

ECO-HOTEL 3D PRINTING

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Abstract

The construction industry is constantly looking for new ways to improve project efficiency and profitability. Many new technologies are trying to revolutionize the world by using new technology and 3D printer devices to create eco-friendly and cheap hotels with a very low cost that build complex structures in the shortest possible time.

However, traditional building methods have remained relatively unchanged for decades. 3D printing (3DP) is a promising new technology that not only has this potential

It is an effective means to increase the efficiency and profitability of the project in this field, but it also has positive environmental effects. However, as it exists today, the technology is severely limited by size, materials, skilled labor, and industry reluctance.

This research emphasizes the new technique, potential and future applications of 3D printing in the construction industry of new hotels with environmentally friendly materials.

Keywords

3D printing hotels, 3D printing; Sustainable materials

INTRODUCTION

3D printing a technology known as “additive manufacturing,” which involves a layer-by-layer addition of material to form an object, referring to a three-dimensional file, with the help of software and a 3-dimensional printer.

This technology has been utilized for a wide array of applications. For example, the medical industry uses 3DP technology to produce high quality bone and joint transplants, as well as anatomical models for research and analysis purposes (Murray et al., 2015). Architects use 3DP to create complex 3D models for their clients, 3DP is even used in the aerospace industry to print airfoils (Thomas et al., 1996). In recent years, 3DP technology has gotten a lot of attention from the construction industry as a promising building method. However, the current state of 3DP technology possesses many limiting factors that effect its integration into the construction industry.

3D printer technology has made significant progress with increasing production in the past few years and is progressing in the field of building houses and objects and even medicine and food, and despite this research in the field of creating environmentally friendly hotels According to the geographical position and the choice of materials of that region, they should be built at a low cost, strong structures, and in any way that the designer designs it, the architects can build it. We introduce them.

Literature Review**3D PRINTING TECHNOLOGY****History of 3DP:**

In 1981 Dr. Hideo Kadoma of the Nagoya Municipal Industrial Research Institute developed a system of printing solid layers of quick-drying photopolymers that corresponded with a cross-sectional slice of a CAD model, he called it Rapid Prototyping (RP) (Fig. 1). Three years later, Charles Hull patented Stereolithography which is a technique that utilizes the reaction between a liquid photopolymer and a UV laser beam. When exposed to the UV light, the liquid photopolymer will instantly turn each layer into a solid plastic mold consistent with the shape specified by the 3D CAD model. In 1992, Hull’s company, 3D Systems, produced the SLA-1 which was the worlds first commercial Sereolithography Apparatus (SLA). That same year, Carl Deckard patented the Selective Laser Sintering machine

(SLS) which is a similar technology that utilizes a powder photopolymer reaction rather than liquid (Goldberg, 2014). Throughout the 90's and into the early 2000's, SLA and SLS was used primarily in the industrial manufacturing setting for casting small parts and components for a variety of plastic products. In 2005, ASTM recognized Additive Manufacturing (AM) as the standard term for all of these processes. ASTM defines additive manufacturing as "a process of joining materials to make objects from 3D model data, usually layer upon layer" (ASTM Standard, 2012.). 3DP is based on the AM methods.

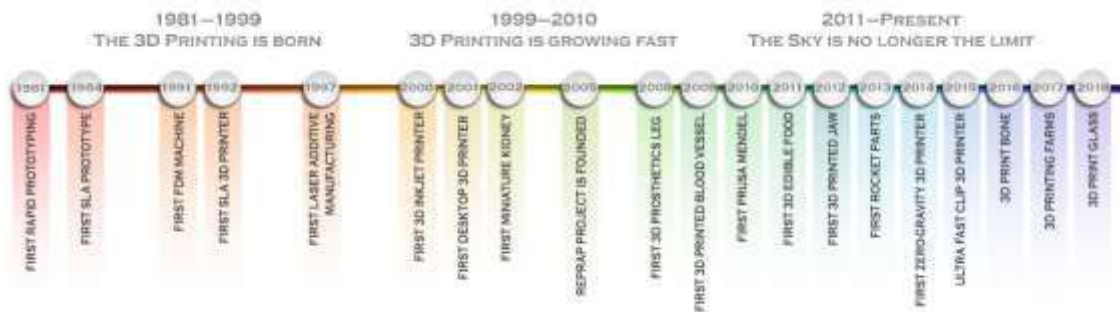


Fig. (1) 3D Printing History, from (<https://3dfusion.ro/3d-printing-history/>)

3D printing in Architecture and Construction

3D printing architecture models have become an interesting alternative. Typically, architectural models are made of cardboard, wood or other moldable materials. Architects need models to study the aspects of their design. 3D printing at a construction scale will have a wide variety of applications within the private, commercial, industrial and public sectors. Demonstrations of construction 3D printing technologies to date have included fabrication of housing, construction components (cladding and structural panels and columns), bridges and civil infrastructure, artificial reefs, follies and sculptures (Nithesh N, 2018).

Many architects and interior designers are extensively using 3D printing to create new and unique designs that give the overall ambience of a property with a truly modern and cosmopolitan look. With new design flexibilities with 3D printing, designers are now not constrained by any technical limitations for any object. They use 3D printed organic vessels made of salt polymers to indoor, while the exterior cladding is composed of polymer printed blocks Fig. (2). They can unleash the best of their creativity and make unique designs that were not previously possible with conventional manufacturing techniques (Naboni



Fig. (2) interior space made of 3d printed , from (<https://www.archdaily.com/890494/interior-design-and-3d->)

Fig. (2) Comparison of traditional construction and 3D printing construction process (Nadarajah 2018)

And Fig. (3) show the trend of publication outputs in 3DCP over the last 10 years

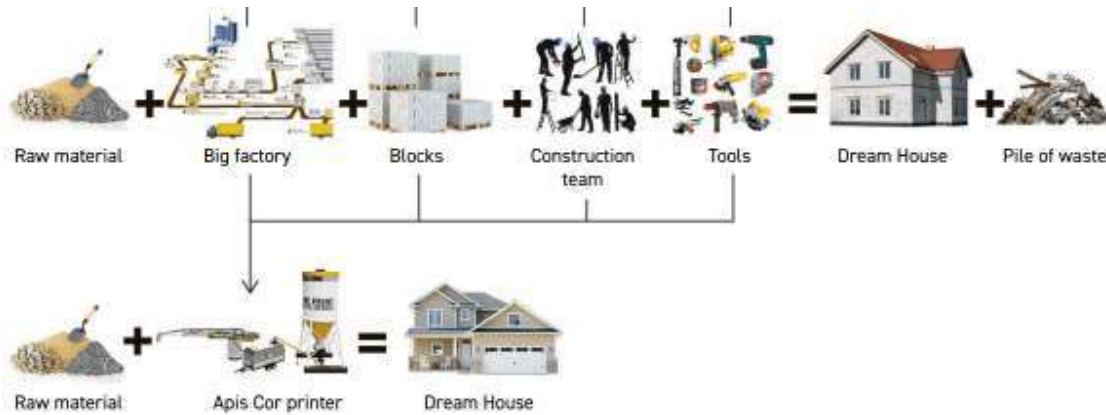


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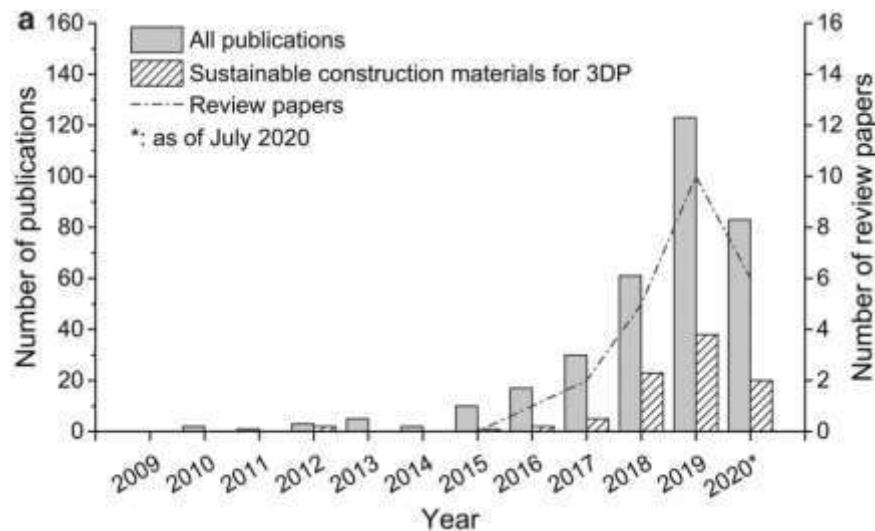


Fig. (3) Trend of publication outputs in 3DCP over the last 10 years, from <https://www.liebertpub.com/doi/10.1089/3dp.2020.0331>

Fig.(4) show the countries that generate the most publications and citations in the field, respectively. While the United States leads the world in total publications (63), it is the United Kingdom that has generated the most citations (2019). In addition to the United States, nine other countries have produced at least ten papers: Singapore (44), China (37), Australia (32), Netherlands (26), Germany (19), United Kingdom (19), France (14), Russian Federation (14), and Switzerland (10). In total, 41 countries are represented in the 297 papers included in this systematic review.

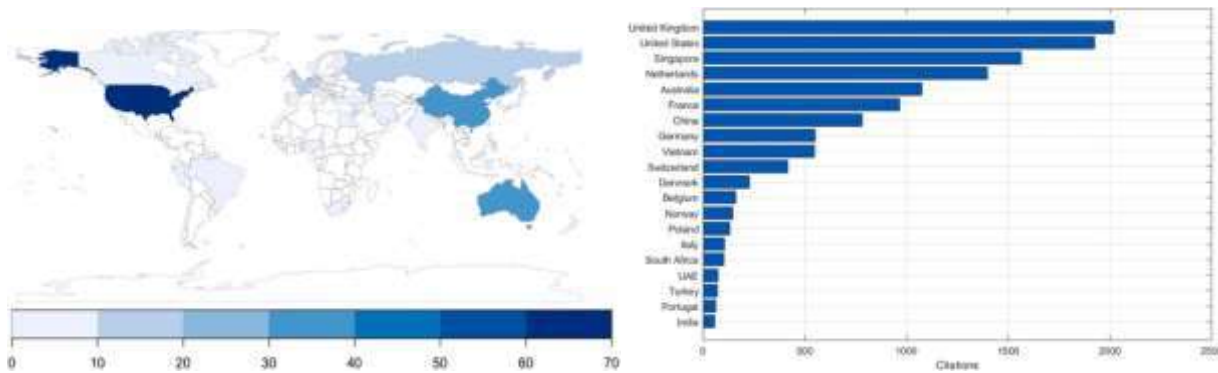


Fig.(4). Total publications by country. file:///C:/Users/PC/Downloads/2021_Jrnl_Schuldtetal._AIC.pdf

3D printing Types:

There are many different types of 3D printers, and today we will categorize 3D printers based on the way that the printhead moves. The two most popular types of printing systems are Cartesian and Delta, and new printing systems are constantly being developed (FabWeaver, 2022).



3d printing echnology or additive manufacturing has made significant progress in industries ranging from manufacturing to medicine in the past few years. The construction industry is one of the industries affected by this technology.

3D printer in construction

At the Southwest Conference and Festivals, ICON Construction Technology and the nonprofit New Story unveiled a \$10,000 3D printed house using the Vulcan ICON\$ 3d printer.They claim this is the first licensed home and compatible code in the United States, built using a 3D printer.

The Vulcan ICON 3D printer can print a 650 sq ft (64 square meter) house in 12 to 24 hours using a concrete mixture of layers of wall. Windows, ceilings, doors, plumbing and electrification are completed after printing is finished.



Fig.(5)3D printed house cost: \$10,000 Located: USA
The 12 Most Exciting 3D Printed House Builds 2022 - 3DSourced

The model they introduced at SXSW is used as an office. After developing and testing the materials, they hope to reduce production costs to about \$4,000 and possibly construction time to six hours. As part of their partnership, they plan to build 100 homes in El Salvador next year with the goal of providing housing solutions to underdeveloped communities around the world.

Using 3D printers in the construction industry

ICON is one of the new start-up companies that has not been established for a few years and hopes to make 3D printing buildings a reality. Companies such as Apis Cor, Technology Branch CyBe, Cazza, XtreeE and 3D Printhuset are other companies that operate in this field.

The use of 3D printers in the construction industry is still a fledgling technology. Many buildings produced with 3D printers have been used to demonstrate the stability of this technology. Currently, only a handful of 3D printed buildings are built for daily use or occupation. Winsun Inc. in China has built a number of bus stops and public restrooms with 3D printers. There is also an office building in Dubai and a residence in Russia built in this way. Last year, 3D Printhuset completed Building on Demand (BOD), a hotel office in Copenhagen. The office was created to comply with EU-made rules. The concrete mixture includes recycled tiles and sand to make the material more environmentally friendly.

3D printers and challenges ahead

Two major challenges are used in improving 3D printer construction materials and devices. Regardless of whether printing is done on or off-site, the 3D construction printer should be able to continuously and uniformly inject any layer of material. Gantry-style printers and multiaxial machines are two popular ways to create 3D printers in the construction industry. For on-site construction, the structure must be installed after printing and without any damage to the structure.



Fig.(6) 3D printing bulding - Bing images



Fig.(7) 3D printing bulding - Bing

The second most important challenge is obtaining the right mix formula for printing materials. Materials, which in most cases are some types of concrete mixtures, must be sufficiently resistant or dry at sufficient speed in order to support and bear the weight of each subsequent layer.

The developers of printed buildings must ensure that the materials of choice are suitable for the weather conditions and conditions in which the buildings are printed. The issue of durability, scalability and longevity of the building are other things that should be considered when choosing materials and devices.

The International Coding Council (ICC), one of the participating organizations working with America Makes and Additive Manufacturing Standardization Collaborative (ANSI), is developing a roadmap for standards and specifications for 3D printer use in a range of industries including construction. We hope this will lead to the ICC passing codes for 3D printed buildings.

Advantages of 3D-printed buildings

Some of the main advantages of using 3D printing in the construction industry are reducing the time and cost of construction compared to traditional construction methods. Also, creating less waste than conventional construction methods is another advantage of this method. The use of bioplastics or concrete made with recycled materials can make building materials environmentally friendly.

Another advantage of 3D printing is its endless possibilities for designing and façade. Architectural design using 3D printing technology is limited only by the architects' own imagination.

Low costs can be an important boon for affordable housing developers. There has even been research to use construction 3D printers for space exploration where structures are built on the moon and Mars using local materials.

Considering all the progress made in the field of 3D printing of construction, it seems that in the near future this technology will be recognized as a reliable and marketable method.

Types of 3D printer methods in the construction industry

Different types of 3D printing methods are used in the construction industry. This technology includes the following methods: extrusion or injection (concrete/cement, wax, foam, polymer), powder bonding (polymer bonding, reactive bonding, sedimentary) and additive welding. 3D printing in the field of construction includes a wide range of applications in the private, commercial, industrial and public sectors. The potential benefits of these technologies are: faster manufacturing, reducing production costs, increasing complexity and precision, and producing less waste.

Advantages of 3D printers in the construction industry



Fig.(8) 3D printing bulding - Bing This is the world's first 3D printed hotel.

Lewis Yakich hotel

Printing a Hotel Suite in 100 Hours

Hotel owner and materials science engineer Lewis Yakich worked with 3D printing specialist Anthony Rudenko to create the hotel suite. The two men worked together to design the massive 3D printer that spews out the concrete made from sand and volcanic ash.

"The Philippines is actually a great place for concrete printing because of the weather," says Yakich. "Currently everything is made out of concrete, and it's a third-world country so it can do a lot of good in disaster zones, etc." The resulting 3D-printed hotel suite houses two separate bedrooms, a living room, and spa complete with its very own 3D-printed jacuzzi. According to Yakich, the room should meet engineering standards, allowing the suite to be commercially operational.

In total, the suite took more than 100 hours to print.



Fig.(9) Hotel Is 3D Printed from Sand and Volcanic Ash - Bing



Fig.(10) [Hotel Is 3D Printed from Sand and Volcanic Ash - Bing](https://inhabitat.com/wp-content/blogs.dir/1/files/2015/09/Lewis-Yakich-3D-printed-hotel-suite-3-889x667.jpg)
<https://inhabitat.com/wp-content/blogs.dir/1/files/2015/09/Lewis-Yakich-3D-printed-hotel-suite-3-889x667.jpg>
their building which measures 10.5 m x 12.5 m (approximately 34.5 feet x 41 feet) in dimensions with a height of 3 meters (approx. 10 feet), making it about 130 square meters (1500 square feet). It is a two bedroom villa with a living room and jacuzzi room (with 3D printed jacuzzi), all of which will be part of the prestigious Lewis Grand Hotel. In all, the structure took approximately 100 hours of print time to complete, although the process was not a continuous one.



Fig.(11) Lewis Yakich exterior view



Fig.(12) Lewis Yakich interior view

At this time, the hotel suite is complete—but you won't be able to make a reservation just yet. It's still unknown when it will become open to the public or how much it will cost for a night.

This build was just the beginning for Yakich. He plans to use 3d printing to make a positive impact on the Philippines. In fact, he has secured permission from the government to build 200 3D-printed projects for low-income families.

Habitas Reveals New 3D Printed Luxury Hotel In Todos Santos, Mexico



Fig.(13) Habitas Reveals exterior view

Following two successful launches in Tulum and Namibia, the Habitas brand is now setting its sights on major expansion with its next stop being Mexico's Todos Santos. Located on Todos Santos beachfront, one hour from San Jose del Cabo airport, the new Habitas Todos Santos will span over 24 coastal acres. It marks the group's second Mexico location following the launch of its flagship in Tulum in 2017.



Fig.(14) A view of the beach

Offering 80 rooms to be released over two phases, highlights of the new property will be its stunning ocean-front pool, farm-to-table restaurant, holistic spa and organic herb garden. A broad range of programming will be available for guests including diving in Cabo Pulmo, trekking and mountain biking in Sierra de la Laguna, fishing excursions, surfing, Habitas' Sunset Sessions with bonfires, and Quetzal Sound Sensoroma (sound meditation).



Fig.(14) A view of the pool

The unique construction of the Todos Santos project is done using Habitas' innovative build model: 3D printing in its own factory and then assembling the hotel on-site using sustainable materials and building practices to ensure low environmental impact.



Fig.(15) A view of the buildings

Habitas is building the entire Todos Santos property in just four months and as with all of their properties, will operate under the Habitas flag as an experience and lifestyle brand focused on wellness, sustainability, community and experiences, redefining the concept of traditional luxury.

Oliver Ripley, CEO of Habitas co-founded the brand in 2016 alongside Eduardo Castillo and Kfir Levy, with their Tulum property launched in 2017.

BIG and ICON envision a 3D-printed campground for El Cosmico in Marfa, Texas



Fig.(16) A view of the buildings

Danish architects Bjarke Ingels Group (BIG), and ICON, a leader in advanced construction technology and 3D printing, have teamed up to work with hotelier Liz Lambert to rebuild and reimagine El Cosmico, a distinctive campground hotel in Marfa in Texas, with a vision to innovate luxury camping in the Texan desert. The proposed project aims to relocate and expand the campground to a 62-acre desert area, along with introducing a collection of radical new dwellings.



Fig.(17) A view of the buildings

Together, they plan to extend and rebuild the existing El Cosmico campground to showcase an entirely new architectural approach, made possible by large-scale 3D printing—including domes, arches, vaults, and parabolic forms.

"I have had a vision for the evolution of El Cosmico for many years that includes several spaces that add to the experience both for guests and locals—a pool, a hammam, and more space for art and skills-building workshops," mentioned Lambert in the official release. "In collaborating with the revolutionary thinkers at BIG and ICON, not only do I get to fulfil this dream, but we get to do it using this incredible 3D printing technology that marries the oldest principles of raw earth-based building with a futuristic technology that works more quickly, sustainably, and efficiently than modern construction. What's more, the innovation and beauty of the types of structures we can build extends far beyond the box. It's fitting that ICON has a contract with NASA to build the first dwellings on the Moon and on Mars. I am excited that we get to explore their incredible work right here in our own little cosmic landscape under the stars in far West Texas."

The El Cosmico project will comprise a campground, small circular and dome-topped vacation dwellings, and larger BIG-designed homes with up to four bedrooms that boast of expansive views of the Davis Mountains. ICON's proficiency in creating soft and curved surfaces makes this design come to life.



Fig.(18) The 3D-printed design is influenced by the desert and cosmos, resulting in a primitive architectural styleImage: Courtesy of ICON and BIG

"Our collaboration with El Cosmico and ICON has allowed us to pursue the formal and material possibilities of cutting-edge 3D printed construction untethered by the traditional limitations of a conventional site or client," said Bjarke Ingels, founder and creative director of BIG, which has its offices in Copenhagen and New York. "Liz Lambert's legacy for reimagining hospitality and her pioneering of a contemporary Texan aesthetic combined with the minimalistic nature and culture, art and landscape of Marfa has been the perfect fit to pursue a new architectural vernacular language for El Cosmico in Marfa. Organic shapes, Euclidian circular geometries and a colour palette born from the local terroir makes El Cosmico feel as if literally erected from the site it stands on," the press statement quoted him further.



Fig.(19) The project aims to explore the possibilities of 3D-printed constructionImage: Courtesy of ICON and BIG The construction process will use ICON's Vulcan 3D printing system, which uses a proprietary cement-like mixture called Lavacrete. ICON's 3D-printing technology will create curved, hut-like structures using a concrete mix resembling desert sand. The use of 3D printing will automate the construction process, similar to how it can be utilised for building structures on the Moon or Mars.

A 3D-printed performance pavilion will be built by El Cosmico in Austin, Texas, to mark the occasion, in collaboration with The Long Center for the Performing Arts. The Long Center was established in 2008, and has since become a cultural icon of Austin, encouraging innovation and creativity via its dedication to the arts community and bringing people together through one-of-a-kind events.

Opening this September, Kisawa Sanctuary on Benguerra Island in Mozambique will be the world's first ultra-luxury eco resort built using 3D-printed materials. Olivia Palamountain reports

Kisawa Sanctuary in Mozambique is redefining responsible travel quite literally from the ground up. In a purported world first, elements of this luxury retreat on Benguerra Island have been 3D printed in a sand and seawater mortar that fuses sustainability and tradition with technology.

Patented 3D sand-printing technology has been commissioned specifically for the project and used across various aspects of the build. The sand and seawater amalgamate provides a tactile, natural finish to the building façades and has also been used to generate 3D-printed components for flooring, tiling, and masonry.



Fig.(20) A view of the beach

A next-level environmentally conscious approach continues throughout the 740-acre property. Local artisans were commissioned to dress and furnish each of the 12 bungalows and the Kisawa Residence in a move that has created more than 1,000 jobs for the community – think carpentry details, textiles, thatched roofs and traditional Mozambican weavings.

Scheduled to open in September, Kisawa Sanctuary will offer guests maximum privacy, minimum disturbance and optimum appreciation for the natural environment. Each of the bungalows sits on its own one-acre beachfront plot, complete with a private swimming pool.



Fig.(21) A view of the buildings

In addition to private dwellings, guests can also choose between multiple dining venues across the Kisawa Sanctuary. This includes two beach clubs, a lagoon-style swimming pool, the Barraca beach bar, a library and a lounge at the main terrace.

The stand-alone spa specialises in traditional Chinese medicine and Ayurvedic offerings with striking architecture inspired by the island's thatched houses and community buildings.

At Kisawa there is no set schedule; guests decide their own agendas. Everything from dining hours, treatments and activities are customised to the needs of the individual.



Fig.(22) Lewis Yakich interior view

Determined that Kisawa should be a conservation sanctuary first and a luxury retreat second, founder and creative director Nina Flohr has brought her vision for the resort to life in partnership with nonprofit sister organisation, the Bazaruto Center for Scientific Studies.

This facility is dedicated to the preservation of the local subtropical ecosystem, and will also benefit from Kisawa’s groundbreaking 3D-printing tech, manufacturing coral reefs to reinvigorate marine habitats.

Flohr says: “My mission for Kisawa is to create a level of hospitality and design that, to my knowledge, does not exist today, a place that inspires feelings of freedom and luxury born from nature, space and true privacy,” she said. “We have used design as a tool, not as a style, to ensure Kisawa is integrated, both culturally and environmentally into Mozambique.”

Rates start from £4,500 per night for a one-bedroom Bungalow including a dedicated team of staff, private chefs, all food and beverage, all wellness and spa, hotel activities such as diving and marine safari, plus your own electric vehicle and e-bikes to navigate the property.

P R O J E C T I N	Building Name	Lewis grand hotel	Habitas reveals	El cosmico	Kisawa sanctuary
	Architect	Lewis Yakich	Oliver Ripley Kfir Levy Eduardo Castillo	ICON company	Nina Flohr
	Time of building	100 hrs	four months	-	-

F O R M A T I O N	Type	hotel	hotel	hotel	hotel
	Location	philippines	mexico	texas	Benguerra Island in Mozambique
	Height	12.5 m	3 m	3 m	-
	year	-	2017	2024	2020

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[Our Habitas Todos Santos | Our Home for Connection in Baja Sur habitastulum.com](http://habitastulum.com)

[Habitas Reveals New 3D Printed Luxury Hotel In Todos Santos, Mexico \(forbes.com\)](https://forbes.com)

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[Kisawa Sanctuary is the world's first resort built using 3D-printed materials \(globetrender.com\)](http://globetrender.com)