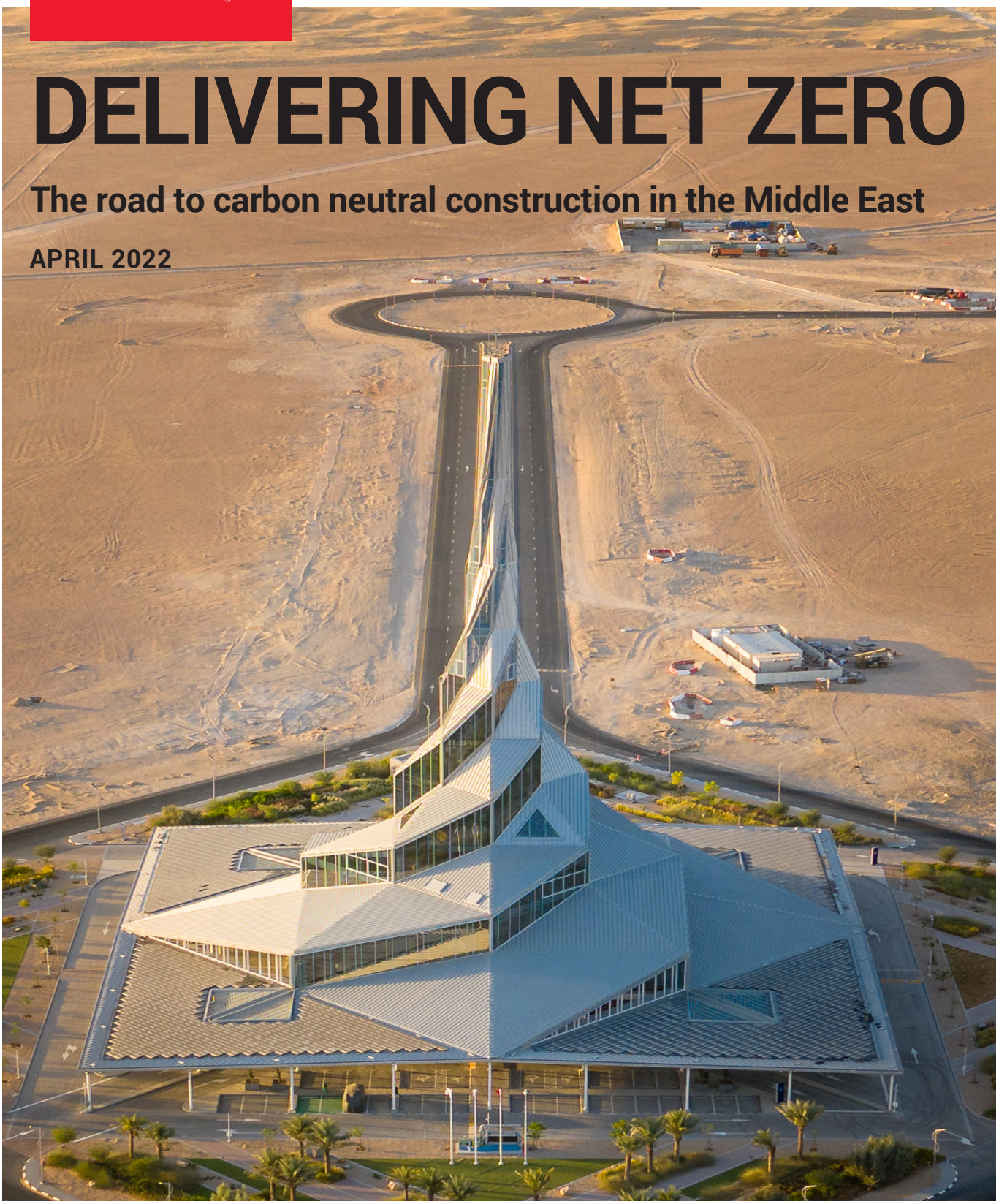
MEED
Middle East business intelligence

DELIVERING NET ZERO

The road to carbon neutral construction in the Middle East

APRIL 2022



AUTODESK

Building information modelling (BIM) is a relatively recent technology within the construction industry that, when properly introduced, can result in more efficient design practices

BUILDING A LOW CARBON FUTURE

Driving the shift towards a sustainable, efficient and resilient projects industry

Sustainable development cannot be achieved without transforming the way we build and manage our urban spaces. According to the United Nations Development Programme (UNDP), the world's urban population is expected to reach 6.5 billion by 2050, and although cities occupy just 3 per cent of the earth's land area, they account for 60-80 per cent of energy consumption and at least 70 per cent of carbon dioxide emissions.

Countries such as Saudi Arabia, the UAE, Bahrain and Qatar have pledged to decarbonise their economies. A major step in this direction is the Dubai 2040 Urban Master Plan, which maps out a comprehensive plan for sustainable urban development in Dubai.

Saudi Arabia has created a National Transformation Project to integrate sustainable development goals into its Vision 2030 national planning process. Qatar is also undergoing a massive change for the upcoming FIFA 2022 World Cup and ensuring the stadiums are being built in an energy-efficient manner.

In addition to these initiatives, the next two instalments of the UN climate change conference – Cop 27 and Cop 28 – will take place in Egypt in November 2022 and in the UAE in November 2023, reiterating this region's commitment to decarbonisation and sustainable development.

According to the UNDP, making energy greener could increase global GDP by $98 trillion by 2050. Embracing a circular economy where used goods are re-used, recycled and upcycled at greater value has the potential to create 6 million jobs.

Technology and innovation play a key role in a country's economic progress and in ensuring sustainable development. Additionally, new technologies are transforming the design and construction process and helping to reduce waste and mitigate environmental impact.

Building information modelling (BIM) is a relatively recent technology within the construction industry that, when properly introduced, can result in more efficient design practices.

As an example, the energy analysis performed with BIM-based simulations can provide design alternatives ahead of the final execution, which makes the building energy-efficient and saves both time and money.

It also ensures faster and more predictable time to market with lower costs and lower impact on the environment. In order to make the most of these new technologies, companies must invest in reskilling and upskilling their workforce.

There is a clear urgency for regional firms to prioritise environmental sustainability within their business strategy and rethink traditional approaches to derive better outcomes from value-driven data analytics.

Stakeholders in both public and private sector must work together to accelerate the pace of change and leverage technology solutions at scale.

“Technology and innovation play a key role in a country's economic progress. New technologies are transforming the design and construction process and helping to reduce waste and mitigate environmental impact.

OPPORTUNITY FOR CHANGE

The drive to decarbonise the economy is set to transform the project industry in the region

Reducing carbon dioxide emissions in buildings is critical to achieving net-zero objectives. As the biggest consumer of raw materials, generating between 25-40 per cent of the world's carbon dioxide emissions, the buildings and construction industry is vital in the global drive to achieve net-zero carbon by 2050.

But the challenges in reaching a net-zero, energy efficient and resilient buildings and construction sector are considerable.

According to the World Economic Forum, buildings represent 39 per cent of global greenhouse gas emissions, including 28 per cent in operational emissions and 11 per cent in building materials and construction.

Image source: www.mbrsic.ae

Dewa's Solar Innovation Centre is the world's largest single-site solar park and holds platinum rating from LEED (Leadership in Energy and Environmental Design).

The signing of the Paris Agreement in 2015 was a landmark moment in global efforts to address climate change. In order to meet the targets set in this agreement and subsequent UN 2030 Agenda for Sustainable Development, the World Green Building Council has set a route to net-zero carbon that relies on 100 per cent of new buildings operating at net-zero carbon by 2030 and 100 per cent of buildings operating at net-zero carbon by 2050.

Cost of materials

One of the long-term consequences of the Covid-19 pandemic has been the severe disruption in the supply and distribution of materials and goods. The sudden surge in demand caused by the lifting of the pandemic restrictions has caused prices to rise and is creating a demand-supply disbalance.

This means that industry stakeholders must explore smarter ways to manage construction materials and reduce waste.

Green building is often perceived as an expensive luxury owing to the misconceptions surrounding the actual cost of green buildings compared to their conventional counterparts.

"One of the industry's misconceptions is that the investment is higher in green buildings," says Anas Bataw, director of the Centre of Excellence in Smart Construction (CESC) at Herriot Watt University – Dubai.

Citing a study by the World Business Council for Sustainable Development (WBCSD), Bataw adds that the cost of installing green building features and technologies is significantly overestimated as the research participants perceive the upfront cost of a green building to be higher than that of a traditional building.

But this is not the reality. In fact, according to the US Green Building Council (USGBC), the initial cost of developing a green building is only 2-3 per cent

higher than its conventional counterpart. Further, the initial cost of incorporating green building features is often balanced by the savings in operation and maintenance cost, as they are designed to operate more efficiently.

"The traditional approach of looking at built assets as a capex investment alone is like considering only part of the story and we need to consider costs in the context of the whole life cycle," says Christopher Seymour, managing director - Middle East at Mott MacDonald.

Seymour explains that building sustainably at the beginning of the last decade meant attracting a capex premium, and costs could increase by over 15 per cent just to achieve a LEED Gold standard rating.

"This is not the case anymore. Cost is no longer a valid reason to not design and build in a sustainable manner. The fact is that most building codes now demand sustainable architecture and as such the capex cost of achieving it is a moot point," he adds.

Timely adoption and investment have a huge role to play in creating savings in the project life cycle and this where the cost argument becomes more critical. Very often more investment in assets at the front end of a project will create a more sustainable and lower cost outcome.

Embracing new alternatives

Covid-19 has turbocharged the digitalisation of the region's construction industry, and project sponsors and construction clients today, expect digital data and smart technology to drive efficiency, safety, sustainability and whole lifecycle profits.

The adoption of technologies such as 4D and 5D building information modelling (BIM), digital twins, cloud-based project controls, artificial intelligence (AI), robotics, 3D printing, internet of things (IoT) and big data analytics has become essential to remain competitive in the market.

There are several technical, social and management challenges facing the construction sector, says AESG's chief executive officer, Saeed Alabbar, particularly when technologies are not adopted at the beginning of a project as a solution to achieve clearly defined sustainability goals.

He adds that the technologies needed to achieve the net-zero goal already exist, and the need of the hour is to focus on adopting practices that help improve efficiencies and reduce operational costs.

"BIM is definitely leading the charge in digital construction. It is a key technology that helps streamline several aspects of the design process to push the performance of the building envelope. And the next step beyond BIM is leveraging the digital twins," says Alabbar.

"Principally technology plays a vital part in the drive to sustainable architecture through the creation of sustainable solutions and building components," adds Seymour.

"The pace of development that we now see in the market would not have been possible without technology, and the previous comparatively slow development is partly due to the lack of technological development in this industry. Now every solution has a technology angle but technology alone is no longer a defining factor. Thus, the task now is more about embracing new alternatives and rewarding innovation," he explains.

Norway's Route E39 Coastal Highway Project

- The Norwegian road authority leveraged emerging technologies and BIM techniques for the design and construction of Route E39.
- This $490 million project automated close to 70 per cent of design updates when changes occur.
- The project set strict criteria for the model-based digitalisation with BIM level 3.

20% reduction in the project's carbon emissions associated with construction

70% design updates were fully automated resulting in reduced clashes and increased accuracy

90% reduction in the number of traditional drawings printed and produced on a similar scale

Source: NorConsult

Opportunities with Tech Adoption

- Developing building information modelling (BIM) systems
- Employing low-cost, sustainable building materials and autonomous construction equipment
- Using drones and wearables at construction sites
- Applying Augmented/Virtual/Mixed Reality in design and development
- Leveraging smart signaling systems and predictive monitoring
- Using nanotechnology to develop smart materials

Source: Frost & Sullivan

Dubai's 3D Printing Strategy

- 25 per cent of buildings in Dubai to be 3D printed by 2030
- Initiative aims to exploit technology for the service of humanity and promote the status of the UAE and Dubai as a leading hub of 3D printing technology
- 3D printing technology is expected to reduce construction costs by 50-70 per cent, and labour costs by 50-80 per cent
- The value of the 3D printing technology based construction sector in Dubai is expected to be about AED3bn by 2025
- Use of technology will help lower costs, reduce project implementation time and manpower requirements as well as waste generated from construction which can be harmful to the environment.

Source: Wam

Better design and new technologies provide the means to build more sustainably. The potential of thinking differently is highlighted in recent research by Dr Karthikeyan Kandan, a senior lecturer in Mechanical Engineering at De Montfort University Leicester (DMU). in which he developed a new type of brick made from plastic waste.

The brick will provide 10 times better insulation than traditional bricks made from clay and has been created using 3D printing and lattice architecture technologies, which involves criss-crossing strips of the plastic materials to form a grid or weave.

"The Baya weaver bird's nest's ingenious construction gives it excellent thermal insulation and mechanical properties for inhabitation," explains Dr Kandan. "Inside there is a central nesting chamber, which makes it the ideal micro-climate for inhabitation. By replicating this structure, we have manufactured a brick that improves energy efficiency of modern buildings and therefore can reduce carbon footprint."

Government role

The UAE and Saudi Arabia are leading the decarbonisation of the region and are rushing to switch to renewable energy and nuclear power, while also exploring pilot projects in the hydrogen field.

Several decarbonisation projects are underway in the neighbouring countries as well, particularly in Egypt, Jordan and Morocco.

"Sustainable construction practices are no longer considered a luxury but are the need of the hour. In the Middle East specifically, there have been a lot of changes over the years owing to factors such as rapid urbanisation, population increase, staggering amounts of energy being used, and high emission levels," says Bataw.

Government mandates and policies play a leading role in pushing the sustainability and decarbonisation agenda. Decarbonising the economy is at the top of the regional policy agenda and is set to transform project delivery in the region.

"The role of government is key in the digital and sustainability story both as a regulator and as a client. As a regulator, the government can steer the industry towards digital and sustainable solutions and as a client it can make markets and create demand. The private sector needs to stay ahead to remain relevant and to survive and in this way the market ecosystem works to everyone's benefit," adds Seymour.

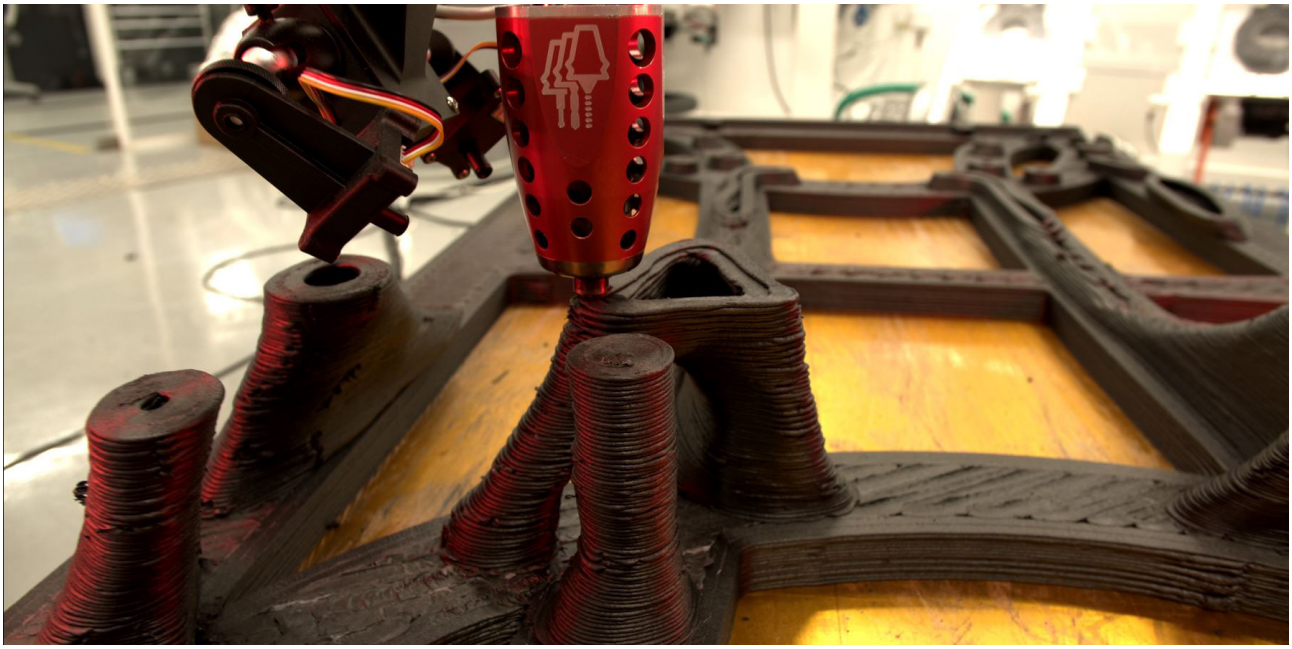


Image source: Dar

The smart bridge was created using a robotic arm with a customised end-effector for printing fibre-reinforced polymers.

STEPS WITHOUT FOOTPRINTS

New building techniques and advances in materials are disrupting the construction industry

In addition to being a huge consumer of energy and raw materials, the construction industry is a major producer of greenhouse gases and solid waste. These factors combined with scarcity of natural resources and the limited availability of skilled construction labourers, have made it critically important to explore new ways of creating our built environment.

Design and engineering consultancy Dar wanted to break out of the established constraints of traditional construction and design for more sustainable and innovative construction. This led the company to seek digital manufacturing methods harnessing artificial intelligence (AI) and data capture in design and project delivery and using automation with robotics to increase efficiencies.

Digital technology provided Dar with the opportunity to adopt processes and material with lesser embodied carbon. Meeting such a goal, however, requires merging numerous technologies with extensive research work to generate new concepts, and that can be achieved best through concerted collaborative work with other technology leaders.

Generative design

The use of emerging technology is facilitating collaborations, ensuring that there is faster and more predictable time to market with lower costs and lower impact on the environment.

After collaborating on several technical programmes, Dar and Autodesk decided to join forces to create a smart 3D-printed pedestrian bridge that was made using sustainable material - the Dar Smart Bridge.

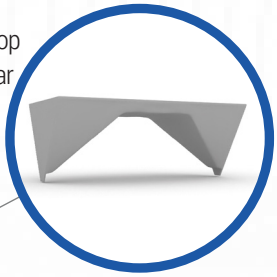
"We worked on a generative design approach coupled with an intelligent self-learning manufacturing system to transition from traditional construction processes to an AI-driven process," says Ghassan Zein, senior associate and design application manager at Dar.

DAR SMART BRIDGE

The Dar Smart Bridge is a two-metre interactive pedestrian bridge made from fibre reinforced polymer (FRP).

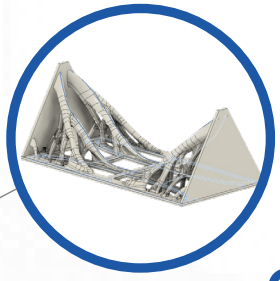
MARCH 2019

Onsite workshop to introduce Dar to generative design software tools



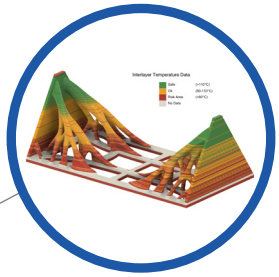
MAY 2020

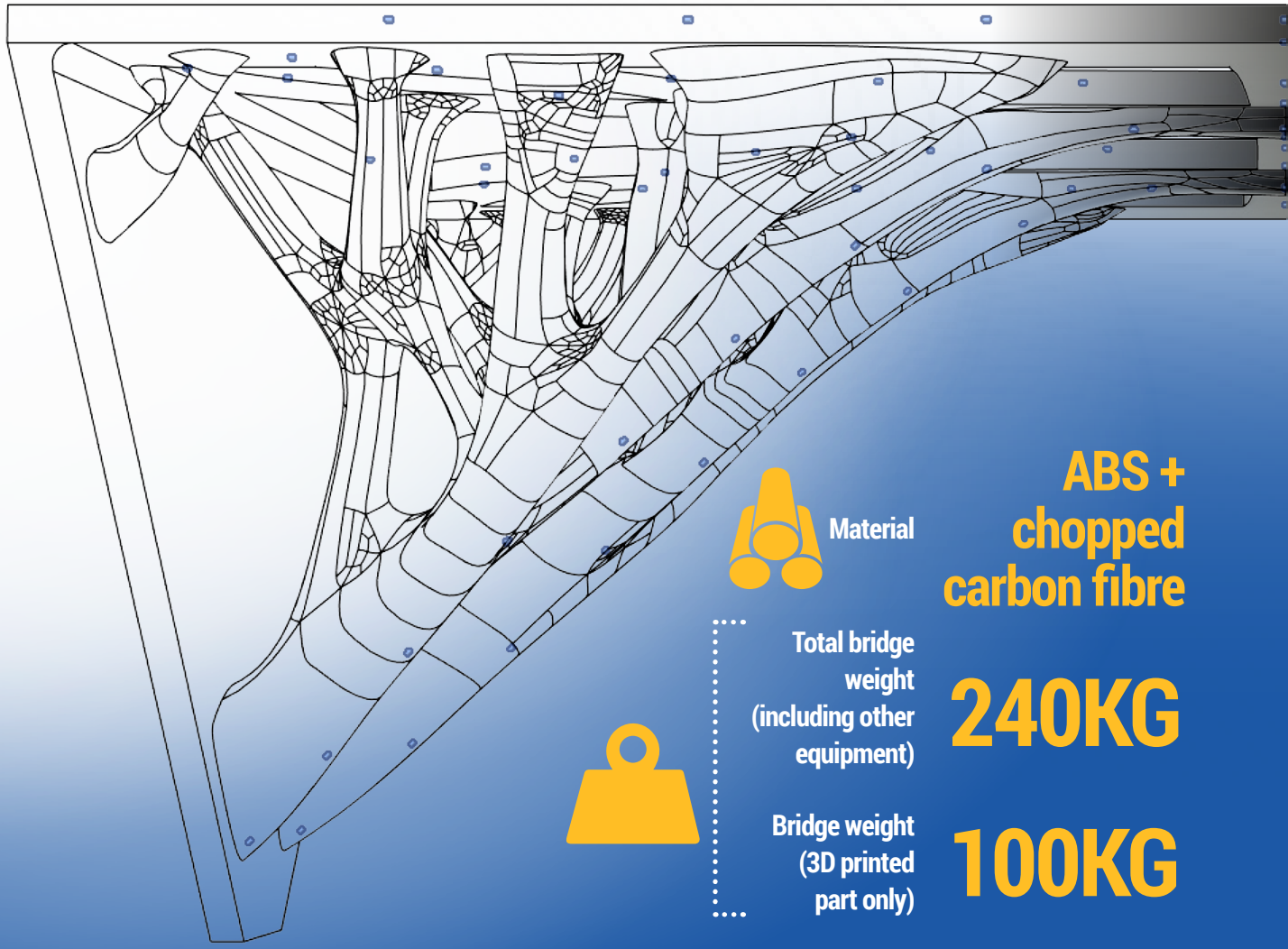
Project kick-off exploring manufacturable design options



SEPT 2020

Material research and robot cell preparations complete





Material

ABS + chopped carbon fibre

Total bridge weight (including other equipment)

240KG

Bridge weight (3D printed part only)

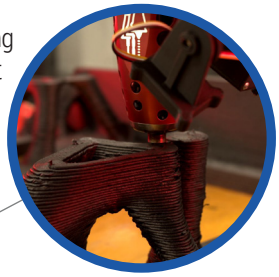
100KG

It utilises new and emerging technologies and processes including generative design, additive manufacturing, and robotic technologies.

The generative design approach uses the power of AI and the cloud to develop designs that conform to a set of parameters and constraints.

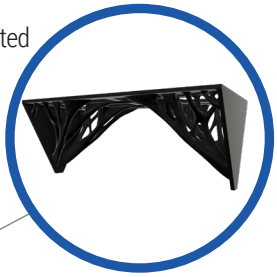
FEB **2021**

Sensor embedding tests and 'difficult geometry' tests complete



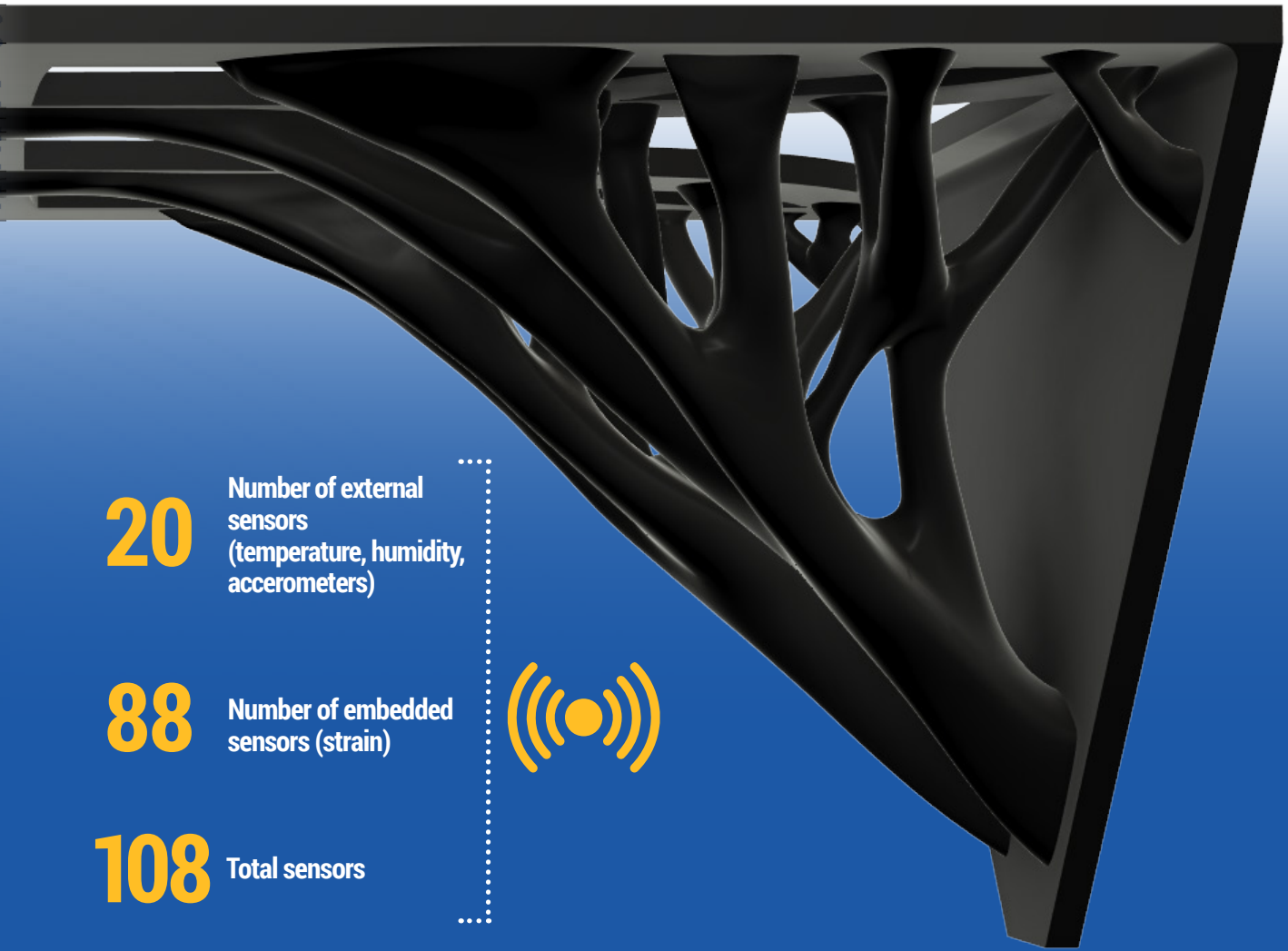
MAR **2021**

Bridge printed



NOV **2021**

First public event



20 **Number of external sensors (temperature, humidity, accerometers)**

88 **Number of embedded sensors (strain)**

108 **Total sensors**

Image source: Dar

Sustainable construction will offer extended economic benefits and have a positive impact on the environment.

"The beauty of the generative design process is its ability to create optimised geometry from the beginning rather than creating architectural geometries and then optimising them," Zein adds.

"Using generative design, it is possible to explore different permutations of a solution to quickly generate multiple design alternatives. It tests and learns from each iteration to decide what works and what doesn't," says Fikret Kalay, senior research manager of Industrialised Construction at Autodesk Research.

Collaborative efforts

The Dar Smart Bridge project is the product of a research agreement between Dar and Autodesk to explore new ways of building large civil engineering structures, such as a smart bridge.

The bridge was designed and 3D-printed as a proof of concept in two stages: first as a 2-metre bridge to test and refine the process, then as a 5-metre bridge to augment the process to a larger span and monitor its behaviour over time.

"Our primary objective was to assist Dar in the development of an additive manufacturing or 3D printing process for the construction of large civil engineering structures. Autodesk proposed to develop and demonstrate a proof of concept by

Dar Smart Bridge Facts

- The smart bridge earns its name from embedded sensors that enable it to learn throughout its operating life
- It is linked to an interactive artificial intelligence system with the ability to monitor, report and take action
- Data feeding into the bridge's digital twin provided insights that will inform future 3D-printed large-scale fibre reinforced polymer structures
- The manufacturing system relies on an intelligent robot that uses closed-loop data feedback to learn what to print and where
- The additive manufacturing process used to create this bridge avoids formwork and practically eliminates construction waste, creating a structure with a lower carbon footprint

using a robotic arm capable of printing materials and smart materials (sensing fibre or conducting fibre, FRP)," says Autodesk's Kalay.

Selecting the material was another vital aspect. Teams from both Dar and Autodesk conducted careful comparisons and printing tests to choose from a list of available sustainable materials, finally settling on ABS and chopped carbon fibre.

The Dar and Autodesk teams ran numerous trials and came up with different options to choose from. After a consensus emerged on one of the designs, Dar's structural team performed additional structural analysis and simulation using other software to ensure the structural integrity of the bridge.

Zein highlights that the smart bridge was designed to use a recyclable material. "In addition, using generative design and 3D printing resulted in optimum saving of the material used, which limited the amount of construction waste created and lowered the overall carbon footprint," he adds.

After rigorous load tests, the bridge was transformed from a passive object to a smart one. To do this, a network of sensors was installed and connected to a mainframe, enabling Dar to observe strains, vibration and temperature through a coupled digital twin. This will provide Dar with insights throughout the bridge's lifespan and inform future designs of 3D printed structures.

Optimised returns

Cost remains a challenge with pioneering sustainable materials because they require extensive testing to determine their properties and printability as well as structural load testing.

For the construction process, other concerns include the printers themselves as well as the local availability of sustainable materials. This is especially the case for a pilot project with research and development work.

Zein notes that the project's discoveries and outcomes have paved the way for better future projects, particularly at a time when the world is demanding economical and sustainable construction methods and approaches.

Admittedly, the added value of adopting new technologies goes way beyond cost reduction.

Zein insists that sustainable construction using new design and construction technologies integrated with the use of recycled and recyclable materials will offer extended economic benefits and have a positive impact on the environment.

SUSTAINABLE THINKING

The future of construction materials

Focus on sustainability
This is expected to drive the development of energy-efficient and recyclable construction materials globally.

Increasing modularity
There will be greater implementation of offsite and prefab construction and modular construction within the industry, which reduces overall construction time.

Increasing automation
To address the lack of skilled labour globally, construction developers are relying on automation tools and techniques such as building information modelling (BIM) to boost productivity.

Verticalisation
Urbanisation and the shift towards newer, slender and taller skyscrapers will drive the usage of materials such as thinner concrete, structural steel, and large and clear glass facades.

Rise of DIY trends for home renovation activities
The markets witnessed a surge in online orders for do-it-yourself (DIY) home renovation materials. The need for home renovation was further magnified because of office closures and increasing work from home (WFH) by office workers during the pandemic.

Development of open and multipurpose spaces
Architects and developers will focus on developing rooms that can provide multiple functionalities to work and relax.

Increasing use of lightweight materials
There will be greater use of lighter construction materials, including construction plastics and composites, which are cost-efficient and easier to install.

Awareness of antimicrobial materials
Challenges with surface contamination will see increasing use of microbe-resistant coatings containing antimicrobial agents.

Source: Frost & Sullivan

INNOVATIVE SOLUTIONS

The building sector is adopting new techniques for efficient materials use and to minimise waste

The construction sector is being disrupted by technology, socio-economic factors and regulatory demands.

Technology is enabling the industry to deliver projects sustainably, reduce waste and improve efficiencies, while innovative new materials and methodologies are helping deliver greener and smarter buildings.

Technologies such as AI, big data and analytics are helping to make the construction sector more reliable, efficient and sustainable. With the advent of automation, repetitive and dangerous tasks on site can now be automated, ensuring better health and safety. Smart machinery, the Internet of Things, 5G and robots are all a part of construction technology today. In the future, building design and construction will be increasingly digitised from concept to completion, and beyond – in construction, manufacturing and operations.

Dubai-based Amana has implemented building information modelling (BIM) throughout its projects to promote the creation of comprehensive, accurate, time-sensitive, and validated models of every little detail of the construction site.

> **Modular construction reduces labour costs of a project by 30 per cent, with even higher savings depending on the project's scalability and the level of complexity of activities shifted offsite**
>
> *~ Riad Bsaibes, president and CEO of Amana Investment*

"By leveraging technologies such as BIM in a manufacturing environment, standardised products can be produced in a factory environment, and then get shipped to be assembled on site," says Riad Bsaibes, president and CEO of Amana Investments.

"This level of detail enables us to create a detailed 3D visualisation of each component being constructed to ensure the clients requirements are met. The adoption of BIM has enhanced project coordination, collaboration, and efficiency among stakeholders."

Key challenges

Modular construction is a time-saving, waste reducing, safe and clean process that benefits all stakeholders – developer, designer, contractor and the environment.

The turnaround time is shorter and it prevents cost overruns by removing uncertainties in the delivery schedule of the project.

Furthermore, the labour requirements are lower and the resulting quality of the finishes is much higher. It also improves workplace safety and reduces environmental impact when compared to traditional on-site construction.

Amana entered the modular construction field in 2012, after four years of research and internal development.

"Through modular construction, we aim to challenge existing traditions, improving efficiencies and the quality of our built environment. This led to the creation of our first offering, DuBox. DuBox is an innovative design-build off-site concrete modular construction solution," says Bsaibes.

Following the success of DuBox, Amana launched the DuPod in 2021, which supplies made-to-fit bathroom pods, kitchen pods, and stand-alone retail pods to clients and contractors across the region. Some of DuPod's notable clients include the

Atlantis Waterpark in Dubai and the Dubai Expo 2020. The company has also delivered products to several projects at The Red Sea Development Company in Saudi Arabia.

As with any new technology, there are several challenges in adopting modular construction.

It is a new delivery model and thus there is always resistance to change among stakeholders. Therefore, change management is key to convincing the different parties involved to adopt this non-traditional delivery model.

Second, no construction/manufacturing can commence before the detailed design of the complete building is fully approved. This results in the design process being a major bottleneck, which is not the case in traditional construction where design can be released in phases allowing construction to proceed while the rest of the design is completed.

All material approvals must be made completely in advance, which can result in another bottleneck in the process.

Changing mindset

Bsaibes notes that it is very important that the design-build party undertaking the modular project is fully versed in the whole process and is empowered to drive it through.

"This calls for a change in mindsets and can be achieved by increasing awareness and educating the industry about off-site construction," he adds.

Talent acquisition poses another challenge, given the specific skills required for modular construction. Further, the shift from traditional construction to a digitised manufacturing environment requires employee reskilling and upskilling.

The cost of a modular building is dependent on client requirements and the scale of the project. According to Bsaibes, modular construction reduces labour costs of a project by 30 per cent, with even higher savings depending on the project's scalability and the level of complexity of activities shifted offsite.

"It has an unparalled advantage in the fact that the manufacturing environment enables us to recruit, train and retain local talent," he adds.

As technology intersects traditional construction, there is a growing demand for digital skills. Investing in people's learning and development as well as new technologies such as modular construction will ensure knowledge continuity and development, and the delivery of quality projects.

Image source: dupod.com

Atlantis F&B pods: DuPod uses latest BIM Technology which generates accurate models and specific data for the off-site construction.

Image source: dupod.com

The Red Sea Project utility pods: Sustainable development through modular bathroom pods in the Coastal Village Residential Complex.

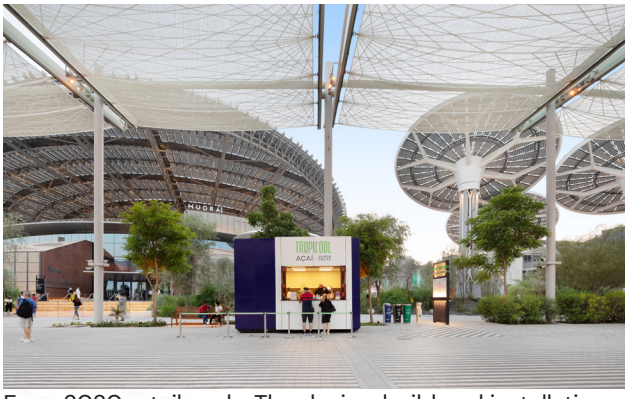


Image source: dupod.com

Expo 2020 retail pods: The design, build and installation of self-standing F&B Kiosks follow the caterer's design and reflect on the overall theme of the event.

PLANNING A GREENER FUTURE

Sustainable construction needs a clearly defined route map to meet its carbon neutral targets

For many years the construction industry has lagged behind most other sectors in terms of innovation and digital adoption. This is now changing. Rapidly.

Digitalisation in construction has been greatly accelerated by the adoption of building information modelling (BIM) mandates by governments around the world, and more recently by the publication of related international standards.

The technologies underlying this digitalisation powered developments that enhanced collaboration and automation, improving designs and bringing down costs and construction time.

The adoption of these technologies has made construction safer, quicker and more cost effective than ever before. Nonetheless, construction activities remain hazardous, expensive and energy-intensive.

There is a clear need to implement effective, low-carbon policies and to enable cost-effective investments in a net-zero building stock to decarbonise buildings along their life cycle while addressing resilience.

Introduction of sustainable and efficient design practices will contribute to reduced waste generation and energy consumption. The use of technology can also facilitate collaborations among project stakeholders.

Successful BIM adoption will depend to a large extent on embracing the end-to-end use of data such that the building model is generated at the outset and is managed as a digital asset in the same way the physical asset to which it relates is managed. This calls for investment in the right resources to derive true value.

Although the construction industry is evolving to introduce manufacturing processes such as off-site pod and modular construction, the journey to sustainable construction needs a clearly defined roadmap and goals that are in line with the net-zero carbon emission targets set by governments.

Over the coming years, the construction industry must continue pushing the adoption of transformational approaches to create a built environment that is not only net-zero carbon and resilient but which also provides inspiring places to live and work.

As people's needs evolve, the built environment will have to be flexible to accommodate for these changes, offering more resilient solutions.

The road to a greener, sustainable future is becoming more attainable for the construction sector as government visions to drive sustainable economic growth combined with global net-zero carbon goals attract strong investment in infrastructure projects.

ABOUT AUTODESK

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Today our solutions span countless industries, empowering innovators everywhere to combine technologies in new ways, unleash talent, and unlock insights to make the new possible.

Visit www.autodesk.ae to learn more

ABOUT MEED

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Recently acquired by GlobalData Plc, MEED is now part of one of the largest data and insights solution providers in the world with the capacity to build global communities for our clients.

Our purpose is to support the region's companies to make better and more timely decisions through our innovative data solutions and grow through our comprehensive and world-class marketing solutions.

To find out more email: info@meed.com


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