Futuristic Technologies in Construction

An electronic handbook
compiled and edited by
Asian Contractor Association
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Asian Contractor Association
2015 E. M Franklin Ave
Austin, TX 78723
www.acta-austin.com
asiancontractor@gmail.com
Tel: 512-926-5400

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Background

It's no secret that technology is revolutionizing literally every aspect of modern day life. The construction industry, continually being updated and upgraded with the latest technology, is one such example of this.

Technology in construction comes with devising innovative new ways of constructing and whilst the changing future of construction is largely unknown, there are some construction technology trends that are paving the way for certain futuristic construction technology.

So, what can we definitely expect the future to hold for construction? Here's ten futuristic construction technologies of the future for you to have a gander at.

Self-healing concrete

Millions of pounds are invested in maintaining, fixing and restoring roads, buildings, tunnels and bridges annually. This is because all concrete eventually cracks and needs to be restored. Self healing concrete would add years to a building's life and be an enormous help time-wise and financially.

The science behind this technological marvel shows itself when water enters a crack. This reactivates the bacteria that was mixed in during the mixing process. When the bacteria is activated, it excretes calcite which then heals the crack.

Invented over 2,000 years ago, concrete has consistently remained one of the most commonly used building materials. It is solid, durable, easy to mass produce, easy to maintain, as well as cheap. The downside? Concrete is susceptible to cracks that can compromise the entire structure of a building. If cracks aren't caught and filled while they're small, it can lead to catastrophic damages.

However, it seems the days of cracked concrete may be coming to an end. Scientists have revolutionized the industry with the development of self-healing concrete.

Everything You Need to Know About Self Healing Concrete

Over the years, scientists and engineers around the globe have experimented with various healing agents to perfect self healing concrete. Some of these healing agents have been bacteria, sodium silicate, and even fungus.

Bacteria-Based Self Healing Concrete

Self healing concrete was invented by Henk Jonkers, a microbiologist and professor at Delft University of Technology in the Netherlands. Jonkers began developing self healing concrete in 2006. After three years of experimenting, he found the perfect healing agent - bacillus.

"You need bacteria that can survive the harsh environment of concrete," Jonkers said in an interview with CNN. "It's a rock-like, stone-like material, very dry."

Bacillus is a perfect match for the job. The bacteria will thrive in the high-alkaline conditions of concrete and produce spores that can live up to four years without any food or oxygen.

Jonkers finalized his creation by adding calcium lactate to the limestone concrete mixture in order to feed the bacillus so that they can produce limestone to repair cracks in the concrete.

"It is combining nature with construction materials," Jonkers said. "Nature is supplying us a lot of functionality for free. In this case, limestone-producing bacteria."

Sodium Silicate-Based Self Healing Concrete

An engineering student with the University of Rhode Island, Michelle Pelletier, created a similar self healing concrete in collaboration with Arijit Bose, a professor of chemical engineering at her university. Their self healing concrete is inexpensive, utilizing a micro-encapsulated sodium silicate healing agent, according to an interview with Pelletier on New Atlas.

As cracks form in the concrete, these capsules rupture and release the sodium silicate. The healing agent reacts with the calcium hydroxide within the concrete, forming a calcium-silica-hydrate gel that repairs the crack and hardens in about a week.

Fungus-Based Self Healing Concrete

Taking inspiration from our own bodily functions, Ning Zhang of Rutgers University, as well as Congrui Jin, Guangwen Zhou and David Davies of New York's Binghamton University created a fungus-based self healing concrete, according to New Atlas.

Their concrete relies on spores from the Trichoderma reesei fungus. These spores remain dormant until the first cracks begin to emerge, at which that point they begin to fill these areas in.

The Future of Self Healing Concrete

As you can imagine, self healing concrete is a total game-changer. It gives us the ability to construct buildings without worrying about damages or intensive maintenance. Not only will structures benefit from self healing concrete, they are a wonderful solution for sidewalks. Smooth pavement can be laid down in cities and suburbs, without having to worry about wear and tear.

However, self healing concrete is still in the midst of being perfected. While it may be hard to get your hands on some self healing concrete at the moment, you

can expect it to dominate the industry within the next few years. In the meantime, there are recipes to create your own self healing concrete online.

One of the most commonly used building materials is once again revolutionizing how we build and design our infrastructures. With self healing concrete, wear and tear will no longer be a worry for concrete buildings or sidewalks. Although it is still in development, scientists are taking many different approaches to perfecting self healing concrete. Some of these healing agents have been created using bacteria, sodium silicate, as well as fungus.

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Tansparent Aluminium

Transparent aluminium is a bullet-proof new state of matter that is almost as strong as steel. Despite its herculean strength, it looks like glass which is four times weaker and shatters easily. Transparent aluminium is a new material and a see-through metal that is just breaking through the construction industry and adds a futuristic feel to buildings.

This new material is such advanced construction technology that it is made out of aluminium oxynitride (AION) and is created through the use of laser technology.

Oxford scientists have created a transparent form of aluminium by bombarding the metal with the world's most powerful soft X-ray laser. 'Transparent aluminium' previously only existed in science fiction, featuring in the movie Star Trek IV, but the real material is an exotic new state of matter with implications for planetary science and nuclear fusion.

In the journal *Nature Physics* an international team, led by Oxford University scientists, report that a short pulse from the FLASH laser 'knocked out' a core electron from every aluminium atom in a sample without disrupting the metal's crystalline structure. This turned the aluminium nearly invisible to extreme ultraviolet radiation.

"What we have created is a completely new state of matter nobody has seen before,' said Professor Justin Wark of Oxford University's Department of Physics, one of the authors of the paper. 'Transparent aluminium is just the start. The physical properties of the matter we are creating are relevant to the conditions inside large planets, and we also hope that by studying it we can gain a greater understanding of what is going on during the creation of 'miniature stars' created by high-power laser implosions, which may one day allow the power of nuclear fusion to be harnessed here on Earth.'

The discovery was made possible with the development of a new source of radiation that is ten billion times brighter than any synchrotron in the world (such as the UK's Diamond Light Source). The FLASH laser, based in Hamburg, Germany, produces extremely brief pulses of soft X-ray light, each of which is more powerful than the output of a power plant that provides electricity to a whole city.

The Oxford team, along with their international colleagues, focused all this power down into a spot with a diameter less than a twentieth of the width of a human hair. At such high intensities the aluminium turned transparent.

Whilst the invisible effect lasted for only an extremely brief period – an estimated 40 femtoseconds – it demonstrates that such an exotic state of matter can be created using very high power X-ray sources.

Professor Wark added: 'What is particularly remarkable about our experiment is that we have turned ordinary aluminium into this exotic new material in a single step by using this very powerful laser. For a brief period the sample looks and behaves in every way like a new form of matter. In certain respects, the way it reacts is as though we had changed every aluminium atom into silicon: it's almost as surprising as finding that you can turn lead into gold with light!'

The researchers believe that the new approach is an ideal way to create and study such exotic states of matter and will lead to further work relevant to areas as diverse as planetary science, astrophysics and nuclear fusion power.

A report of the research, 'Turning solid aluminium transparent by intense soft X-ray photoionization', is published in Nature Physics. The research was carried out by an international team led by Oxford University scientists Professor Justin Wark, Dr Bob Nagler, Dr Gianluca Gregori, William Murphy, Sam Vinko and Thomas Whitcher.

Transparent aluminum is a form of aluminum that is see-through.

Most commonly someone speaking about transparent aluminum is referring to AION (aluminum oxynitride), a ceramic alloy. However, aluminum can exist in an elemental, metallic form made transparent by bombarding with a soft x-ray laser.

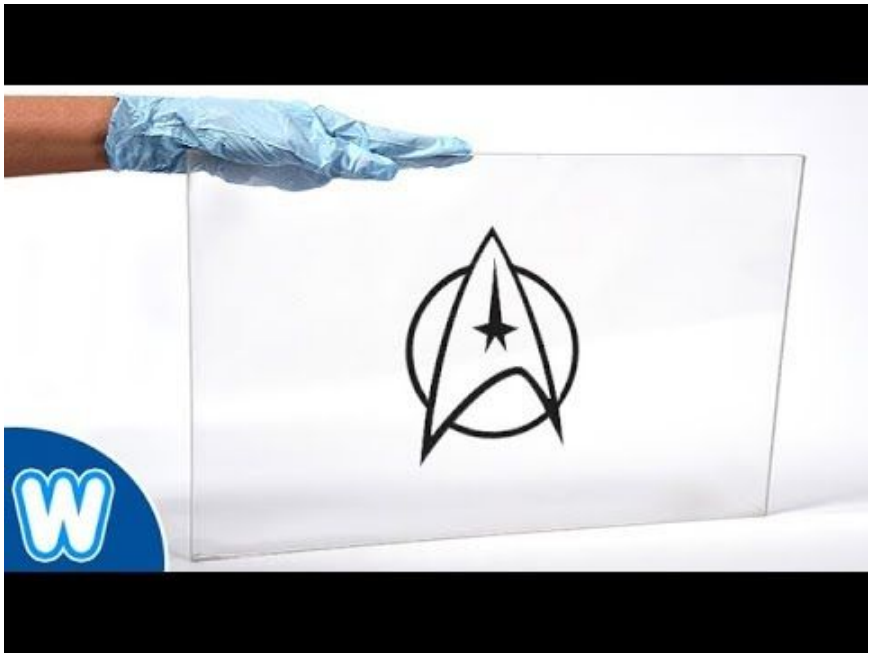
In Star Trek IV, the Enterprise's engineer, Scotty, barters with a materials scientist using his future-based knowledge of transparent aluminum, one-inch of material as strong as six inches of the their polymer-based material.

In reality, AION does represent a great increase in strength: applications in bullet resistant "glass" create transparent armor that can stop an armor-piercing .50

calibre round travelling 2700 feet-per-second, at less than half the traditional thickness of bullet-resistant glass that would fail to stop the same round. In this application, it is used as a layer in an AION glass and polymer sandwich.

AION is difficult to produce: aluminum oxynitride powder must be pressurized to 15,000 pounds per inch in rubber molds submerged in hydraulic fluid. Then the molded and still opaque material is heated to 2000'C and kept at that temperature for two days. The AION emerges transparent after cooling and is ready for a final grind and polish for extra clarity and strength.

It has been argued transparent metallic elemental aluminum was really what Scotty said was "the ticket, laddie." Even recently many claimed this material would never be a reality. Oxford University scientists claim to have discovered that aluminum subjected to brief pulses of the FLASH laser, focused down to an area smaller than a cross section of a human hair, made it transparent. However, the effect only lasted forty femtoseconds and each pulse of the laser required enough power to supply a whole city.



Aerogel Insulation

Sometimes known as 'frozen smoke', aerogel is semi-transparent and is produced by removing the liquid from a gel, leaving behind the silica structure which is 90% air. Despite being almost weightless, aerogel holds its shape and can be used to create thin sheets of aerogel fabric.

Aerogel fabric is beginning to be used within the construction industry, due to its incredible insulation properties. Aerogel insulation makes it extremely difficult for heat or cold to pass through and has up to four times the power of fibreglass or foam insulation.

Aerogels have been in existence for more than 80 years. Invented in 1931 by Dr. Samuel Kistler at the College of the Pacific in California, silica aerogel is a lightweight solid derived from gel in which the liquid component of the gel has been replaced with gas. When the liquid is removed, what remains is "puffed-up sand," with up to 99% porosity. The result is an extremely low density solid with several remarkable properties, most notably its effectiveness as a thermal insulator. Aerogels also have value in emerging applications such as energy storage, filtration and carbon capture.

The solids in silica aerogels are poor conductors, consist of very small, three-dimensional, intertwined clusters that comprise only 3% of the volume. Conduction through the solid is therefore very low. The remaining 97% of the volume of aerogels is composed of air in extremely small nanopores. The air has little room to move, inhibiting both convection and gas-phase conduction.

These characteristics make aerogels the world's lowest density solid and most effective thermal insulator. After many decades as a laboratory curiosity, Aspen Aerogels has successfully commercialized a technically and economically viable form of aerogel for industrial and building insulation uses. These developments represent the first application of our **Aerogel Technology Platform** based on silica aerogels.

Aspen Aerogels offers high performance aerogel insulation blankets for both hot and cold service applications. Our Pyrogel®, Cryogel® and Spaceloft® aerogel blanket insulation products have been widely used in industrial and building insulation markets for over a decade. Our unique patented process integrates aerogel into a fiber-batting reinforcement to create flexible, resilient and durable aerogel blankets with superior insulating properties.

The aerogel part of our high performance insulation blankets is comprised of synthetic amorphous silica (SAS). The other major ingredient in our products is a

non-woven, needled batting comprised of either E-glass fibers or a blend of polyester (PET) fibers and E-glass fibers.

Synthetic amorphous silica has been produced for more than 100 years for a variety of uses (adsorbents, fillers, anti-caking agents) and consumer products (toothpaste, cosmetics, food, animal feed). The US EPA recently listed synthetic amorphous silica as a chemical on the Safer Chemical Ingredient List, part of the Safer Choice program. The Safer Chemical Ingredients List (SCIL) is a list of chemical ingredients that the Safer Choice Program has evaluated and determined to be safer than traditional chemical ingredients.

Synthetic amorphous silica is oleophilic, so it readily absorbs the oils from your skin. This characteristic is why synthetic amorphous silica is used in cosmetics as an anti-sheen agent. For worker comfort when working with Pyrogel®, Cryogel® or Spaceloft® aerogel blanket insulation, we recommend safety eyewear, work gloves, long sleeves, and long-legged work clothes. Respiratory protection is recommended if dust exposures exceed occupational exposure limits. Aerogel dust is easily washed from the skin and clothing using soap and water.

Robotic Swarm Construction

Developed by researchers at Harvard, robotic swarm construction was designed based on how termites work. Termites work together like a 'swarm' and construction robotics are programmed to work together in this manner.

Four-wheeled robots are programmed in each instance to build a certain design and come with sensors to detect the presence of other robots, so that they can work together.
Robot swarm construction designed and developed in the Harvard University. Harvard University's "Self-organizing Systems Research Group" built and programmed the small construction robotics to work together as a swarm. The concept of this technology inspired by termites and their skill in constructing monumental pieces using mud. The Harvard robotics researchers followed the termites working style off without taking any orders from others to create this technology.

The robots (four-wheeled) used in this technology has the ability to build a brick-walls by lifting and laying the small bricks in the required position. With the help of sensors installed within their design, robots can detect the presence of other robots in their way. They also follow the rule of getting out of each other's way by using the sensors. Due to this application, there is no need for controlling operation for these robots. Like termites, no one needs to control them, but they only need programming to build the things in a proper design.

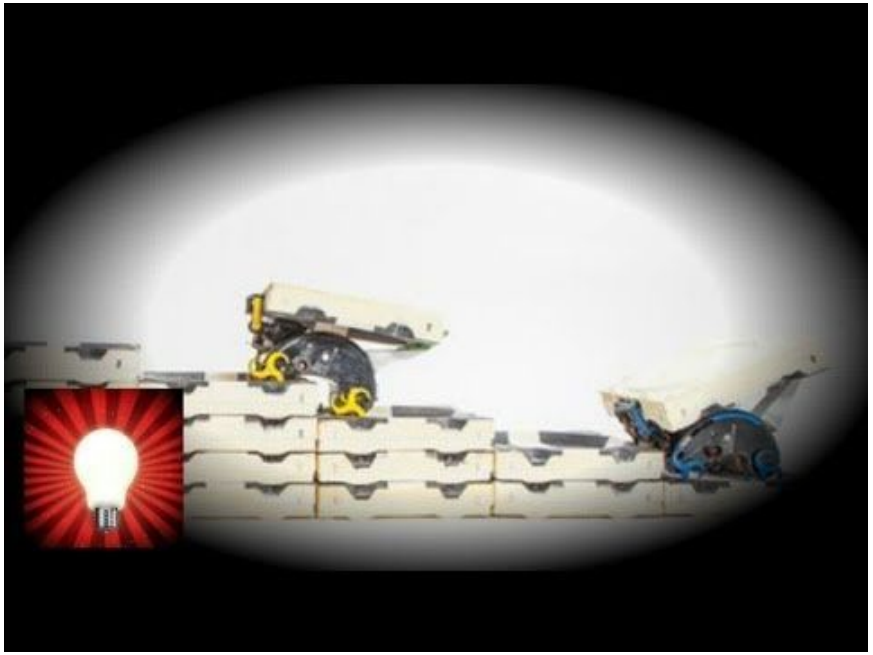
Design factors of Swarm Robots
The following factors have to consider to get the potential benefits from this technology:-

1. The actions and timing of robots are isn't always predictable. The robots should be correctly programmed to avoid these type of problems.
2. The hardware design of robots should be simple enough to construct a specific design.
3. The robot should have the ability to use sensors for manipulating and sensing their shared environment.
4. The robots should be self-controlled.

Applications of Swarm robots:

1. Construction of space station
2. Construction of deep underwater gas pipelines
3. Construction of brick towers.
4. Disaster rescue missions
5. Surveillance and environmental monitoring

Conclusion:
As this technology improves more, it will help us to build things where humans can't build those things easily. In the future, robot swarm technology will become an alternative solution to underwater construction, hold back floodwaters and others.



3D Printed Houses

3D printed houses are a glimpse into the future of construction. 3D printing homes will involve creating parts off-site and constructing the building on another occasion. It was pioneered by Apis Cor and based on San Francisco recently proved that they can 3D-print walls out of concrete in a relatively short space of time.

The 'printer', which is similar in look to a small-scale crane, sets layers of concrete mixtures. 3D printed homes could be a great solution for quickly covering the housing needs of people who have been affected by physical disasters such as tsunamis, hurricanes and earthquakes or for those in poverty.

Smart Roads

Also known as smart highways, smart roads are the future of transport and involve using sensors and IoT technology to make driving safer and greener. They give drivers real-time information regarding traffic information (congestion and parking availability for example) and weather conditions. This innovative technology can generate energy, charging electric vehicles on the move, as well as for street lights.

The road is an often-overlooked part of the modern transport infrastructure. We've all heard of self-driving cars, navigation apps, and ride-hailing services. But as it turns out, the road itself can be a platform for an amazing array of innovations. Roads can be upgraded with communication, lighting and power transmission technologies that can support sustainability, improve safety, and transform the driving experience.

What Is Smart Road Technology?
Smart roads use Internet of Things (IoT) devices to make driving safer, more efficient, and greener. Smart roads combine physical infrastructures such as sensors and solar panels with software infrastructure like AI and big data.

Smart road technologies are embedded in roads and can improve visibility, generate energy, communicate with autonomous vehicles, monitor road conditions, and more. Here are a few examples:

IoT connectivity: Cities can connect roads to IoT devices, and gather traffic and weather data. This type of connectivity can improve safety, traffic management, and energy efficiency.

Traffic management networks: For improving safety and reducing congestion. The network uses speed cameras to provide warning signs for hazardous conditions, and sends automated traffic diversion signals that control traffic.

Traffic lights optimization: Systems that use data from closed-circuit television (CCTV) cameras or smart vehicles to optimize traffic lights and update commuters on jams or bottlenecks.

Most transport-related smart tech focus on individual vehicles, although there have been major advances in technological solutions for smart infrastructure at scale. Worldwide experiments in Vehicle to Infrastructure (V2I), Vehicle to Vehicle (V2V) and Vehicle to Pedestrian (V2P) technologies are expected to make urban transport smarter.

From Sci-Fi To Reality: 7 Smart Road Technologies

1. Solar powered roadways

Photovoltaic cells are embedded within hexagonal panels made of tempered glass, which are used to pave roads. These panels contain LEDs, microprocessors, snow-melting heating devices and inductive charging capability for electric vehicles when driving. Glass is renewable and can be engineered to be stronger than steel, and to allow cars to stop safely even when traveling at high speeds. While this idea has gained widespread support, attracting over $2 million in crowdfunding, scalability is a challenge as it remains expensive.

2. Smart pavement

Specially engineered roadways fitted with smart features, including sensors that monitor and report changing road conditions, and WiFi transmitters that provide broadband services to vehicles, homes and businesses. The smart pavement can also charge electric cars as they drive.

3. Glow in the dark roads

Glowing markers painted onto existing roadway surfaces use a photo-luminescent powder that absorbs and stores daylight. The 500m long strips glow for 8 hours after dark. This technology is still in the testing phase, and the glow is not yet consistent, but it could be more cost-effective than traditional road lighting.

4. Interactive lights

Road lights activated by motion sensors to illuminate a particular section of the road as a car approaches. The lights dim once the car passes. Suited for roads with less traffic, interactive lights provide night visibility as needed and reduce energy wastage when there are no cars. One design, developed by the Dutch Studio Roosegaarde, uses wind generated by passing vehicles to power lights.

5. Electric priority lane for charging electric vehicles

Embedded cables generate magnetic fields that charge electric vehicles while driving. A receiver coil in the vehicle picks up electromagnetic oscillations from a transmitter coil embedded in the road and converts them to AC, which can then power the car. Inductive charging technology already exists for static cars, but future wireless technology could charge batteries while in motion.

6. Weather detection

Networks of AI-integrated sensors detect weather conditions that impact road safety. Road Weather Information Systems (RWIS) in use today are limited because they only collect data from a small set of weather stations. A larger future network could use automated weather stations to collect atmospheric and weather data and instantly upload it to the cloud. Dynamic temperature-sensitive paint could be used to highlight invisible roadway conditions like black ice.

7. Traffic detection

Data that helps travelers plan their routes. Sensors lining highways monitor traffic flow and weight load, warn drivers of traffic jams, and automatically alert the authorities about accidents. Fiber-optic cables embedded in the road detect wear and tear, and communication between vehicles and roads can improve traffic management. For example, Rapid Flow Technologies uses artificial intelligence (AI) to manage traffic lights, which respond to each other and to cars.

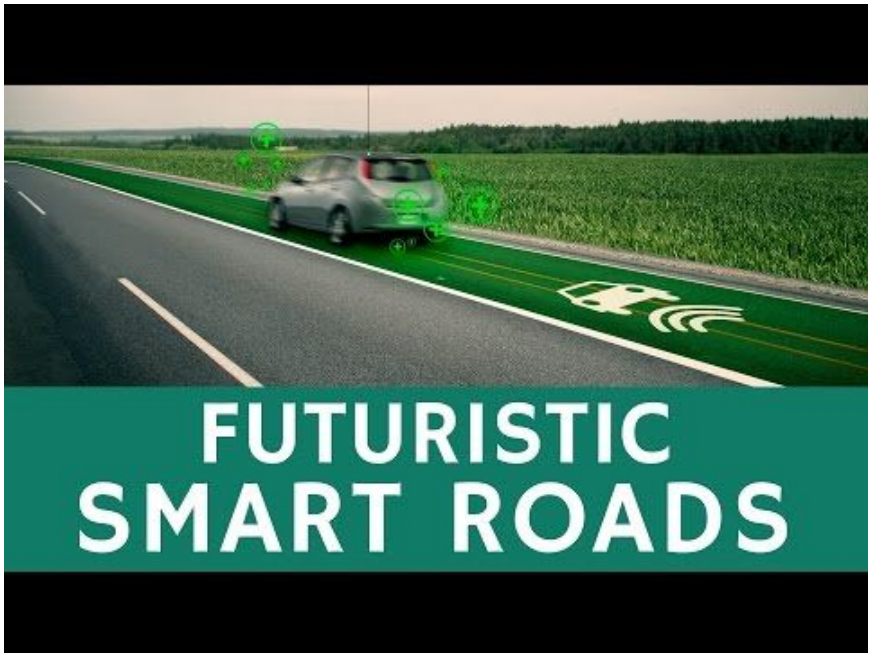
Encouraging The Adoption Of Smart Road Tech

Many governments and transport authorities understand the value of smart road technologies. However, developing smart city infrastructure at scale can be costly

and complex. Leaders can break down smart road projects into chunks, starting with low-investment, narrow-scale initiatives that can provide initial value, setting the stage for high-investment, large-scale efforts.

In the early days of motor-powered mobility, cars were available, but there was no suitable road infrastructure; the first private cars were hardly more effective than horse-driven wagons. Gradually, authorities recognized that only a major investment in road infrastructure would help the population reap the benefits of new transport technology.

Similarly, today's municipal governments and inter-city transport authorities should wake up to the importance of smart roads, as an essential platform for mobility innovation. Smart roads will power smarter cars, empower drivers, and provide governments with unprecedented visibility and control over the living fabric of motor-based traffic.



Bamboo Cities

Bamboo cities are cities made from innovative modular bamboo structures that interlock. It's a form of sustainable construction and a renewable resource that is stronger than steel and more resilient than concrete. The purpose is to hold a new community in the trees and as the number of inhabitants increases, the structure will extend to accommodate this.

As the structure extends to accommodate the number of people, it grows in strength. Modular structures are incredibly scalable and can grow in any direction, making it perfect for a city in the trees. Another added bonus – they can resist earthquake tremors due to bamboo's high flexibility.

Bamboo might just be the perfect natural building material. It's abundant: The plant can grow up to four feet per day, and, when harvested, it regrows without having to be replanted. Not to mention, it's two to three times stronger than steel. But few architects have explored the plant's untapped potential as a construction mainstay. Enter Penda, a Beijing- and Vienna-based architectural firm that has been perfecting its blueprints for a modular bamboo structure for several years. The firm, founded in 2013, first unveiled plans to use bamboo for a project called One with Birds, which featured a hotel comprising bamboo tents and towers, inspired in part by tepees constructed by Native Americans. The basic tent unit, built using an X-shaped bamboo joint fastened with rope, can be articulated horizontally and vertically.

Construction is relatively simple, requiring very little equipment. Even the scaffolding needed for building a bamboo tower can be made using bamboo. The benefits of bamboo structures, however, are greater than just construction ease. In many parts of the world, bamboo is readily available, replenishable, and, compared with other building materials, negligibly expensive. When growing, the plant releases nearly 35 percent more oxygen and absorbs nearly 35 percent more carbon dioxide than most trees. Canes from one building can be reused several times over in other projects. Bamboo structures can also be easily deployed as disaster shelters to many regions of the world.

But Penda's vision is even grander. The firm imagines an entire city built with its bamboo modules. By using the designs from its hotel concept, Penda estimates that a city of 200,000 inhabitants could be built by 2023 using a sustainable scheme for planting and building. Harvesting from 250 acres, the city builders would plant two canes of bamboo for each one they cut down for use in their city. The pace at which construction is completed is crucial to ensuring that the project makes as little environmental impact as possible. In late 2015, Penda built its first prototype, called Rising Canes, for Beijing Design Week, so perhaps soon bamboo structures will sprout up around the world.

Smart Bricks

Smart bricks are modular connecting bricks and are similar to ‘Lego.’ Made out of high strength concrete and developed by ‘Kite Bricks’, smart bricks are versatile and come with substantial thermal energy control and a reduction in construction costs. As they are modularly designed, they are easy to connect and have space for insulation, electricity and plumbing.

Brick has been a reliable construction material for centuries and has proven itself time and time again. There is no shortage of brick structures around the world still providing good service; brick is beautiful to look at, it has excellent sustainability credentials and it’s hard to beat on price.

However, now this construction material we have trusted for thousands of years is going through an age of reinvention. These energy-generating “smart bricks” are said to turn ordinary buildings into efficient, living machines.

Designed to self-adapt to changing environmental conditions these “smart bricks” will monitor and modify air in the building and recognise occupants.

If that sounds more like science fiction than reality, it really isn’t.

The re-invented bricks, developed by a team of scientists from the University of the West of England, also up their game in the sustainability field as they are capable of recycling wastewater and generating electricity from sunlight. They will be able to fit together and create 'bioreactor walls', which could then be incorporated in housing, public building and office spaces.

The smart living bricks will be made from bio-reactors filled with microbial cells and photosynthetic organisms. Each brick will contain Microbial Fuel Cells (MFCs) containing a variety of micro-organisms specifically chosen to clean water, reclaim phosphate, generate electricity and facilitate the production of new detergents, as part of the same process.

The MFCs that will make up the living engine of the wall of smart bricks will be able to sense their surroundings and respond to them through a series of digitally coordinated mechanisms.

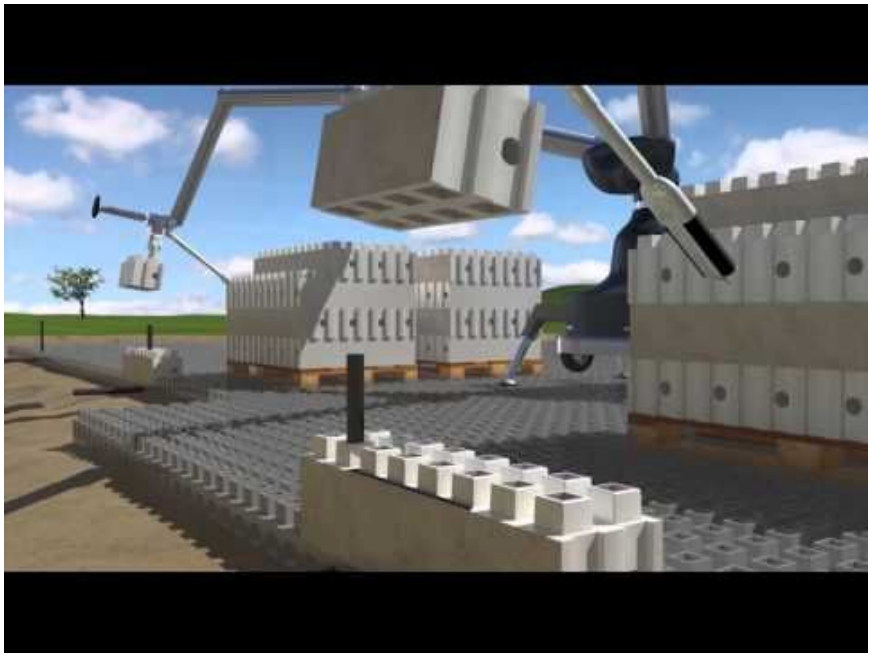
Imagine each smart brick as an electrical analogous computer; a building made of such bricks will be a massive-parallel computing processor.

Walls in buildings comprised of smart bricks containing bioreactors will integrate massive-parallel computing processors where millions of living creatures sense the occupants in the building and the internal and external environmental conditions.

So what does this mean to the buildings we live and work in? Well, it turns out it could mean quite a great deal.

These living bricks may eventually transform homes and office buildings with a more sustainable approach to construction and building functions, with the MFC modules made into actuating building blocks as part of wall structures. This will allow us to explore the possibility of treating household waste, generating useful levels of electricity, and have 'active programmable' walls within our living environments.

These technologies could completely transform the places where we live and work, enabling us to not just use our buildings but to co-live with them. Instead of mere dwellings, our buildings would be more like large-scale living organisms addressing all environmental and energy needs of their occupants… namely, us.



Vertical Cities

Vertical cities may soon become reality as the world's population grows and land increasingly becomes scarce. They are tetris-like buildings of towers for thousands of people to inhabit. Supporting an blooming population, vertical cities are a space-saving solution to preserve land for food, nature and production.

Pollution Fighting Buildings

Also known as 'vertical forests', they are high-rise forest buildings designed to tackle air pollution. Pollution fighting buildings will be home to over 1,000 trees and 2,500 shrubs to absorb pollution in the air and to help filter it to make the air cleaner. Trees are highly productive in absorbing carbon dioxide, making this a cost-effective construction innovation.

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4201 Ed Bluestein Blvd., #2105, Austin, TX 78721
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www.acta-austin.com
asiancontractor@gmail.com

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