufacturing Platform, in the framework of the AM-motion project, has very recently elaborated its roadmap identifying challenges and opportunities for the AM development and successful market uptake in different target sectors, including construction.

The built environment sector is one of the sectors that consumes[2] the most natural resources (aggregates, cements, etc.) and at the same time has one of the highest global impacts on economy and society[3]. Today it faces challenges such as lack of digitization, need to increase efficiency, improve safety or reduce environmental impact.

The application of AM technologies can importantly contribute to overcome the above-mentioned challenges by reducing the use of natural resources to the strict minimum and allowing freedom of forms for the creation of unconventional building components. This will help to reduce the material costs and contribute to a diversification in building design.

Furthermore, AM technologies have an important role to play in the reuse and valorisation of waste in the construction process and the fabrication of high value and intelligent building components. This will greatly contribute to achieve an improved life cycle of materials and to improve building energy management through the use of integrated sensors resulting in an better energy performance of buildings.

Moreover, there is a clear cost-based opportunity to save time and materials by reducing waste and the need for formwork/mould making. The increased use of automated construction will increase the efficiency of the construction process and lead to new and more qualified jobs for the workers in the construction sector.

And last but not least, the possibility to come up with innovative designs and personalized creations responding to the individual needs of end-users will contribute to an improvement of living conditions with a non negligible societal impact.

3D Printing challenges in METABUILDING

To tackle the above issues, the European construction sector needs to challenge its usual practices and innovate at a higher pace than ever before. Based on the improvement of productivity and sustainability or the development of elements with high added value for the construction sector, several challenges have emerged from the METABUILDING stakeholder workshops.

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[1] https://www.am-motion.eu/

[2] https://www.europarl.europa.eu/legislative-train/theme-a-european-green-deal/file-strategy-for-a-sustainable-built-environment

[3] https://www2.deloitte.com/content/dam/Deloitte/at/Documents/presse/Deloitte-Global-Powers-of-Construction-2019.pdf

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TOPICS FOR THE ADDITIVE MANUFACTURING CHALLENGE:

4.1. Waste reuse through integration into large 3D printing processes for the construction sector

One of the characteristics of the construction processes is the large dimensions of the components. This type of large-scale elements implies a high consumption of material resources. This high consumption of materials could turn into an opportunity if the materials were recycled from waste from the construction sector itself or other sectors.

The main challenge here is to develop a printing process for construction elements that allows the incorporation of waste materials (secondary raw materials or SRM) in order to combine the advantages of 3D printing (personalization, security, speed, etc. ...) with circular economy principles, leading to a reduction of the environmental impact. Supported activities could focus on the identification of different waste streams that are compatible with construction applications, their evaluation and the analysis of the integration of these SRM in a 3D printing process for construction and the identification of main applications where to integrate printed materials with a load of SRM. Proposals are requested to design and develop technologies that allow 3D printing with some percentage of recycled materials, to create components for the construction industry. Depending on the starting point of the development (starting TRL[4]) the project could integrate a validation in testbeds or pilot buildings of using recycled/waste material in a particular 3D construction process.

Expected Outcomes/Impacts:

- New 3D printed construction components integrating SRM as main component in the base material.
- Reduce construction waste through its reincorporation into the process.
- Reduce the impact of other industries by integrating their waste into the construction process.
- Reduce the consumption of natural resources by the construction industry through replacing part of conventional material (cement, aggregate, etc ...) with recycled waste.
- Reduce the general carbon footprint of construction processes.

4.2. Integration of new functionalities in construction components by means of 3D printing

One of the fundamental advantages of additive manufacturing is its ability to develop high value-added elements or elements with advanced functionalities. Thus layer-by-layer manufacturing processes provide opportunities that conventional technology cannot achieve.

This topic focuses on the development of printed construction elements that, in addition to fulfil their usual function, provide improved functionalities to a traditional building component. The elements needed for achieving the enhanced capabilities will be integrated during the 3D printing process. A proposed solution could for example focus on printed elements that incorporate insulation systems (thermal, acoustic, others); "smart" elements that allow the measurement of key variables or parameters in their field of application and permit integration into Industry 4.0.; elements that integrate measurement devices/sensors that ensure the quality of the process and/or connect the building with its energy management systems; design and development of advanced/intelligent components or event 3D printed components for green façades integrating plants (green walls or roofs).

Of particular interest for this topic is the development of *3D printed components for the building envelope* (e.g., prefabricated 3D printed panels with embedded functions for façades or roofs) as the building envelope is key for the energy performance of buildings, new and/or refurbished, and in the centre of public policy efforts to boost a massive and much needed "renovation wave" in order to urgently tackle climate change.

Expected Outcomes/Impacts:

- New 3D printed construction components integrating embedded functionalities.
- Industrialised, prefabricated 3D printed modules or components integrating embedded sensors/actuators connected with the Building Energy Management (BEM) system.
- Increased efficiency and productivity during the construction process.
- Improve construction quality through the integration of Industry 4.0 concepts.
- Smart building envelope components" connected to Internet of Things (IoT) / BIM / Digital Twins Increased energy performance of buildings.

[4] Technology Readiness Level, see https://ec.europa.eu/research/participants/data/ref/h2020/wp/2014_2015/annexes/h2020-wp1415-annex-g-trl_en.pdf

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