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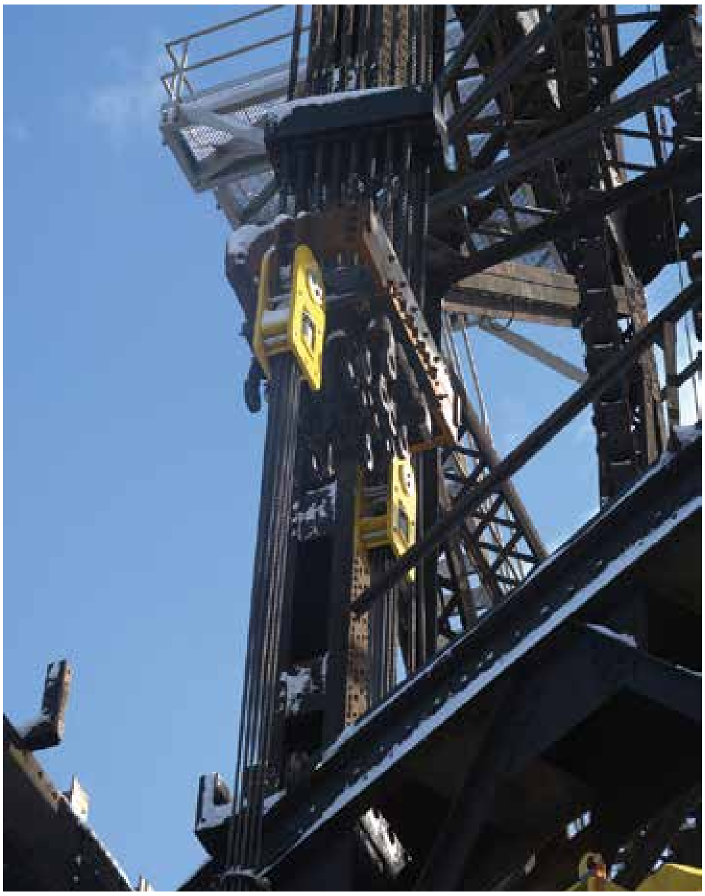
Connecting the world

Much of the transport infrastructure that was built as the age of the automobile bloomed in the mid-20th century is now reaching the end of its life… or gone well beyond it. The challenges of replacing major structures within tight deadlines and with minimum disruption is always a challenge. Cranes have always played a major role in this, but a growing range of alternative lifting equipment and techniques is providing lifting engineers with a wide range of innovative options. Will North reports.



As the name suggests, alternative lifting encompasses a range of tools united by one common factor - they do not directly involve the use of cranes or regular lifting machines. Within that simple categorisation there is a wealth of equipment, tools and techniques which are often used together to design a lifting solution that is custom designed for the job at hand.

Although a sweeping generalisation, one of the key differences between alternative lifting systems and cranes is that they do not lift from above, although there are plenty of exceptions. Rather they tend to lift from below or slide, skid and turn through cramped environments, on sites where there is not enough space or access to the load from above, or access for the size of crane required to lift the weight.

One sector in which alternative lifting techniques are often used - as they can be impossible to reach with most cranes - is bridge construction and replacement, where key stages of jobs must be completed within exceptionally tight deadlines and closing a bridge for more than a few hours can have a major impact on both passenger transport and business.

Limited lifespans

In recent years, governments and transport agencies worldwide have had to face up to the challenges of decaying infrastructure. In the second half of the twentieth century, most governments went on major road building sprees, bringing modern transport networks into the age of the car and the truck. Now, 60 to 70 years later, most of the bridges in these highway systems are showing their age and have often gone well beyond their planned lifespan. The USA's interstate system is a good example of this. President Eisenhower signed the Federal Aid Highway Act of 1956 into law in June of that year, sparking off a massive building programme to construct more than 40,000 miles of four lane highways that included thousands of concrete bridges. There are sections however, such as the Pennsylvania Turnpike, that date back to 1940.

In a recent white paper, Dutch international heavy lift and haulage contractor Mammoet addressed some of the issues facing transport agencies. Rafael Martinez, sales manager at Mammoet, says: "Although there are now conventions in place to ensure a good minimum lifespan for bridges, before the 1990s this was much less common. In the 1950s, 60s and 70s, the lifespan of a bridge was usually designed to be around 50 years. That means that bridges built in recent memory may be less durable than expected, with lifespans that shorten the further

back in time we go. The method of construction can vary markedly between bridges of different ages and localities, which means there is no 'one size fits all' solution to removing them."

Overnight installation

On many of larger bridge construction projects, it is becoming increasingly routine to build the entire structure - or substantial portions of it - off site and then, over the space of a few hours, complete the installation with the aid of barges or SPMTs (Self Propelled Modular Transporters). Jacking systems such as the Mega Jack range - developed by ALE, which is now part of Mammoet - often play a starring role in these jobs.

Systems like this use hydraulic jacks together with modular steel box blocking. The boxes interlock with each other to build a structurally stable support tower. The hydraulic jacks raise the load just enough to slide in another box to raise the tower height. With each stroke, the tower gets a little higher or visa versa when lowering.

The old bridge is removed

This is an incredibly versatile approach. The original system, developed at ALE, could lift up to 5,200 tonnes per tower which allowed it to be used in offshore fabrication yards. Offshore rigs could be constructed in modules weighing many tens of thousands of tonnes and then stacked one on top of another using the Mega Jack system.

Later versions focused on more modest 'everyday' capacities. The latest version is the Mega Jack 800 which lifts up to 800 tonnes per tower. The system was first deployed on a multi-phase project to replace the Loenersloot Railway Bridge in The Netherlands in 2014 working alongside SPMTs, strand jacks, large All Terrain cranes and a heavy skidding system.

Mammoet used the Mega Jack system very effectively last Spring on a project to install 8,400 tonne bridge sections for a replacement road and rail bridge over the Danube, in Linz Austria (See C&A issue 23.2, page 17). In October, Mammoet added 10 more Mega Jack 800 towers to its fleet.

Crossing the Seine

Mammoet is by no means alone in using this type of equipment for bridge work. Most recently, Belgian international crane and heavy lift company Sarens was called on to install the two bridge spans for the new Seibert Bridge over the river Seine between the Île Seguin (the island between the western Paris suburbs of Boulogne Billancourt and Sevres) and Meudon in France.

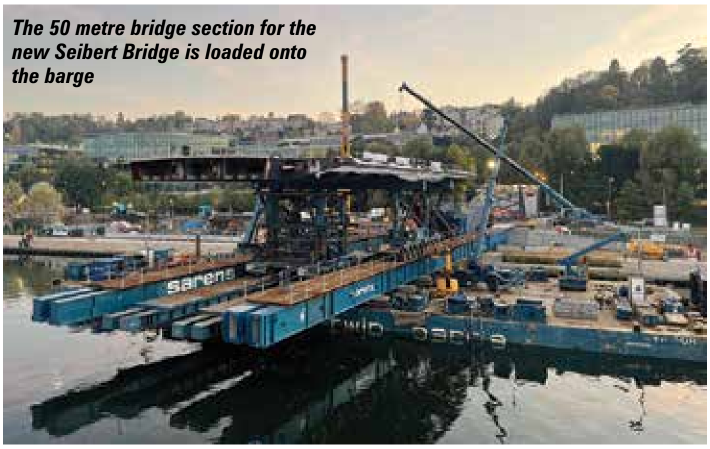
The new bridge has an overall length of 150 metres made up of a 100 metre span over the Seine, plus a 50 metre span over a road on the Meudon side of the river. It replaces one dating back to 1931, one of several bridges onto the island built to serve a Renault factory which was built on the Île Seguin in the early 1930s. The factory closed in 1992 and was demolished between 2004 and 2005. The old bridge was closed to traffic in 2017 and removed by Sarens using a barge and jacking method in 2019.

The 100 metre span of the new structure weighed around 2,240 tonnes and was constructed out of 125 smaller sections. These were fabricated off site and delivered to the Île Seguin where the bridge assembly took place last summer.

The jacked up Loenersloot bridge moves into position

SPMTs, Mega Jacks and barge on the Danube in Linz

The 50 metre bridge section for the new Seibert Bridge is loaded onto the barge

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The 100 metre main span moves towards the barge

Project engineer Tomas Spinnoy said: "The bridges were pre-assembled on the island 10 metres above the water level of the Seine. The distance between the barge and quayside was approximately 15 metres, requiring the building of a complex structure to transport these bridge parts into their final position on the barge."

The size of barge required to transport the bridge would have been too wide to navigate the Seine. So, a twin barge - the Karel-Victor - travelled to site as individual units and was reconnected at the job site.

With the barge in place, massive beams were installed on the barge, blocked up to match the 10 metre height of the quay, to create a bridge from the quay to the barge and span the 15 metre gap, while extending the effective barge width. The assembled bridge spans were then able to be transferred aboard. This required the carefully choreographed use of 84 axle lines of SPMTs along with the jacking towers, to manoeuvre the spans onto the barge, float them out and then position them. The new bridge is due to open to traffic this summer.

See the video https://www.youtube.com/watch?v=tU7ysT7lXyc

The jacking system lowers the bridge deck into position

Political stalemates

But not every bridge job is on anything like this scale. For road users it doesn't really matter how far a bridge spans, whether it crosses a 10 metre canal in an industrial suburb or is part of a long causeway covering several miles - if it is the only way to get where you want its closure is a problem. There are thousands and thousands of these smaller bridges that need major repairs or replacement. This has become an issue of increasing importance in recent years, particularly in the US. As this article was being written, the Forbes Avenue Bridge in Pittsburgh, Pennsylvania collapsed, taking a bus and a number of cars with it. Thankfully, the traffic was unusually quiet for the time of day, however, 10 people were injured, but at least no one lost their life.

For those who follow the US infrastructure sector, the incident will have sparked a degree of déjà vu. In 2007, a bridge collapsed in Minneapolis and ignited a renewed focus on the need for bridge repairs, inspections or replacement. But unlike Eisenhower in the 1950s, several US presidents have struggled to get the necessary funding through congress and the Senate. President's Bush, Obama and Trump all failed to make any real dent in the problem. Where there was investment, it was made at a state and local level.

The Pittsburgh collapse occurred a few days before president Biden was due to visit the area. Unlike his three predecessors, and during a period of intense polarisation in US politics, he had helped steer a bipartisan infrastructure bill through both houses of congress. That may reflect his negotiation skills or a wider willingness among US politicians to take the issue seriously and compromise on key issues. More likely it shows just how desperate the problem has become.

Fixing the US' transport infrastructure will be a generational project. The new funding, properly known as the Infrastructure Investment and Jobs Act, promises $350 billion for highway improvements over the next five years. Bridges will be a key part of that investment.

The new bridge installed

The collapsed Forbes Street Bridge in Pittsburgh


Wittpenn bridge

A new approach

While the scale of the work needed around the world is vast, the range of lifting equipment and techniques available has never been better and continues to develop. While 800 tonne jacking towers combined with SPMTs are more than capable of moving a whole bridge, a recent technique - developed by US specialists Engineered Rigging - allows a bridge to be safely removed with little more equipment than can be carried in the back of a van.

The first job using Engineered Rigging's new technique took place in New Jersey in January. The company had been commissioned by a demolition contractor to find a way to remove the central span of the old Wittpenn lift bridge. Completed in 1930 it takes the busy Route 7 over the Hackensack river, connecting Kearny and Jersey City. Every day more than 50,000 vehicles crossed over it, including 2,000 trucks.

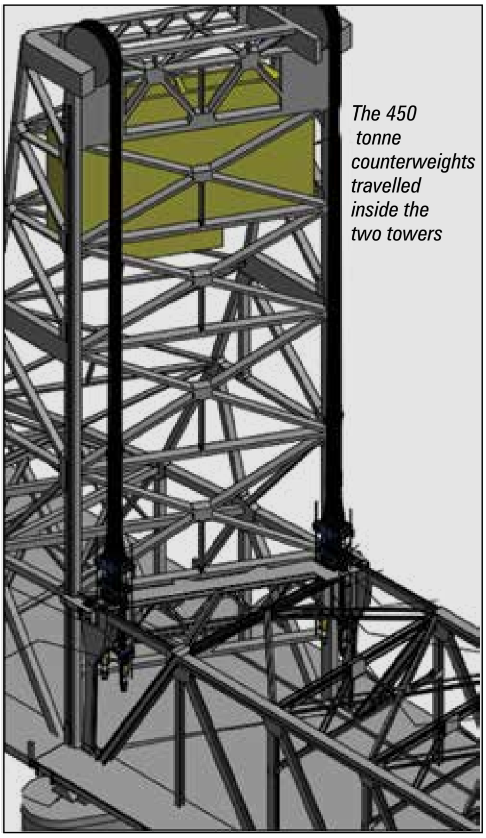
The Wittpenn now sits between two other bridges - its replacement road bridge which opened last year and another old lift bridge which carries a live rail track. Lifting, or more accurately lowering


Wittpenn bridge

The new Wittpen road bridge alongside the old one

the central span, needed to take place within a single eight hour window. While the Wittpenn's location proved a challenge, its design offered a creative thinking professional engineer Christopher Cox, co-founder of Engineered Rigging, an opportunity.

As a vertical lift bridge, the Wittpenn central section (the lift span) connects to two steel girder towers, topped by large sheaves over which lifting and lowering cables pass. One end of the steel cables is attached to the lift span structure, while the other is attached to the counterweights which weigh around 450 tonnes each and run within the towers. As the counterweights are lowered the lift span is raised, allowing ships to pass underneath.



The 450 tonne counterweights travelled inside the two towers

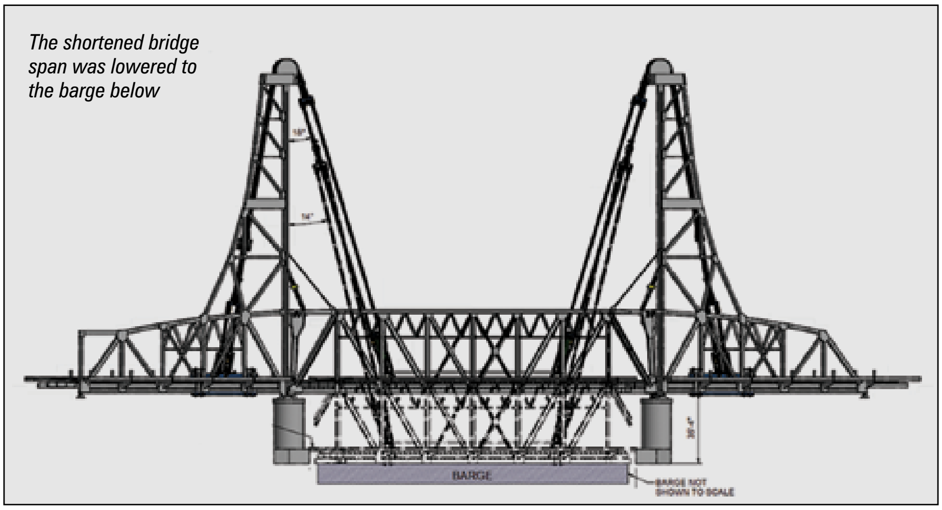
Cox's approach was to work with the bridge, using its structure along with 200 tonne Enerpac strand jacks to lower the span to the water. An inspection determined that parts of the bridge structure had decayed over the years to a level that presented some risks. Engineered Rigging calculated a series of reinforcements and new attachment points, manufacturing around 180 tonnes of fabrications and components at its shop in Russellville, Arkansas.

The first job was to disconnect and lower the counterweights to the deck at the base of the towers. The strand jacks were mounted under the bridge lift towers using 'dog bone' mounts, designed at the Arkansas shop. The ropes from the strand jacks were temporarily clamped to the lift bridge cables, which run from the central lift span, up and over the sheaves at the top of the tower, to the counterweights. The strand jack ropes and bridge cables were secured using a purpose-built connection. The bridge lift cables were then detached from the central lift span, transferring the counterweight load to the jack ropes.

Lowering the counterweights took just under five hours to complete, using the SCC (Smart Cylinder Control) system. The demolition crew then broke these up and carried away the resulting 900 tonnes of concrete rubble.

Meanwhile, Cox and the Engineered Rigging team got to work on the almost 900 tonne central lift span structure. In order to ensure its integrity during the lift, beams and lifting points were clamped to the lift span and some decayed joints were reinforced. The strand jacks used on the bridge counterweights were repositioned to connect to these beams, where they would be used as static rigging. A further eight strand jacks were attached to the tower spans, and over the lift tower sheaves to connect with those now on the central lift span, using Engineered Rigging's connection system.

The team tested the new connection points and deck integrity, by applying 900 tons (around 820 tonnes) of test loading. The ends of the lift span, which rest on the abutments when the deck is in its lowered position, were removed, reducing the overall weight of the remaining span to around 600 tonnes. With the span supported on the strand jacks and clear of the tower foundations, the new set of jacks on the tower spans were used to lower the span slowly to the barge below and carried away, all within the short shutdown window allowed.



The shortened bridge span was lowered to the barge below

The deck is lowered steadily to the barge

For equipment and engineering experts like Cox and Engineered Rigging, jobs like this are no longer 'one offs'. Bridges of this size are a vital part of the road network between major cities, and all require maintenance, repair or replacement. I asked Cox how many projects they hope might be suitable for this technique. He laughed and said: "About 3,000."

If you are not familiar with them, strand jacks use hydraulic jacks and rope clamps to pull or let out multiple strands of wire rope. A strand jack - in most operations - remains stationary relative to the load and pulls the rope through itself, moving the load attached to the ropes. Multiple strand jacks can be used together, to lift hundreds or thousands of tonnes. Strand jacks can be positioned using nothing more than a pick & carry industrial crane.

Reaching further

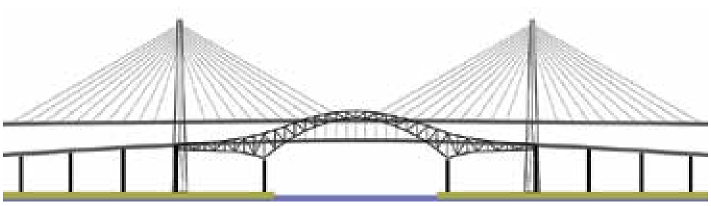
Techniques like that developed by Cox at Engineered Rigging are likely to play a significant role across the USA and further afield. But as we have already said there are plenty of projects that are much larger and require an entirely different approach.

This was the case on the replacement of the Gerald Desmond Bridge in California, which was opened in 1968, replacing a pontoon bridge built by the US Navy during World War II. It connects Long Beach with Terminal Island, where the Port of Los Angeles and Port of Long Beach both have facilities, The arch bridge is a vital part of the US economy with the bridge owners estimating that 15 percent of all imported sea cargo in the country crosses it by truck.

Increasingly large concrete chunks were falling from the bridge, which was built in 1968, highlighting the need for its replacement. It was also too low to allow the latest generation of container ships to pass below. The bridge has been replaced by a modern cable stayed bridge, the second longest in the country and the only one in the Los Angeles metropolitan area.

F&M Mafco provided four derrick cranes to install the bridge decking. As with most derricks, the cranes comprise of a number of relatively lightweight elements, designed to be easily transported and assembled on site. They offer a good ratio of lifting power to weight, as they are anchored to the structure through a sub frame. There is a long history of their use in bridge building - they can travel along the bridge deck as

The 1968 Gerald Desmond Bridge



The replacement bridge concept alongside the old bridge

One of the four F&M Mafco derrick cranes in position

it extends to the other side, lifting materials and span sections from barges below or from road transport.

The bridge consists of two towers, connected by cables to the bridge deck below. Two of F&M Mafco's derricks were installed on each tower, mounted on skidding systems. They worked in opposite directions with one derrick on each tower facing inward, to eventually join with its partner from the other tower, while the other derricks on each tower faced the banks and were used to build the approach spans outwards from the towers.

The derricks start by raising the first span sections from a barge and lifting them into position to be fixed to the tower foundation. The derrick then travels out on to the newly installed span section, once the cable supports are installed, the derrick can then raise the next sections, continuing until the bridge is complete. Meanwhile the other two derricks move towards the banks.

The technique is known as 'balanced cantilevered' construction. This consists of the symmetrical addition of bridge segments that starts on both pier tables, then extends toward the top of the approaches and middle of the main span over the water channel. The balanced approach keeps the heavy bridge segments stabilised as the main span construction progresses. The central spans met in 2019 and the bridge opened to traffic in 2020.

Each pair of derricks face and move away from the towers in opposite directions