

Heritage Recovery with 3D Printing

DETAILS

SECTOR | Transport, Energy, Water Waste

STAGE | Operations and Maintenance

TECHNOLOGIES | 3D Printing

SUMMARY

Heritage is often one of the treasures that humanity has a duty to preserve for the knowledge and enrichment of future generations, something that sometimes involves a compromise between the need to preserve it and to show it. We consider 3D printing we consider a very powerful tool, together with the help of scanner technologies, to achieve both objectives.

With the large scale 3D Printing technology with Concrete, we can reconstruct elements that were lost or damaged for different reasons, or totally or partially replicate heritage pieces (scale of choice), without the need to resort to skilled artisans, today difficult to find. This technology also helps optimize the consumption of material as well as the execution time of the replica, which undoubtedly constitutes a great contribution in this field.

Technology is capable of carrying out the entire process (scanning and printing of the model).

The phase in which the model to be printed is generated is very important for the final result. Here, Reality Capture technology manages to reproduce in the space with fidelity the geometry that you want to reconstruct or replicate, with advanced scanners that can achieve this objective at a very affordable cost and with significant time savings. These scanners are becoming increasingly competitive and improving its quality.

In turn, this capture must be treated so that 3D printing software can "slice" the figure correctly, for a correct impression. In this field we must say that there are significant advances that make this transition easier and faster, which undoubtedly contributes to reducing the impact that this task has on the total cost of the exercise.

Once we have the printing model, the technology that offers the best results for this type of reconstruction or replication work is that of Powder Bed in large-scale concrete. This technology offers us total freedom of forms, in addition to having a more than acceptable precision, and even in a very simple way to integrate in the final solution other types of solutions that lead us to increase this precision, such as subtractive printing, mix of elements in other materials, etc ...

One aspect to take into account is the transport of the final printed result. If the element to be rebuilt or replicated is of such a dimension as to pose a logistical challenge or an excessive transportation cost, we have different ways to solve the problem. We can choose to make the impression in smaller parts, and put them together on site as if it was a three-dimensional puzzle. Another alternative is to send the large-scale 3D printer to the place where we want to reconstruct or replicate, and print on site.

This use case is a contribution from the Government of Spain, with some adaptations from the Global Infrastructure Hub.

VALUE CREATED

Improving efficiency and reducing costs:

3D Printing is more efficient and less costly than conventional methods technologies because of its particular working process. Normally you would need formwork, especially when the element to replicate has complex forms, holes, etc. In these cases, we need the aid of an artisan to build the formwork that receives the mortar, with a significant impact on time and cost. With the 3D Printing process, no formwork is needed.

With Reality Capture it is a simple process to have the 3D model of a heritage element, insert it in a 3D Printing Powder Bed concrete machine, and build the element in concrete. We don't need an artisan. The element is formed here layer by layer, using only the material needed. The no hardened material around the printed element helps to hold it and this way, our Powder Bed machine has real free form manufacturing capabilities.



With the 3D Printing process construction, we arrive in two steps from the model to the real element with less people involved. It results in less time of working, thus more efficiency and lower cost.

Enhancing economic, social and environmental value:

From an economic standpoint, it is cheaper to use the 3D Printing technology to recover the heritage than conventional methods. Moreover, once we have made the 3D model, we can help preserve the element in a virtual way forever, using this model to make a Virtual replica that allows enjoy it in a virtual way, too. Further physical replicas can also be made on demand.

Social contribution is also an important input: helping preserve our culture for future generations is an example, bringing replicas to blind people that can touch and get to know heritage elements is another important benefit of this 3D Printing use case.

With 3D printing we come near to zero waste product generation in the construction process, as practically all the material we need for printing, and no hardened, can be reused. Constructing on site can also be a relevant environmental benefit of this technology, saving transportation impact.

POLICY TOOLS AND LEVERS

Legislation and regulation

To build a heritage element, the official entity responsible of the element has to give the permission to replicate it. Beyond this use case, the development of the concrete printing technique will need new building legislation and standards to be developed and help foster its normalization.

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Dubai may lead regulation set to use 3D printing in the construction industry, as Dubai Future Foundation has already announced.

A future-enabled workforce

This technology will coexist with the conventional methods of construction, and offer opportunities for many workers, architects, engineers, public and private Entities etc related with culture and the preservation of the heritage, boosted by the concept of a new way of enjoying it.

RISKS AND MITIGATIONS

Technology Maturity:

Technology is reaching maturity to fabricate in different types of materials, but further development of materials, machinery and new designing methods are still necessary, especially for concrete large-scale 3D printing.

Ensured Reliability:

This technology has proven its reliability for many use cases. Challenge is now set on large-scale printing, especially for structural elements.

Infrastructure Readiness:

Technology is commercially available: a high number of companies offer their own 3D printing technology, including printers and printing materials. New materials and use cases are under development.

For concrete 3D Printing, we find two main technologies: Powder Bed and Extrusion.

Powder Bed: This technology is based on printing 5mm full section layers. The process consists on extending one layer of dry material (paper) on which a printing head applies a binder (ink) on the corresponding section of a previously sliced 3D digital model.

Extrusion: This technology consists on the deposition of a mortar through an extruder following a predefined path, layer by layer to create exterior walls of an element to be filled later on with concrete.

Both are ready to print and give you a solution of build in concrete, but with differences.

“Powder Bed”



Extrusion



	Shapes. Free form	Main value	Performance
Singular construction, Preservation of historical heritage, Urban furniture, Sculptures		Products	Prefab walls, buildings, extruded shapes.
	Dry mortar + binder	Material	Extruded mortar
	Low	Presence on market	High
	High	Design capability	Limited
Modular and assembly on/off site		Execution	Modular or In situ

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EXAMPLES

ACCIONA has the technology capable of carrying out the entire process (scanning and printing of the model), the experience of six years of research and development around 3D printing within our 3D Printing Skill Center, and the recently inaugurated global 3D printing center in Dubai.

Some examples related to conservation and the recovery of lost heritage (non-exhaustive):

- **Replica of “The Bear & Strawberry Tree”. Madrid Emblem**
 - It represents in a real-life form the coat of arms of Madrid Emblem.
 - Original Sculpture located Puerta del Sol Square (Madrid, Spain).
 - Replica donated to Guadalajara (Mexico) in 2017
 - A bear that supports its paws on the trunk of a strawberry tree and the strawberry tree.
 - Author: Antonio Navarro Santafé. Year 1697.



- **Replica of Romanic Arc “Arco de San Pedro de Las Dueñas de Leon”**
 - Life-size replica of one of the reference elements of the National Archeologic Museum collection, a XII century Romanic arc fully preserved.
 - Both original and replica currently located at the Spanish Archeological National Museum (Madrid, Spain).



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