



3D Printing Technology for new concrete shape

3D Printing is a technology developed since 1970 and it was applied firstly to materials such as polymers, metal and clay. It consists in depositing successive layers of material under computerized control in order to realize a model designed by a specific 3D software. In recent years, cementitious materials were introduced in the 3D printing sector.

Since 2015, Italcementi - HeidelbergCement Group has begun to study 3D printing technology in the cement domain in his laboratories in Bergamo, i.lab. In particular, Italcementi has conducted research activities in this field developing cementitious material that could be adaptable to different 3D printing technologies, in order to develop an innovative solution to be applied in the construction world.

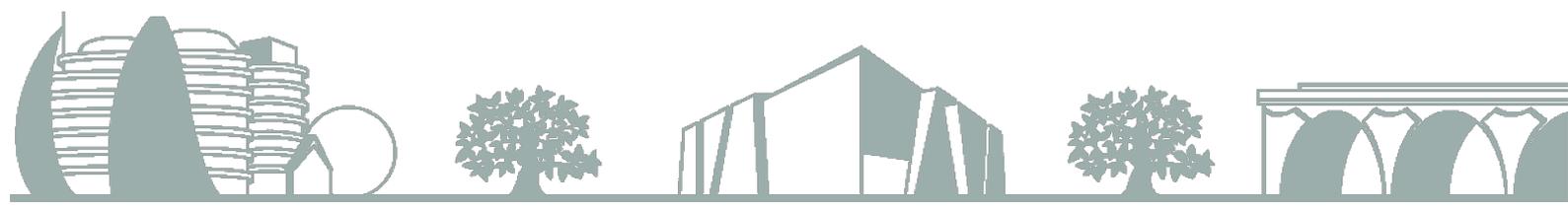
A new "building" culture, a new design and implementation system based on digital technologies that involves architecture and design firms, construction companies, research centers, universities.



Fig.1 - 3D printed element realized with Cobod International

Values and advantages of 3D printing

- **Flexibility:** greater freedom for the architect and the creator of the project in creating and personalizing his own ideas and those of the client, even when they are made up of complex shapes. In addition, the concept of flexibility can be found in the easier managing construction sites in poorly served areas or in very crowded urban centers;
- **Sustainability:** a sustainable alternative that joins the traditional "way" of building. The processing waste is reduced, recycled materials and local materials can also be used, coming from elements created themselves with 3D printing, all in the full respect of the principles of the circular economy;
- **Safety:** building site managed in safety, with reduced noise and dust, and with less overlaps and risks;
- **Accuracy:** 3D printing offers a direct information transfer from the 3D model to the construction operations, through an excellent realization of the details and reduction of the possibility of errors;
- **Rapidity:** 3D printing is a faster and sometimes less expensive process than traditional printing thanks to a more efficient use of materials and site organization.



Today, three main applications' field has been experimented by using the material solution developed by Italcementi and validated through case studies in collaboration with selected Partners:

- The building segment;
- The formwork segment;
- The precast panel segment.

The further development is to overcome the current limits of concrete 3D printing and studying its applications and solutions for structural uses.

Laboratory research

Italcementi started to study the 3D printing technologies applied to cementitious materials in the Innovation laboratories, focusing on the materials' properties: cement and concrete.

The know-how captured and the technical skills developed by the research team during the laboratory phase have been supported investing in laboratory machines and partnerships.

The team has included several competences, from engineers, materials chemists, architects and laboratory technicians/researchers, to a total of about 15 people from 2015, with over 15,000 hours of research up to 2018.

The network and Partners

A network including universities, architects and engineers firms has been created. It includes, among others, the Harvard College Graduated School of Design, the University of Naples "Federico II" (Department of Chemical Engineering, Materials and Industrial Production and Department of Structures for Engineering and Architecture), the University of Florence (Consortium for the Development of Large Interphase Systems) and innovative start-ups expert in extrusion technology and 3D printing machines providers, such as COBOD International.

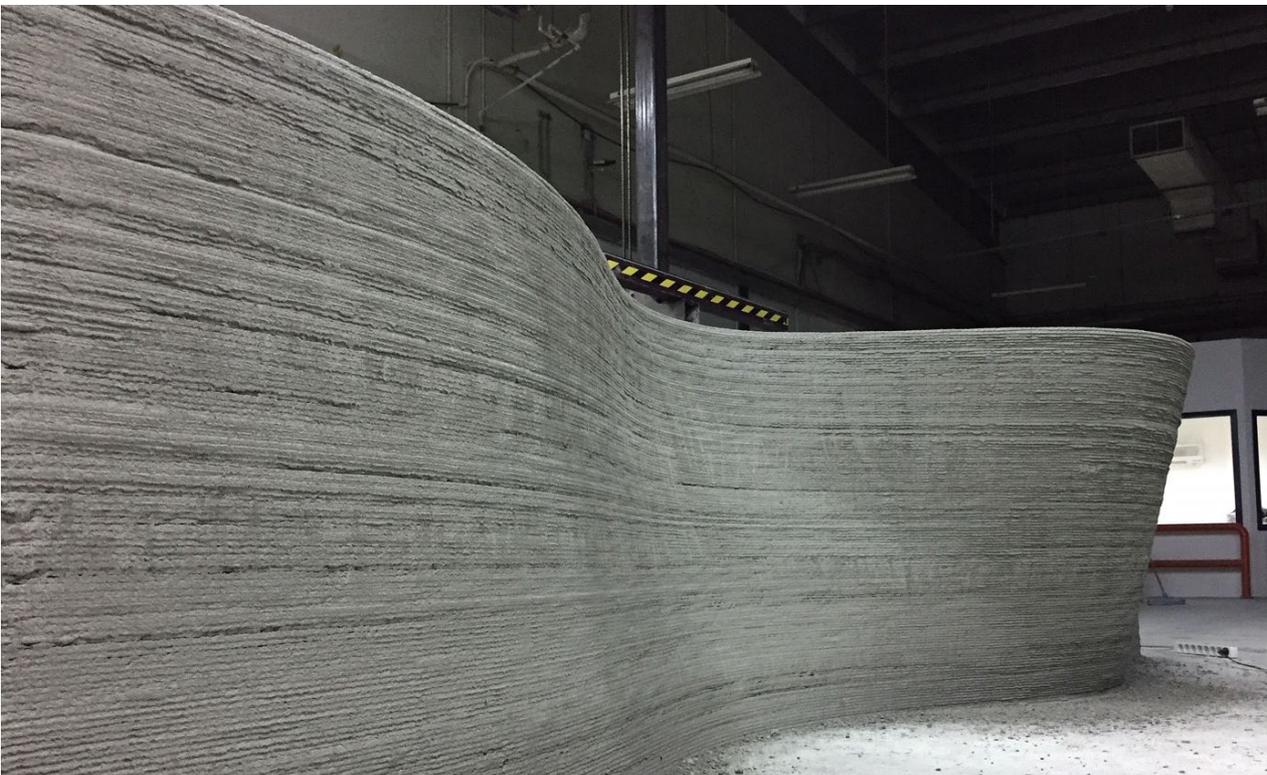
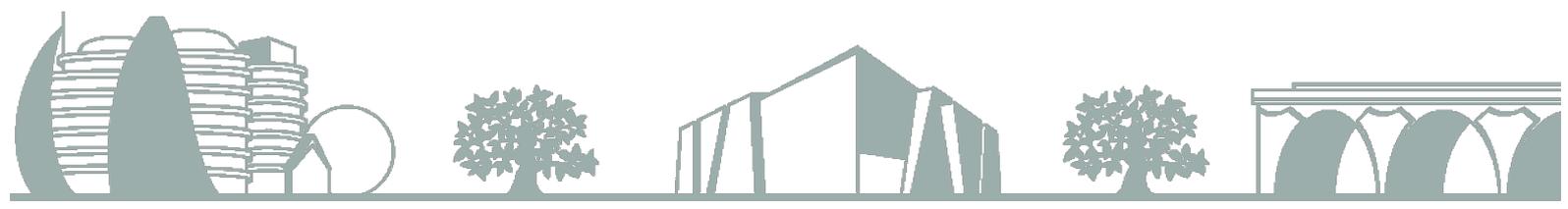


Fig. 2 - 3D printed wall realized with Cobod International



Case study: 3D housing 05

Italcementi, in collaboration with Massimiliano Locatelli/CLS Architetti, now Locatelli Partners, Arup Italy and Cybe Construction, presented “3D Housing 05”, the house of 100 square meters, 3d printed on site at Piazza Cesare Beccaria, in the occasion of the Milano Design Week 2018.

A research that Italcementi carried out about the possibilities that 3D printing technology offers in the field of sustainable architecture, responding to the increasingly urgent demand for innovation in the world of housing. “3D Housing 05” is a house designed with a new architectural language and realized by means of a revolutionary technology.



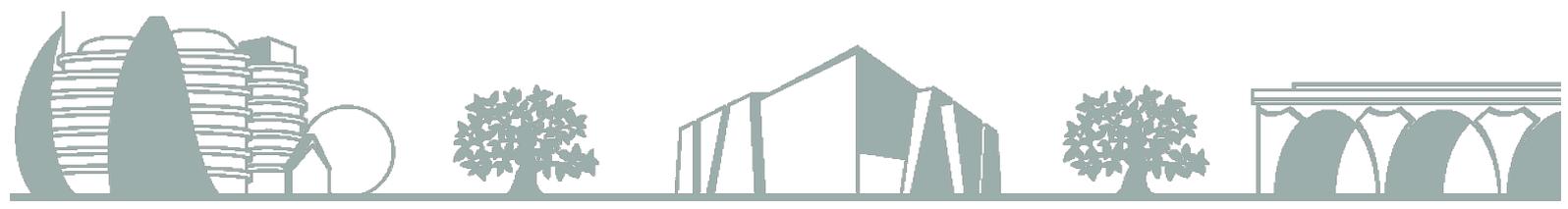
Fig. 3 - “3D Housing 05”, details of the 3D printed walls’ texture



Fig. 4 - “3D Housing 05” printing phase



Fig. 5 - “3D Housing 05” in Milan (Italy)



Next steps of research

The steps of the Italcementi research, following this first realization experience, involve both the development of formulations able to be processed by different extrusion 3D printing systems, and the study of solutions in which 3D Printing can be used for structural applications. With regard to this last aspect, the collaboration with MATERIAS and the Department of Structures for Engineering and Architecture of University of Naples "Federico II", and with its spin-off company Etesias s.r.l. is considered strategic for the development of new structural design concepts, as well as for the contribution to the appropriate definition of standards and regulations. The collaboration intends to bring innovation to the area of "personalization" of structural objects and, consequently, to the entire design process of the same. Moreover, downstream of the printing process, it is possible to realize real structural elements in reinforced concrete (i.e. characterized by the presence of metal reinforcement) through an assembly technique with the aid of steel devices that make the structure monolithic. Ultimately, this is a very peculiar and unique process of realization (design-to-product).

The control of the entire design-to-product supply chain enables the inclusion of intelligent devices in the production phase, for example, for structural monitoring or information exchange in an infrastructure network.

The use of 3D printing leads to a new culture of sustainable "building", a system of design and construction based on digital technologies that involves architecture and design studios, construction companies, research centers and universities.



Fig. 6 - 3D printed reinforced concrete curved beam (University of Naples)

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