

3D Printing – Focus on homes, buildings, and large structures

What is 3D Printing?

2D printing on paper uses one or perhaps a few layers of ink.

3D printing (also known as additive manufacturing) is the construction of a 3-dimensional object with the help of computers.

One builds the structure by adding thin layers.

Subtractive vs Additive

Think of a sculptor who chips away at a block of marble vs building something by adding just what you want.

(Moving graphic)

The material used does not have to be Polymers (think plastics), but can be many things such as metals, cement, ceramics, and even wood.

What is the origin of the idea of 3D printing? Well, Science Fiction, of course.

Two books in 1945 and 1950 presented this idea.

Murray Leinster pen name of William Fitzgerald Jenkins

Things pass by (1945)

Raymond F. Jones *Tools of the Trade* (1950)

During the 50s, 60s, 70s and beyond there were some incremental improvements, but not much real progress.

What are the potential benefits?

Waste -think of the marble the sculptor chips away or the pile of waste materials at build site.

Transportation costs – Reducing the energy needed to move materials around the country or world.

Warehousing - no storage costs.

And there are potential environmental benefits linked to these three items.

What if you didn't need to build a bunch stuff, move it, warehouse it.

What if we could build on demand.

Some call 3D printing the next Industrial Revolution.

What do you do if it is difficult to get to the supply store?

Think of the International Space Station. They can't just drop down to the hardware store to pick something up.

in 2015 NASA did a test where they emailed the plans for a wrench to the ISS where they were able to print the wrench.

There are examples of 3D printing in many areas.

In 2015 the aviation industry used it to manufacture a 3D fuel injection nozzle.

It went from 20 individual parts to 1 with a 25% reduction in weight and the result was 5 times more durable.

Dr. Mary-Elizabeth Brown is a concert violinist who turned \$7 worth of plastic into a violin with a beautiful sound.

The health care industry has many examples.

One being a prosthetic limb made exactly for the intended person.

As you may have heard; guns can also be printed using 3D techniques.

These are sometimes known as "ghost guns" since they are untraceable.

Museums can Replicate artifacts by doing a 3D scan of the item and building a new one.

This eliminates the problems associated with making a plaster cast of the item.

Of course, you can then easily produce souvenirs.

The fashion industry has used 3D printing for some time.

Custom jewelry is just one example.

You can also make shoes, dresses, and frames for glasses.

3D printing has been used in the transportation industry.

It is often used to make prototypes and spare parts, but sometimes entire cars have been printed.

One example is a helicopter engine made with 16 parts instead of the usual 900 parts.

3D printing enables faster prototyping which reduces manufacturing costs, increases product customization, and improves product quality. It is also used to produce components with unique properties that are difficult to achieve using traditional manufacturing methods.

Depending on the technique and material used, you can also make hollow items instead of completely solid items, thus reducing raw materials and cost.

Even the food industry is getting into the act with 3D printed candies, crackers, and pizzas.

Of course, my personal favorite is chocolate.

Some printers use a continuous filament of a thermoplastic material. A filament is fed from a large spool through a moving, heated printer extruder head, and is deposited on the growing work.

Printers for this fused deposition modeling cost about \$2,000 10 years ago but are now less than \$200.

3D printing in the construction industry.

Some years ago I was in a board meeting when someone said: "You can always encourage kids to go into the trades instead of going to college. There will always be a need for building homes."

I wondered if this was true since I had just read an article about homes being built using 3D printers.

There are two basic methods of producing homes and other large-scale items. On-site and Off-site.

When working on-site, you set up the equipment where you want the building. However, you are dependent on the things like the weather.

With off-site production, you are usually working in a factory so you have much more control and can more easily add components such as rebar, electrical wiring, and plumbing.

At a plant in Germany, they can build a one square meter element every 5 minutes with only two operators.

There are three basic delivery systems for these large printers.

One is the gantry which sits outside of the work area.

Another is a cable system which also sits outside the work area.

And the third is a robotic arm which can be placed within the structure being built.

There are, of course, problems when working with something like cement.

Proper drying time is essential.

Various chemicals can be added to the mixture to eliminate this type of problem.

Aggregates (think stones) are added to cement for strength.

Of course, these stones should not be too big, or they will clog up the nozzle of the delivery system.

Much of the research and development into 3D printing for buildings is focused on these problems.

Here are some examples of 3D buildings.

In May 2016, a new office building opened in Dubai
This 2,000 square-foot structure claims to be the world's first 3D-printed office building.

In 2017 the first 3D printed home in Europe was produced.

One company is planning on building 100 3D homes in Georgetown, Texas.
Reservations began this year with prices in the mid \$400,000 range with 8 floorplans for 3–4-bedroom homes with 2-3 baths. These homes can be printed in 5-7 days compared to 16 weeks for timber frame homes built in the same area.

In 2020 this same company also completed seven 400 ft² homes for another city's homeless population. Each home was printed in 27 hours.

In 2021, Habitat for Humanity, the world's largest non-profit home builder organization, built two 3D printed homes in Williamsburg, Virginia, and Tempe, Arizona. The Virginia home was 1,200 square feet and printed in just 28 hours which is about 4 weeks faster than their usual methods. The 1,738 home in Arizona saved about 15% per square foot in building cost for the walls. The roof and some other components were completed by traditional methods.

It is not just concrete that can be used for building a home. A 600 square foot home named BioHome3D is entirely recyclable and bio-based made from wood fibers and plant-based resins.

It is not just a building that can be constructed with 3D printing. In 2021 a Dutch city completed the world's longest 3D printed concrete pedestrian bridge, spanning 95 feet. It was estimated that 3D printing saved about 50% in materials because the concrete was only placed where structural strength was actually required. The bridge was built offsite and later assembled on-site.

What does the Future hold?

3D building is in its infancy.

Think of the time when handheld calculators first came out.

They were big and clunky and cost over \$800.

Now they cost less than \$7.

There are major improvements coming every year.

Current claims of 10% - 30% cost reductions seem realistic.

It should also be noted that when they say a home can be build in x days, they are not counting the gantry setup time and perhaps some of the site preparation.

Some say environmental claims are overblown based on current materials and technologies.

Low-cost structures that can be quickly built can help for natural disasters, homelessness, and immigration.

The Tecla house can be used after a natural disaster or to house immigrants. Note that the name is a portmanteau of the words “Technology” and “Clay.”

It uses local clay and water with rice husk fibers as a binder.

This house made of clay also mitigates the carbon emissions problems associated with concrete.

This presentation started with Science Fiction, so we should end here too.

A moon base could be built with 90% local materials,
namely Regolith, which is the loose, unconsolidated rock and dust that is above the bedrock.

The structure would shield the astronauts from small meteorites, radiation, and temperature extremes.

Other techniques may not require any materials from earth.

An excellent resource to start with is Wikipedia.

But beware...

2017 military concrete Barracks Hut and bridge beams.

2017 The system can build homes, commercial buildings, roads and bridges.^[47] ARCS can complete projects from 500 square feet to more than one million square feet

Aggregates – not to big or clog nozzle (1/10 best)

ICON: 3D Printed Homes

<https://www.hp.com/us-en/shop/tech-takes/10-strangest-3d-printed-objects>