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We live in a world of design. The need for innovative structures that make life easier and are more sustainable is stronger than ever. Today, smart and lean designs reduce costs and save resources, while adding grace and beauty to the built environment by taking materials and the very laws of nature to their limits.

Cross-laminated timber technology allows us to design wooden high-rise buildings that are resource efficient, but also great to live in. A decade ago, this was unthinkable.

At sea, innovative foundation designs allow offshore wind turbines to be installed in a single lifting and assembly process that reduces construction time and expenses. This lowers renewable energy costs – the main barrier to accelerating the green transition.

All of this is only possible because engineers, architects and planners passionately strive to improve designs and thus benefit people and society. And because we explore the vast possibilities that 3D technologies and sheer computer power offer us at a rapidly increasing pace.

This edition of Response is dedicated to the ambition of rethinking structures – not only the actual, physical structures we see in buildings and infrastructure, but also the less visible designs that organise our societies.

Enjoy your reading.

Jens-Peter Saul
Group CEO
FORMING FOUNDATIONS FOR THE FUTURE
The global wind industry continues to break records for new investments and capacity, but high costs remain a major challenge. As the fastest-growing part of the sector, the offshore wind industry is finding new ways to design smarter turbine foundations to help ensure a renewable – and affordable – future.

By Jesper Toft Madsen

Towering above the sea surface, offshore wind turbines with wingspans the length of two Airbus 380s can be a fascinating sight. Deep down at the bottom of the sea, however, advanced machinery forms a vital basis for wind energy production.

Anchored in the seabed and shaped like an upside-down cup, the suction bucket foundation uses negative pressure to withstand the extreme weight of the superstructures above sea level and the enormous horizontal loads exerted on the support structure by the wind turbine and waves.

This type of jacket foundation has a bearing capacity able to support turbines even in weak seabed soils, thus enabling the structures to resist external loads such as strong currents, collisions and harsh weather. At the same time, it helps meet one of the offshore industry’s biggest challenges: costs.

According to a 2015 report by the Oxford Institute for Energy Studies, the offshore wind industry has to shed 26% of its capital and operating costs to become “highly competitive” with other energy sources by 2023.

The high costs of planning, fabricating, installing and operating large and remotely located structures are the main reason that wind still covers only 11.4% of total electricity consumption in the EU, despite another record-breaking year in 2015, according to Jan Matthiesen, Director of Offshore Wind at the London-based advisory organisation Carbon Trust.

“The industry needs to be more competitive. We’re on the right track, as we’re starting to grasp the size and scale of wind farms and get more certainty by securing funding as well as gaining clearer policies,” says Jan Matthiesen, who is also responsible for the Offshore Wind Accelerator, a collaborative RD&D programme aiming to reduce industry costs.

BIGGER AND DEEPER

In an attempt to produce more stable and more efficient wind power, companies are constantly designing bigger turbines and moving into deeper waters farther offshore. This reinforces the need for cost-efficient foundations able to withstand larger loads and more extreme weather, including large waves but also earthquakes and hurricanes.

“It takes something extraordinary to resist 25-metre waves and make turbines last for 25 years. The industry is continually looking for new ways to optimise resources while strengthening structural robustness. As a company, we’ve been helping to solve this complex challenge by optimising foundation designs for the past 30 years. We’re eating the elephant one bite at a time,” says Søren Juel Petersen, Global Market Director for Wind & Towers at Ramboll Energy.

Offshore wind farms are still predominantly built on monopiles consisting of a large steel pipe, five to eight metres in diameter. However, as turbines grow and are installed at greater sea depths, jacket foundations with lattice designs using thinner pipes are emerging as a lighter and more adaptable option in some waters.

INSPIRATION FROM OIL AND GAS FIELDS

For the past 20 years, suction bucket jackets (SBJ) have been used for oil and gas platforms. In 2014, DONG Energy installed the first three-legged
SBJ technology at an offshore wind farm, the Borkum Riffgrund 1, 37 km off the German island of Borkum. The installation was quicker, cheaper - and even quieter.

“We designed the suction bucket jacket with three cup foundations that are slipped into the seabed through suction. It’s installed in a single lifting and assembly process, which reduces construction time as well as the associated costs. It’s also quieter to install and therefore meets new noise restrictions set to protect local ecosystems,” says Søren Juel Petersen.

Having designed more than 2,400 foundations for 40 offshore wind farms, Ramboll has an over 65% market share of offshore foundations installed worldwide. Whatever type of structure is involved – the monopile, concrete gravity base, traditional jacket design or a jacket with suction piles – the focus is on improving form and functionality.

“A major challenge is to gradually decrease the number of tonnes of steel used per installed megawatt. We’re doing this by simplifying jacket designs, and the resource savings also reduce costs for welding, loading and installation,” explains Søren Juel Petersen.

DESIGNS CRITICAL FOR COST-EFFECTIVENESS

The Oxford Institute for Energy Studies projects that larger turbines and more competition across the value chain would have the greatest impact on reducing costs between now and 2020, in combination with investments in serial manufacturing of substructures.

Jan Matthiesen of Carbon Trust also believes that “there is a great potential to bring costs further down.”

“IT TAKES SOMETHING EXTRAORDINARY TO RESIST 25-METRE WAVES AND MAKE TURBINES LAST FOR 25 YEARS.”

Søren Juel Petersen
Global Market Director,
Ramboll Energy
WIND ENERGY IN NUMBERS

• In 2015, the world set a new record for wind capacity, adding 63.7 GW of capacity. The growth rate was 17.2%, and the total capacity is now 435 GW.

• Wind is the fastest-growing power source in Europe, representing 44% of all new investments in 2015.

• Offshore wind power installations represented 24% of the EU wind energy market in 2015, up from 13% in 2014.

• China is the global leader in wind power, with a market share of 51.8%. In Europe, Germany and Spain have the greatest capacity, while the UK accounted for 48% of new investments in 2015.

• The European Wind Energy Association (EWEA) believes the export potential is great, especially for countries like Denmark, Germany, the Netherlands and Poland, all of which are big suppliers of offshore wind foundations.


150 MONOPILES MOVE INTO DEEPER WATERS

By Jesper Toft Madsen

This year, 150 wind turbines will rise from water depths as deep as 37 metres in the Gemini offshore wind park 85 km off the Dutch coast. With an annual production of 2.6 TWh (terawatt-hours), it will become the world’s most productive wind farm, supplying clean electricity to more than 1.5 million people.

The park differs from most other wind farms, explains Klaus Andersen, Project Manager and Head of Department at Offshore Wind, Ramboll Energy. Ramboll’s wind and tower specialists and geotechnical experts have developed individual designs for each of the 150 monopiles. Using advanced calculations of wave movements, currents, water depth, wind direction and soil conditions, the Ramboll team has tailored the design of each monopile by taking over 10,000 load scenarios into account for the geographic position of every turbine.

“Gemini will cover an area exceeding 10,000 m2, which is why a custom design for each exact location is critical in minimising the operational and financial risks. This approach is unique, because we use our own software to make individual calculations instead of grouping several positions,” he says.

Engineers, manufacturers and contractors have worked together to examine how designing smarter structures can ease production, handling and installation. Klaus Andersen believes that this combination of technological development and knowledge sharing is the ideal approach to finding holistic solutions.

“It’s not just about design. For instance, the installation time for each position is typically 36 hours. By constructing as much as possible on shore, we have contributed to limiting it to 16-18 hours.”

“Innovative foundation designs are critical in lowering costs for the whole industry, especially if you look at the potential to reduce the amount of steel and gain a better understanding of wind conditions and wave behaviour,” he says.
COMMON SIGNALLING MAKES RAIL TRAVEL SMOOTHER
The European Rail Traffic Management System (ERTMS) is the most efficient tool to make the European railway network interoperable. Denmark is the first country in Europe to upgrade its entire signalling system, and Ramboll is heading the complicated work.

By Michael Rothenborg
management buildings, environmental and IT aspects as well as organisational implementation and contract management.

TECHNOLOGY PREDATING WORLD WAR II
Although changing signalling systems is not exactly cheap, the political decision-making process was less protracted than usual for huge infrastructure projects.

“Large sections of the Danish signalling system were so outdated that its continued maintenance and repair had become difficult. Still, implementing a nationwide system instead of continuing with a variety of local solutions with high maintenance costs is visionary,” says Otto Anker Nielsen, a professor in traffic modelling at the Technical University of Denmark.

Most of the signalling equipment was based on 1950s-60s relay technology, and some even predated World War II. At the same time, the engineers, designers and rail workers with the required expertise were nearing retirement, and specific local standards and specifications meant minimal competition, with only a few companies to supply spare parts and other equipment. Comparative studies of different strategies showed that totally replacing all existing equipment - regardless of age or level of technology - is the best and most economical solution. Three factors make total replacement the most efficient solution at the lowest investment.

Long-distance train passengers have the most to gain from the new signalling system, but city commuters will also benefit.

“DENMARK IS DEFINITELY ONE OF THE FRONTRUNNERS AND WILL HAVE A POSITIVE AND STIMULATING EFFECT ON OTHER MEMBER STATES.”

Karel Vincel European Commission
WHAT IS ERTMS?

- The main physical changes to the tracks include removing the red-green signal posts and upgrading the technology installed in the tracks, so it can communicate with the ERTMS computer inside the train – with no human involvement needed.

- Originally, ERTMS was developed for the French TGV and other high-speed trains, but Ramboll and its consortium partners are building a more modern version into the first two test tracks in southern Zealand and northern Jutland.

- Concurrently with the physical implementation process, the consortium also sent several thousands of rail employees on training and skills-upgrading courses.

- The Danish rollout of the system is expected to be completed in 2021.

First, it is cheaper to buy materials in bulk. Second, rolling out similar stock at the same time takes only one safety approval instead of 50. Finally, total replacement enables a standardised approach – thus making it much simpler to introduce new lines as needed.

Traditionally, railways have adapted existing equipment, but in this case almost all indicators showed that halting the continuous stopgap repairs and opting for a big once-and-for-all makeover was the best way to future-proof the system.

80% DECLINE IN SIGNAL-RELATED DELAYS

When the upgrade is finished, Danish train passengers can expect better punctuality, faster speeds plus higher capacity – more and/or longer trains – on selected lines and shorter journey times on some routes.

“We anticipate an 80% decline in signal-related delays on main and regional lines and 50% on the local Copenhagen S-bane. Countrywide safety will be greater and more homogenous,” says Jan Schneider-Tilli, Programme Director at Banedanmark.

What is more, future maintenance will be more economical, and the system will provide an unprecedented foundation for more centralised traffic control, energy optimisation and on-time passenger information.

“We are changing not only track structures but also societal structures – because commuting, travelling and freighting goods by train will be easier, especially across borders,” says Peter Koch, Senior Market Director at Ramboll Transport.

THE MOST EFFICIENT TOOL

He points out that rail passengers are not the only ones to gain advantages. All taxpayers benefit. When the tender bids came in, prices were lower than expected, and Banedanmark could return a significant sum to the Danish state.

“Among the ERTMS system’s biggest advantages are the savings you get when train suppliers and operators can relate to the same universal system rather than having to tailor local solutions. It promotes greater competition rather than local monopolies,” says Professor Otto Anker Nielsen.

The European Commission’s ERTMS coordinator, Karel Vinck of DG Mobility and Transport, says that the system is “the most efficient tool to make the European railway network interoperable”.

“Its implementation significantly improves the competitive positioning of rail transport and stimulates the single market for signalling equipment. The European Commission welcomes the decision of member states to switch completely to ERTMS in the next couple of years. Denmark is definitely one of the frontrunners and will have a positive and stimulating effect on other member states,” says Karel Vinck.

Other countries are already showing a growing interest in Denmark’s implementation of ERTMS. “The cost-effective completion, coupled with the modern tender and contract strategies, has sparked inquiries and visits from countries such as Norway, Sweden, Germany, the Netherlands, Belgium and the UK. Even Australia has shown interest in the lessons learned from the Danish signalling programme,” says Peter Koch from Ramboll Transport.

Norway will probably be the next country to roll out the system nationwide.
Imagine a building artistically decorated with sculptures and ornamental pillars. Inside are a bath house, a concert hall, an amphitheatre, a library and a sports facility. It sounds like an all-inclusive spa resort, but is actually a place few people dream about visiting—a hospital.

The above is a description of Asclepeion, an ancient Greek hospital built in 500 BC and considered to be the world’s first. A lot has changed since then. Today, hospital buildings tend to be uniform, monumental blocks located in the outskirts of big cities. Concert halls and amphitheatres are rarities in this functionalistic paradigm.

However, new research suggests that the Greeks were actually onto something when they built their hospitals on the idea of “a healthy mind in a healthy body”. Articles in scientific publications like the Journal of Environmental Psychology and Building and Environment have confirmed that factors such as light, colour, art, music and green surroundings can positively affect a patient’s healing process. Several studies demonstrate that patients placed in sense-stimulating surroundings recover faster than those in a typical clinical hospital environment.

A SENSE-STIMULATING HOSPITAL
In Helsinki, Ramboll Finland has taken these factors into consideration in the design of a new children’s hospital slated for completion in 2017. The hospital structure was developed through the meticulous collection of user information and prior research into the special needs—physical and mental—of hospitalised children and their relatives.

As a result, floor heating has been installed in areas where children are likely to sit down and play, and noise levels in treatment rooms have been minimised.

“We chose to use massive structures that keep noise levels down, as children are particularly sensitive to noise,” explains Esa Ikäheimonen, the project leader at Ramboll Finland. He continues: “Children are also visually oriented and often notice things that we adults pay no attention to.”

Floor vibrations are another major concern addressed in the new hospital structure, as they not only can cause patients discomfort but can also interfere with and thus jeopardise the operation of sensitive hospital equipment.

“We tackled the vibration issue very early on and developed elaborate vibration design criteria for different functional areas, as well as studied the feasibility of various structural systems to meet these criteria,” says Esa Ikäheimonen.

People are discovering that colour, art, music and access to nature are more than mere luxuries for the senses. Sense-stimulating hospital architecture is gradually gaining ground as research confirms that our physical surroundings can have positive effects on our health and well-being.

By Ina Johanne Mønsted
PATIENTS IN A PARTICULARLY SENSITIVE ENVIRONMENT

By Ina Johanne Mønsted

Sometimes not the hospital patient but the environment in which the hospital is built is particularly sensitive, a circumstance that poses certain requirements to the structure of the hospital building.

In Ahmedabad, India, the Sardar Vallabhbhai Patel Institute of Medical Sciences and Research at the existing VS General Hospital campus is located in a high-risk seismic zone.

The hospital is near the riverfront and thus susceptible to greater earthquake damage. Ramboll conducted a site-specific seismic study to understand the various parameters affecting the building during an earthquake and develop a response spectrum that could be used for dynamic analysis instead of the code-specified general response spectrum typically used for most buildings.

The hospital structure is close to completion, with only the helipad area remaining. Once complete, it will house 1,650 beds, a wide range of specialties and an outpatient department. The hospital will also have teaching facilities and staff accommodation, thus making it a critical part of the civic infrastructure capable of serving the region even after major disasters.

A HEALTHY MIND IN A HEALTHY BODY

In the psychiatric department of the hospital in Esbjerg, Denmark, the architectural structures also reflect a deliberate effort to make life in the hospital as comfortable and mentally stimulating for patients as possible.

The psychiatric department is built on the principles of more transparency, light and easy access to nature. And the results speak for themselves: The need to coerce patients into treatment has decreased by more than 30%, and the use of physical restraint has been reduced by almost 70%, according to Mental Health Services in the Region of Southern Denmark.

A main driver of these results has been a new lighting system that simulates natural light and can be modified by the staff to suit the individual patient’s needs. All the bedrooms have windows facing green areas, and the department has been granted new sensory integration equipment, such as weighted blankets and weighted vests, to help calm patients.

RETURNING TO OUR ROOTS

Professor Regner Birkelund at the University of Southern Denmark confirms that the senses have gained a newfound significance in hospital architecture.

“Before the Renaissance, aesthetics was considered as an important factor in our mental and physical well-being. But in step with the Renaissance cultivation of the natural sciences, aesthetics slowly faded into the background. This tendency was further cemented with the development of modern medicine in the mid-19th century. Today, however, with the emergence of the new hospital culture, aesthetics is gradually regaining a role in our healthcare system,” he says.

TODAY, WITH THE EMERGENCE OF THE NEW HOSPITAL CULTURE, AESTHETICS IS GRADUALLY REGAINING A ROLE IN OUR HEALTHCARE SYSTEM.

Regner Birkelund
Professor,
University of Southern Denmark
Haste makes waste goes the old saying. But this is not always true, as Ramboll concluded after improving its so-called Fast Track model.

The Fast Track model is aimed to shorten the time from design to completion. It is a project delivery strategy where construction commences before the design is complete, and where the number of sequential relationships are reduced and replaced with parallel relationships.

One example is Novo Nordisk’s strategically important 1R Purification Pilot Plant in Bagsværd, Greater Copenhagen, which the pharmaceutical company will put into operation this year.

At a very early phase in the plant design, Ramboll estimated and aligned the structural and architectural layout with all stakeholders. This allowed the client to meet its top priority: to gain time. Using the Fast Track model, Ramboll was able to team up with the client and other key project stakeholders to develop a strategic design and robust project execution process. Likewise, the short and restricted design schedule meant that the first 3D model had to be based on a number of assumptions and estimates. This demanded active engagement in the development of the model to provide a sufficiently accurate basis for the necessary decisions and dialogue to come.

Some changes had to be incorporated during the execution phase, including the addition of floor space on the second storey, but this was an expected cost accounted for in the initial budget.

The Pharma Fast Track model entails other risks: the final cost of the project can be uncertain, which means risks need to be identified and managed from the outset, because construction commences before the design is complete. This leaves only a small window for conducting any value engineering before the design is locked. The Fast Track approach is also more demanding to manage than a traditional Design-Bid-Build project. The schedule factors in practically no buffer time, the building site is extraordinarily busy, and the project is more or less on a critical path at all times.

However, the benefits outweigh the risks, especially because the time from design kick-off to client hand-over is significantly shorter than in traditional projects. On the 1R plant project for Novo Nordisk, Ramboll delivered a weathertight building in 12 months instead of the initially designated 18. An accelerated delivery of this magnitude is especially relevant in the pharmaceutical industry, where minimising the time-to-market is very valuable for the client.

All in all, the Fast Track model is an advantage when certain conditions are met: Most importantly, the model should be based on a trust relationship between the client and the engineering service provider, and there has to be a high degree of flexibility and readiness to implement changes at any time in the project.

If this is the case, haste does not make waste.
High-tech measurements can minimise the cost of maximising recovery from existing oil and gas fields. “Ground-breaking technology,” says a professor at the Danish Hydrocarbon Research and Technology Centre.

By Karina Smedemark

SMART EXTENSION OF PLATFORM LIFETIME

Extending the lifetime of offshore structures is a growing trend in the global energy business. Offshore operators need to ensure that platform structures have sufficient strength to carry their loads safely. Operators are usually able to extend the lifetime of their facilities according to risk- and reliability-based inspection planning, or they can opt to reinforce the structures at considerable cost. Either way, the lifetime extension process entails heavy investment.

“Today, older platforms are inspected at intervals specified by norms and best practice. But it is not possible to inspect all parts of a platform, so finding a cost-effective means of monitoring how the entire structure is doing gives us a much better basis for deciding how often to inspect and where to inspect,” says Rune Brincker, Professor and Head of Structural Integrity Research at the Danish Hydrocarbon Research and Technology Centre.

“Structural health monitoring (SHM) is a ground-breaking technology that can dramatically increase our knowledge about waves and fatigue. SHM can help scope our risk management efforts and potentially reduce operating expenditures for platforms during late field life,“ Rune Brincker concludes.

Ulf Tyge Tygesen, Development Manager at Ramboll Oil & Gas, points out that SHM combines a variety of sensing technologies with an embedded measurement controller to capture, log and analyse real-time data.

“Strain gauges, accelerometers, wave radars and GPSs are mounted on the platform topsides in

MAXIMISING OUTPUT

The International Energy Agency predicts that by 2040 the world will still depend on oil and gas for 50% of its energy supply. With mature fields representing an ever-growing segment of global offshore reserves, there is a keen interest in maximizing recovery from existing oil fields to keep up with global energy demand.

“STRUCTURAL HEALTH MONITORING IS A GROUND-BREAKING TECHNOLOGY THAT CAN DRAMATICALLY INCREASE OUR KNOWLEDGE ABOUT WAVES AND FATIGUE.”

Rune Brincker
Professor, Danish Hydrocarbon Research and Technology Centre
order to transmit real time information about the loads affecting the platform. SHM has been around for a number of years, but the really innovative thing is that we found a way of converting SHM data and feeding it into the existing finite element model of the platform. Using advanced calculations, we can determine the actual state of the structure,” he explains.

**HESS CONTINUED ITS OPERATION**

The Hess Corporation continually invests capital in the Danish North Sea to extend production from the South Arne field. In 2014 the oil and gas company had to meet the challenge of a substructure with a low fatigue design life, for which reason Ramboll carried out wave load calibration and a re-assessment analysis by post-processing data from both SHM measurements and wave basin laboratory tests.

The data showed the platform structure to be better than anticipated, and Hess was able to obtain authority approval for its continued operation without incurring the high costs associated with platform reinforcement and retrofit designs.

Morten Nielsen, Integrity Advisor at Hess, says: “Lifetime extension is not always about adding steel to existing structures, but is much more about utilising what is already there. With a high-quality installation, it is reasonable to anticipate that we can gain many more years of operation than the original design lifetime would suggest.”

SHM also has promising perspectives for offshore structures of the future. The knowledge gained from actual fatigue load scenarios on existing platforms can be incorporated into new platform designs, thus making them more cost-effective.

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**SHM SYSTEMS**

Ramboll also extends the lifetime of offshore structures with:

- Reliability-based inspection planning
- Structural reinforcement
- De-bottlenecking
- System upgrades and revamps
- Production optimisation
- Late field life rationalisation
When cities have a housing shortage and transport capacity issues, they need to think differently. Ramboll is helping Europe’s most congested city do just that.

By Eleanor Fox

**Lack of infrastructure capacity** is a key issue facing modern cities all over the world, not least in the UK. London has a major housing crisis and a transport network that is the most congested in Europe, according to research conducted by the World Bank.

Addressing such challenges is not easy. However, innovative approaches that speed up construction on new-builds, refurbish existing assets and minimise impacts on existing users and surrounding neighbourhoods go a long way.

In London there are at least 40,000 publicly owned brownfield sites – previously used sites that may be contaminated. These sites could provide land for a minimum of 130,000 homes, almost two-thirds of the UK Government’s annual target.

Brownfield sites come with their own set of challenges, but Design for Manufacture and Assembly (DFMA) is an offsite manufacturing technique that can help tackle them. Gary Le Carpentier, Technical Director at Ramboll UK explains:

“Offsite manufacturing, where components are manufactured in a controlled offsite environment, has a number of advantages, including significantly reducing construction times by enabling construction and engineering challenges to be addressed before construction starts. It reduces the number of tradespeople on site by reducing the onsite activities. This helps to offset the increased costs associated with a brownfield site. For example, we have projects where we have saved 2.5 months on a 12-month construction programme.”

Other significant benefits realised include improved health and safety and less onsite noise, which in turn minimise the impact of construction on the local area.

**SUSTAINABLE TIMBER SKYSCRAPERS**

Using materials like cross-laminated timber (CLT) can also reduce construction time and make it easier to build on difficult sites. At Dalston Lane in Hackney, London, Ramboll has designed what is set to be the world’s tallest and largest CLT building by volume.

“The lighter construction weight of CLT enables smaller foundations, something critical to the...
Dalston Lane site, which has High Speed 1 and Crossrail passing underneath. The use of CLT at Dalston Lane has also saved 2,400 tonnes of carbon compared to an equivalent block with a concrete frame and so has great potential as a sustainable and quick-to-construct material,” says Gavin White, Director of Ramboll UK.

Andrew Waugh, Director of Waugh Thistleton Architects, adds:
“CLT structures are the only sustainable solution to provide high-quality, high-density housing, and as such, this project – given its scale and ambition – is a seminal piece of architecture.”

REFURBISHING AN EXISTING FLYOVER
London is investing heavily not only in buildings but also in road and rail, which includes upgrading existing infrastructure to make it fit for purpose. A critical part of Transport for London’s Structures and Tunnels Investment Programme was work on the Hammersmith Flyover, a vital link in West London carrying over 70,000 vehicles per day.

The post-tensioning system had suffered significant erosion that threatened to close the flyover unless the system was repaired. However, the innovative use of ultra-high performance fibre-reinforced concrete (UHPFRC) has enabled the structure to stay open and extended its life for many years to come.

This phenomenally complex EUR 130-million programme is believed to be the first time an all-new pre-stressing system has been installed in a bridge where the original could not be removed. Such techniques and the intelligent use of 3D scanning technology are driving life extension and design efficiency, as well as eliminating programme and safety risks, speeding up repairs and thus minimising disruption to the public.

Managing Director Paul Bottomley from the post-tensioning sub-contractor Freyssinet calls the work unique:
“Replacing, fully, all the old post-tensioning without first removing it on such a significant structure is truly impressive,” he says.

Mat McNab, Head of Buildings, Ramboll UK, adds:
“At a time when resource scarcity is at the forefront of our minds, innovations that make the best use of existing infrastructure and building plots will be vital to securing the increased capacity our growing cities need.”

The use of cross-laminated timber at Dalston Lane has saved 2,400 tonnes of carbon compared to an equivalent block with a concrete frame. The repair of the Hammersmith Flyover was also done in a new sustainable way.
HOLLOWING MOUNTAINS
PHOTO FEATURE

If you don’t believe in moving mountains, there is another way to deal with them - hollowing. Ramboll is doing just that several places in the world, one of the most spectacular project’s being in the Oslo suburb of Holmestrand, Norway.

By Katinka Hustad (photos) & Michael Rothenborg

The Norwegian National Rail Administration is having a double track designed from Holmestrand to Nykirke, a distance of almost 7 km, a mere 400 metres of which will be outside the mountains.

The station interior will be designed to allow high speed trains to pass through the station at 250 km/hour - with passengers waiting on the platforms. This is the first project of its kind and requires painstaking attention to air pressure, wind speed, noise and the management of fire and security systems.

Special care must also be taken to focus on more stringent groundwater control measures, as both the tunnels and the station will be located under urban areas on the Holmestrand plateau.

The project is interdisciplinary, and Ramboll is preparing detailed planning, a zoning plan and a building plan and design, including tender documents.
ZOOMING IN ON NEW YORK’S CLIMATE CHALLENGES
New York is inspired by the scale of Copenhagen’s blue-green infrastructure. The city’s department of environmental protection has selected Ramboll to analyse whether similar solutions can also pay off in the USA’s biggest city.

By Michael Rothenborg

Hundreds of thousands of people fly into JFK airport annually. Only a fraction of them will spare a thought for the canals and waterways visible in nearby Jamaica Bay. However, a team from Ramboll Water will now be zooming in on the canals and waterways as part of a climate adaptation project for the New York City Department of Environmental Protection (NYCDEP).

Heavy cloudbursts can cause rainwater to become polluted and sewage water from the neighbourhoods around Jamaica Bay to overflow. Ramboll has been hired to conduct a best practice study to determine the most cost-effective ways to reduce flooding while improving water quality.

“What attracted us to Ramboll were the company’s cost-benefit analysis skills. The environmental, social and economic sustainability of this project is fundamental to its success,” explains Alan Cohn, Climate Program Director at NYCDEP.

BLUE-GREEN ON A LARGER SCALE
NYCDEP has been studying the climate adaptation work Ramboll and other consultants have done for the City of Copenhagen, especially blue-green infrastructure projects where rainwater is retained and used on the surface for water areas in parks and other places instead of being allowed to overload the sewage system.

Alan Cohn believes that New York can use some of the same tools. He emphasises that the city released a green infrastructure plan in 2010, already manifested, for example, in many parks and streets around the city.

“But we would like to understand whether what we are starting to do now can be adapted for cloudburst management in the future. And the City of Copenhagen and Ramboll have experience in rethinking and using blue-green infrastructure for the larger storms we expect with climate change,” explains Alan Cohn.

New York City’s main objective is to prevent pollution in the canals and waterways where several marinas and other recreational areas are located – and ultimately in some of the city’s beaches.

A PILOT AREA FOR THE WHOLE CITY
With more than 400,000 residents, a portion of the New York City borough of Queens that drains to Jamaica Bay was chosen as the pilot area, because it has more flooding and sewer backups complaints on record than any other area of the city, and certain neighbourhoods are flooded repeatedly.

Ramboll’s study is meant to demonstrate how NYCDEP’s current and future work in Queens and other parts of the city will pay off, and whether other cost-effective projects can be considered in the long term.

“The combination of blue-green and traditional grey infrastructure will serve as a model for other flood-prone neighbourhoods of the city,” says Alan Cohn.

He stresses that cost-effectiveness means not only the amount of savings in terms of avoided property damage but also the extent to which the new green areas will improve residents’ health and quality of life.

Jonathan A. Leonardsen, Consultant at Ramboll Management Consulting and a liveable city expert agrees:

“If a climate adaptation project takes into account the recreational value, and thus the likely increase in, say, real estate prices, a bigger coalition can be formed,” says Jonathan Leonardsen.

Christian Nyerup Nielsen, Global Service Line Leader for Climate Adaptation and Flood-Risk Management at Ramboll adds:

“We are combining our technical and socio-economic competencies to support one of the world’s most amazing cities in its important efforts with climate adaptation and blue-green infrastructure.”

WHAT ATTRACTED US TO RAMBOLL WERE THE COMPANY’S COST-BENEFIT ANALYSIS SKILLS.

Alan Cohn
Climate Program Director,
New York City Department of Environmental Protection
Trench excavation is the traditional method used to enlarge sewer systems, but tunnelling makes the operation smoother for the public. In the same area of Copenhagen 10 municipalities are collaborating on a major recreational climate adaptation initiative. The two projects combined lower the risk of flooding dramatically.

By Michael Rothenborg

**COMBINING GREY AND GREEN INFRASTRUCTURE**

**Three times in just** one year the citizens of Hvidovre, a suburb southwest of Copenhagen, found themselves shovelling sewage water out of their basements. On 2 July, 2011, the worst cloudburst ever registered in the area caused the Harrestrup stream to flood several parks and roads, leaving people standing knee-deep in water in their own gardens. In a nearby scout cabin the level exceeded 1.2 metres.

Hvidovre cannot totally avoid problems with sewage water. But these problems will soon be dramatically reduced.

This is the result of a major sewer and climate adaptation project that Ramboll has undertaken for the Greater Copenhagen Utility (HOFOR) along the Hvidovre-Copenhagen border. The goal is to prepare the area for a new climate reality involving more frequent and more severe cloudbursts.

“The key here is that a traditional sewer upgrading would not be enough. Nor would a so-called blue-green infrastructure approach, where you keep the water on the surface in parks, on football pitches and the like. It’s the combination that does it,” Henrik Søgård Olsen, Country Director, Ramboll Water, explains.

**TUNNELLING LEAVES THE SURFACE INTACT**

In fact, there is little traditional about the sewer upgrade, although the aim is the same: to reduce overflows along the 4.3-km sewer route. To expand sewage capacity, most municipalities dig deep sewer pipe trenches. In Hvidovre, however, boreholes are limited, because Ramboll’s specialists have used another method entirely, drilling tunnels through the fissured limestone and other layers instead.

This spring, the tunnelling machine will excavate 970 metres in a single go, one of the longest stretches ever undertaken in Denmark.

The tunnelling method will enable Hvidovre residents to enjoy a park and other areas unmarred by a 970-metre-long trench. Neither will the infrastructure be affected, as most of the tunnelling is being done under existing transport corridors, including several residential streets, a four-lane motorway and a railway.
A CHEAPER AND BETTER COMBINATION
The new pipeline has a diameter of up to 2.5 metres. Even pipes that big cannot prevent floods in Hvidovre, but nine other municipalities along the Harrestrup stream system are joining forces with Hvidovre on an innovative climate adaption project that will further strengthen the area’s resilience to flooding.

The 10 municipalities share a vision where the almost 30-km system of streams with mostly paved edges returns to a natural state with greener banks, clear water and fish – and where sewage sludge only threatens to overflow into the system or nearby basements after exceptionally violent cloudbursts.

“It is unique both in Denmark and internationally for so many municipalities to be working together on a climate adaptation project like this that also holds big recreational benefits,” says Henrik Sagård Olsen from Ramboll.

The head of Copenhagen’s Climate Unit, Lykke Leonardsen, agrees that the projects are innovative and gives the municipalities and their citizens more for less:

“All our calculations on climate adaptation show that it is cheaper and better for citizens to combine traditional sewer solutions with surface greening initiatives like stormwater storage in parks, recreational schemes and other urban development. In popular terms, you get benefits in two areas, but only pay for one,” says Lykke Leonardsen.

YOU GET BENEFITS IN TWO AREAS, BUT ONLY PAY FOR ONE.
Lykke Leonardsen
Head of Copenhagen’s Climate Unit
A significant challenge in the redevelopment of industrial sites is how to clean up contaminated groundwater. At one site in southern California, geologists and engineers had identified what seemed to be the best solution: inject a slurry of fine iron particles and organic carbon to create a ‘wall’ through which the contaminants would migrate and be degraded. Early tests, though, showed that injecting the slurry would be nearly impossible; another approach was needed.

Ramboll turned to phytoremediation – essentially, planting a grove of trees to degrade contaminants by safely uptaking impacted groundwater. Contaminants in the groundwater become incorporated in the tree tissue, or degraded through internal microbial actions.

However, low groundwater levels following an extended drought presented a major challenge:

“Phytoremediation is not typically used in arid environments, so the drought conditions at the site really challenged us to modify and adjust the technology to apply it successfully,” Carol Serlin, Principal at Ramboll Environment & Health explains.

**DEEPER BOREHOLES**
Engaging phytoremediation specialists from Intrinsyx and Phytoremediation and Phytomining Consultants United, Ramboll conducted a pilot growth study with external experts to identify candidate trees that could tolerate the arid conditions and thrive in the high-saline soils at the site.

To ensure that tree roots could extend deep enough to intercept the groundwater, each of the more than 300 trees planted was put into a 12-inch borehole drilled to depths of up to eight feet below ground.

To help the trees establish firmly, the expert team applied a slow-release fertiliser and other remedies to the root zone during planting. A solar-controlled, gravity-fed drip irrigation system provides each tree with water, using remediated groundwater from another area of the site. The most innovative enhancement, however, was to use a proprietary bacterial endophyte that further degrades contaminants once inside the trees, thus also enhancing overall tree growth.

**EFFECTIVE AND AESTHETIC**
The discovery that phytoremediation could also work in such arid conditions – that can be found in many regions across the world – also netted other benefits: lower implementation costs, reduced long-term operations and maintenance needs, expanded and enhanced wildlife habitats, water reuse and a greener remediation solution.

Mike Gill from US Environmental Protection Agency Region 9 finds that “phytoremediation can be an attractive remedial option for sites where impacts from infrastructure above and below ground are an issue and access to the subsurface is restricted.”

“This aesthetically pleasing, yet effective groundwater clean-up remedy can reduce groundwater impacts and make a positive impact on the local environment, especially in areas where community acceptance is a challenge. Most of us would prefer to see rows of trees rather than a fenced-off area of noisy equipment,” Mike Gill says.

Phytoremediation

1 and 2 Absorption
Contaminants are absorbed into root and leaf tissue.

3 Incorporation
Contaminants are incorporated into root cells, limiting mobility.

4 Degradation
Roots absorb contaminants and break them down.

5 Stimulation
Roots stimulate microorganisms to metabolise contaminants in soil and groundwater.

6 Retainment
Contaminants degrade and are retained within the plant cells.

7 Release
Contaminants are broken down to non-toxic forms and released to ambient air.
MAKING WELCOME CENTRES MORE WELCOMING
The growing numbers of immigrants in Europe are putting migration authorities under pressure. Ramboll restructured 10 German aliens authorities – to the benefit of the clients, the employees and the authorities. The combined approach was the key to success, say the German authorities.

By Michael Rothenborg

Interviews with immigrants made it crystal clear that the German authorities had to do something about their welcome centres. Most immigrants actually found the centres unwelcoming. “Outdated” and “medieval” were among the adjectives used to describe the heavy, drab furniture in the 10 pilot centres nationwide. Ramboll Management Consulting was hired to rethink the centre structures, which one immigrant described as dreadful.

He also referred to the excruciating bureaucracy that was standard procedure at many of the centres. For example, when he entered the waiting room he had to figure out which of three numbers to take, but the instructions were only in German. He thus risked waiting for hours only to find he had taken the wrong number and would have to go out and get a new one.

Even if the number was right, the paperwork was probably wrong – or some documents were missing. Immigrants in this predicament were often told to come back another day - just to start over again.

“It was very clear that the process had to be made smoother – for everyone’s sake,” says certified psychologist Christiane von Bernstorff, Senior Consultant at Ramboll’s Berlin office and responsible for the pilot projects at the 10 welcome centres in Germany.

Restructuring some German welcome centres has made it easier for immigrants to find out how to put their children in kindergarten.

DRAWING ON SUBSTANTIAL EXPERIENCE
Having several hundred thousand immigrants on the move across Europe is stressful for everyone involved. Migration authorities, reception centres and the like are also under pressure, and some are buckling under the immense workload.

To improve the situation, Ramboll was asked to set up smarter work routines, streamline workflows and integrate new colleagues while also treating asylum seekers respectfully and providing humane conditions.

Needless to say, it was not the typical optimisation project: “To be really successful in this kind of work we focus not only on the work processes and organisational design but also on letting employees know that keeping them healthy and motivated is a vital part of the holistic equation,” explains Christiane von Bernstorff.

To this end, Ramboll can draw on its substantial experience in the migration field – in Germany, Denmark, Sweden and Finland and at the EU level – as well as on its core value of being a sustainable society consultant, explains Tonny Johansen, Managing Director of Ramboll Management Consulting.

“Being a sustainable society consultancy means that we take on some of the most challenging projects to help shape and better the society around us. Some projects are within liveable cities, others within school reforms, labour market conditions or social affairs - or in this case in the field of refugees and migration. This is part of our DNA and a large part of why we’re in business,” says Tonny Johansen.

IMPROVING COORDINATION BETWEEN AUTHORITIES
Since the restructuring of the 10 welcome centres, immigrants are usually met by a flesh-and-blood person. They are seen as clients – not burdens – and a front office desk helps them identify the right papers. The signs now appear in several languages. In fact, immigrants can often make an appointment and thus avoid hours of waiting. If, however, they do have to wait, the furniture is light and brightly coloured, there are brochures and magazines to read and often

“RAMBOLL’S HOLISTIC APPROACH IS WHAT MAKES THE DIFFERENCE.”

Martin Lauterbach
Federal Office for Migration and Immigrants
OTHER IMMIGRATION PROJECTS

• In recent years, Ramboll has additionally taken on immigration projects in Finland and Sweden.

• In Finland Ramboll is currently involved in expediting the process of providing public employment services to asylum seekers who get residence permits. Effective public employment services help ensure that newcomers acquire the language and work skills they need to enter the labour market, thus fostering more effective integration. Ramboll also provides the Finnish Ministry of Employment and the Economy with process know-how.

• In Sweden the Swedish Migration Agency hired Ramboll to assist with the lengthy waiting times involved in residence permit decisions, a problem that it faced in 2014. The overall objective was to map and analyse the asylum-seeking process from the time an application for asylum was submitted until the decision to grant a residence permit or repatriate the applicant was made. Ramboll also assisted the agency with interviewing asylum seekers living in asylum camps.

• Ramboll has also worked for the Danish Ministry of Children, Gender Equality, Integration and Social Affairs and handled several projects for the EU Commission.

“Ramboll’s holistic approach is what makes the difference. The project focused not only on the capabilities of the employees but also on their mindsets and on fundamental structural changes. This combined approach was the key to success,” explains Martin Lauterbach, Head of Division at the Federal Office for Migration and Immigrants.

Some welcome centres have created a children’s play corner, so parents can concentrate on the conversation.

“IT WAS VERY CLEAR THAT THE PROCESS HAD TO BE MADE SMOOTHER – FOR EVERYONE’S SAKE.”

Christiane von Bernstorff
Senior Consultant,
Ramboll Management Consulting

“Before the restructuring there was a lot of stumbling around, if, for example, an immigrant family wanted to put their child in kindergarten. They didn’t know where to go. Now the welcome centre can tell them and give them a brochure with all the information they need in one place,” explains Christiane von Bernstorff.

The project has also identified the most problematic grey areas in the legislation. Grey areas with their complex wording are open to interpretation and can thus lead to unequal treatment.

“But if you have more systematic workshops about the legislation, you narrow the grey areas and have more equality before the law,” says Christiane Von Bernstorff.

The results from the pilot projects were sent as a toolbox to all 600 welcome centres in the autumn of 2015. In a survey just before Christmas, around 50% of the 230 authorities interviewed expressed an interest in working with the toolbox.

“Ramboll’s holistic approach is what makes the difference. The project focused not only on the capabilities of the employees but also on their mindsets and on fundamental structural changes. This combined approach was the key to success,” explains Martin Lauterbach, Head of Division at the Federal Office for Migration and Immigrants.
To get more value from public spending, municipalities find themselves reorganising and restructuring. Sometimes a new, innovative solution can prove more cost-effective than an old one. Copenhagen is just such a case. The city is experiencing growth in most sectors, but even this has a downside. As demand for new schools, kindergartens, institutions and more rises, the costs of building them could be sky-high unless handled with great care. Therefore, Ramboll has benchmarked and calculated the additional short- and long-term costs of the special standards the City poses to new building projects. These requirements could encompass materials, floorage and even aesthetic requirements.

Project Lead and Senior Consultant Thøger Kiørboe at Ramboll Management Consulting says:

“Our analysis indicates that the special municipal requirements have the potential to almost double building costs in the most extreme cases. Our sample cases differ greatly and are fairly narrow in scope, but it’s reasonable to say that money can be spent more effectively.”

Søren Tegen Pedersen, Planning Director, Copenhagen Municipality adds:

“As a result of Ramboll’s financial analysis, politicians have a more transparent basis for making decisions about municipal construction projects, and we can also review a number of our construction requirements. This gives us more buildings for our money and thus helps us to ensure we have the financial means to build schools, maintain the city and construct cycle paths for generations of Copenhageners to come.”

Among other things, Ramboll’s analysis for the City of Copenhagen reduced the cost of preparing building tenders by at least 10%.
Communities are growing denser all over the world. This allows for new sustainable solutions that optimise the use of energy, transport and costs. And buildings and infrastructure projects have to be more than resource-efficient. They should also cater for human needs by improving liveability and social quality.

By Jesper Toft Madsen

1 TUNNEL REINFORCEMENT: LESS TIME, STEEL AND CO2

The use of fibre reinforcement in bored tunnels could cut costs by 40% compared to more traditional lining methods, according to new international guidelines from the International Tunnel Association. In addition, fibre reinforcement can cut up to 50% of the embodied carbon, and involves one less construction step than traditional reinforcement, thus saving time. Fibre-reinforced concrete segments are also more resistant to corrosion.

2 ENERGY-EFFICIENT INDOOR CLIMATE

Optimising cooling systems has been a natural focus in the development of modern office environments in recent years. The considerable heat emitted from lighting and IT equipment increases demand for cooling, which affects the indoor climate. Aquifers that store heating and cooling over time are one of the smart, energy-efficient ways to cool buildings. The basic technique is to drill a well down to an aquifer to be used for heating during winter and cooling during summer. Ultimately, this approach can generate energy savings of 85% in a single office building.
Multi-purpose arena

Traditionally, football stadiums were built for the weekly 3 o’clock kick-off. Now built to meet the needs of the multi-purposed experience economy, however, modern arenas provide a venue for many types of sporting events, concerts, exhibitions and conferences, as well as office space and even residential housing. That means extended opening hours, better utilisation of an otherwise limited seasonal sporting schedule – and thus a better business case.

Wooden skyscrapers

Since the first skyscrapers rose from the ground in 19th-century New York and Chicago, tower buildings have been based on classic steel or concrete structures. However, another classic material could take its place: timber. Its light weight means less load on underground infrastructures and thus an ability to reach greater heights. On top of this, timber requires smaller foundations and can be prefabricated offsite, thereby shortening construction times. Timber is also more resource-effective and leaves a smaller carbon footprint.

Renovating an industrial building

Renovating old industrial buildings, such as abandoned warehouses and silos, for housing or office space is a way of repurposing existing structures. Instead of demolishing old buildings and starting from scratch, renovating them can breathe new life into deserted areas and help restore historic, urban sights. By using add-on constructions, the renovation stays true to the original identity of the building while creating attractive residential or commercial properties.
Contractors worldwide are starting to demand the implementation of 3D technology, and with good reason - they simply gain much higher returns on their investments.

By Kristine Barenholdt Bruun

**INTO THE THIRD DIMENSION**

Since 1781, the world’s oldest iron bridge has crossed the River Severn in Shropshire, UK. But the technology that will save the construction from cracking is the newest around.

By combining two technologies, a Ramboll consultancy team obtained a comprehensive understanding of the bridge’s structural vulnerabilities in about half the time of conventional methods.

“Linking 3D laser scanning to a solid finite element analysis enabled us to save a great deal of time while also improving the strength predictions,” explains Carl Brookes, Technical Director of Ramboll’s Advanced Engineering Team.

Time and money are also being saved in Copenhagen, Denmark, where the new Carlsberg City District provides the framework for a so-called building information modelling (BIM) clash detection. Covering 100,000 m², the process is being used on a scale rarely seen in Denmark.

3D BIM clash detection helps prevent installations from colliding and ensures that the separation distances between electrical installations meet minimum requirements. By incorporating clash detection from the very beginning, Ramboll raised the quality and assured fewer building errors on site. It provided savings of some 5-10% – of a total building sum of EUR 135 million.

**WHAT WILL THE NEAR FUTURE BRING?**

“Smart software with an in-built intelligence that can suggest designs on its own. We will also see a lot more virtual reality-based modelling, since computer power is strong enough to make taking a virtual walk in a building model extremely realistic.”

Poul Hededal
Group Director of Knowledge & Innovation, Ramboll

“Significant shifts towards the use of pre-fabrication and modularisation, virtual reality, and collaborative forms of procurement. This will in turn enable the delivery of cost-effective, smart and sustainable infrastructure.”

Sheryl Staub-French
University of British Columbia, Vancouver
Implementing 3D technology can yield huge gains. Sheryl Staub-French, Associate Professor at the University of British Columbia, who has spent more than 15 years studying BIM implementation, explains:

“The projects from Copenhagen and Shropshire demonstrate the power of an innovative and collaborative use of 3D technology. Ultimately, project owners have the most to gain, including a more efficient construction process, more accurate building information and a higher value for their infrastructure investments,” she says.

CONTRACTORS ARE DEMANDING BIM
Considering the benefits, it is hardly surprising that consultants worldwide are implementing 3D technologies. In fact, even contractors are starting to demand the implementation of BIM, and the UK Government has decided that by 2016 all centrally produced government construction projects, whatever their size, must be delivered using BIM. The programme is part of a strategy to reduce capital costs and the carbon burden of constructing and operating the built environment by 20%.

According to Sheryl Staub-French the potential benefits of BIM simply outweigh the costs.

“It involves a cultural change that in the longer run will affect lots of actors. It will capitalise on the opportunities offered by the digital economy and will provide the foundation for delivering smart and sustainable cities,” she says.

Fully implementing BIM is one thing, realising the full potential of its implementation is another. According to Sheryl Staub-French, this is likely to require expertise, profound changes in working habits and a great deal of agility. At Ramboll, the latter is crucial to the newly developed BIM strategy, stresses Poul Hededal, Group Director of Knowledge & Innovation at Ramboll:

“If you cannot manage and tailor your strategy to take advantage of the potential that software advances bring, you will miss out on brilliant opportunities,” explains Poul Hededal.

"ULTIMATELY, PROJECT OWNERS HAVE THE MOST TO GAIN.
Sheryl Staub-French
Associate Professor,
University of British Columbia,
Vancouver"
Effective collaboration between architects and engineers can reduce critical errors, long delays and cost overruns throughout the building process.

By Kristine Barenholdt Bruun
Tilting, twisting towers or supertall structures?
Courageous cantilevers or bold, bending buildings?
Architects have their heads in the creative clouds while engineers cling to data and science, with no acknowledgement of beauty or innovation. Or at least that is how the stereotypes go.
Although this viewpoint might be highly exaggerated, it holds some truth.
Sinead Mac Namara, structural engineer and Associate Professor at Syracuse University, New York, explains:
“There are definitely differences between architects and engineers. But it’s important to understand that this is an entirely necessary and correct result of their respective educations. In school, engineers are taught to solve very specific, clearly defined problems within their own sub-disciplines. By contrast, architects are taught to think about the whole picture – to have a vision for a complete project.”
Sinead Mac Namara is one of two authors behind the book “Collaborations in Architecture and Engineering” (2014) and has been researching the relationship between architects and engineers intensively:

“Long delays and cost overruns can be a consequence of poor collaboration when constructability issues arise,” she says.
So how can a good partnership possibly be established and maintained, and the risks of adverse consequences thus reduced, if the disparities between the two professions trace back to identities formed in school?
The short answer is simply to avoid bad teamwork, which Sinead Mac Namara asserts probably happens for one of two reasons: poor communication or inefficient project structure, as seen when engineers are brought into the process too late to have an optimal impact on the design.
CREATING A MUTUAL START
In Copenhagen, Denmark, the Niels Bohr Building is starting to take shape, and when finished in 2017, the 53,000-m2 laboratory and teaching facility will accommodate scientists and students from most parts of the world.
Since 2010, a consultancy group consisting of Ramboll engineers and architects from Vilhelm Lauritzen, Christensen & Co, GHB Landscape Architects and Collin Gordon Associates has been working together on the complex project. Their remarkably close teamwork and the use of building information modelling (BIM) are preventing the type of collaborative problems that can result in timeframe and cost overruns:
“We work together in an atmosphere of confidence and mutual respect, which means we can challenge and inspire each other across disciplines and companies. If experts cannot listen and learn from each other, it becomes difficult to create a world-class project,” says Kaare Dahl, who is Senior Manager of Ramboll’s Division for Buildings.
He also attributes the success to the fact that architects and engineers prepared the competition proposal together and that 3D technology was used throughout the entire process.
“Our 3D models allowed us all to access detailed information at various stages and do clash
FIVE DRIVERS OF GOOD COLLABORATION

1 Mutual respect among disciplinary experts
2 Early collaboration, which is particularly important for projects that are large-scale or complex in their technical resolution
3 Emerging tools like BIM software and new contract types such as integrated project delivery (IDP)
4 Establishment of common vocabulary
5 Commitment to mutual teaching and learning

Source:
Sinead Mac Namara, Syracuse University, New York.

detection every fourth week. There is no doubt that our thorough use of BIM has been a huge driver for good teamwork,” Kaare Dahl explains.

MANY PATHS TO SUCCESS
Sinead Mac Namara is unsurprised that the Niels Bohr Building, a project with strong team spirit, also avoids collaborative issues that impact the time schedule and budget:
“Our research shows that early collaboration, mutual understanding and respect for the ‘other’ discipline are all essential factors for good teamwork. All these measures prevent misunderstandings and errors, and ensure that all considerations come into play from the very beginning,” she explains and continues:
“Additionally, emerging tools such as BIM software are starting to play a role in facilitating good collaboration, and this will likely increase over time.”
Curved between the base and tip, a new supertall residential tower on the edge of the Dubai Marina seafront most of all resembles a glass and steel banana.

The arcing structure is 335 metres high, so it might come as a surprise that one of the toughest construction issues lay beneath the ground. Here, a two-sided water pressure from the Persian Gulf on one side and the Dubai Marina on the other posed a major challenge for the construction of a five-storey underground car park.

“With 20-metre deep excavation, it was difficult to minimise the water ingress and provide safe working conditions,” explains Abhijeet Kulkarni, Associate Director of Ramboll’s Structural Engineering Department in Dubai.

Water ingress can usually be stopped by anchoring the shoring walls. But in this case, the proximity of the marina lake and the immense water pressure behind the walls made anchoring below the marina too difficult. Keeping the site dry required innovative thinking:

“We used a two-stage construction approach: First, we installed anchored diaphragm walls on three sides of the plot. Then, on the challenging marina side, we created an unanchored diaphragm wall in combination with secant walls that allowed us to excavate before stabilising the wall,” explains Abhijeet Kulkarni and continues:

“We had to install the first secant wall 20 metres inside the plot along the marina side, where the earth was strong enough to hold the anchors in place and thereby allow excavation for the first phase. We then used the first-phase constructions to support the struts in the second phase by propping the marina-side diaphragm wall to take the earth and water pressure.”

Once completed, the 85-storey building will be the United Arab Emirate’s seventh tallest residential tower and among the world’s top 20.

Credits: U+A Architects.
CITIES HAVE ENERGY
(WHEN IDEAS HAVE POWER)