

Tunnelling

& TRENCHLESS CONSTRUCTION

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Focus on North America



Call of the wild: open-cut utility scores in Colorado
Dentistry in Nevada's mountains
Canadian rail hub heralds model pipe-bursting

Equipment

Toughest tools for the task: bits, rods and HDD systems

Cover story

A fast finish on Contract 220 of the CTRL



Contract 220 of the Channel Tunnel Rail Link project shows how technology transfer worked to full effect, with completion ahead of schedule

TECHNOLOGY transfer between sectors often offers major advantages providing that the equipment can be modified appropriately for work in a different environment. Here equipment designed for surface work proved itself in a tunnelling

situation speeding up the finishing process in a major new high-speed rail tunnel contract.

Last year, *TTC* featured the use of a slipform paver, designed for surface use but adapted for underground work, on the UK's Channel Tunnel Rail Link (CTRL) Contract 240 (*TTC*, March 2005). This article describes similar

work on Contract 220 by a different contractor and subcontractor, but employing a slipform paver from the same manufacturer, Gomaco of the US, a leading manufacturer of this type of equipment.

Contract 220 forms part of the second section of the CTRL Project, connecting central London to the Channel Tunnel and Europe. Four major tunnel contracts are taking the new high-speed line under the River Thames and eastern London. C220 is the largest – from Stratford in east London into the King's Cross main terminal. Three of the contracts used Gomaco equipment to place the tunnel trackbed and walkways. In total, about 35 km of tunnel require some 105 km of slipform paving.



Surface units give CTRL a fast finish

CONTRACT 220 CONTRACTOR HISTORY

- **Tunnel construction and equipping:** the Nishimatsu-Cementation Skanska joint venture
- **Project manager:** Rail Link Engineering
- **Client:** London and Continental Railways (LCR).
- **LCR's formation:** LCR is a special-purpose vehicle incorporated by its eight founder stockholders. Four of these – Arup, Bechtel, Halcrow and Systra – thereupon formed a consortium between them called Rail Link Engineering. It was appointed by LCR as its project manager and engineer. As such, it is responsible for the entire project management, engineering design, procurement, construction management, services during construction and commissioning of the CTRL.

Above: view of the tunnel once all finishing work had been completed

Equipping the tunnels is now almost complete, with the full service to due begin in 2007. This new stretch of high-speed rail was also a key element in London's successful bid for the 2012 Olympic Games providing rapid access between Central London at King's Cross and Stratford, which will be the site of

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"This new stretch of high-speed rail was also a key element in London's successful bid for the 2012 Olympic Games"

Canada's Dux Machinery trucks were chosen early on in the project planning phase because of their shape and hauling capacity

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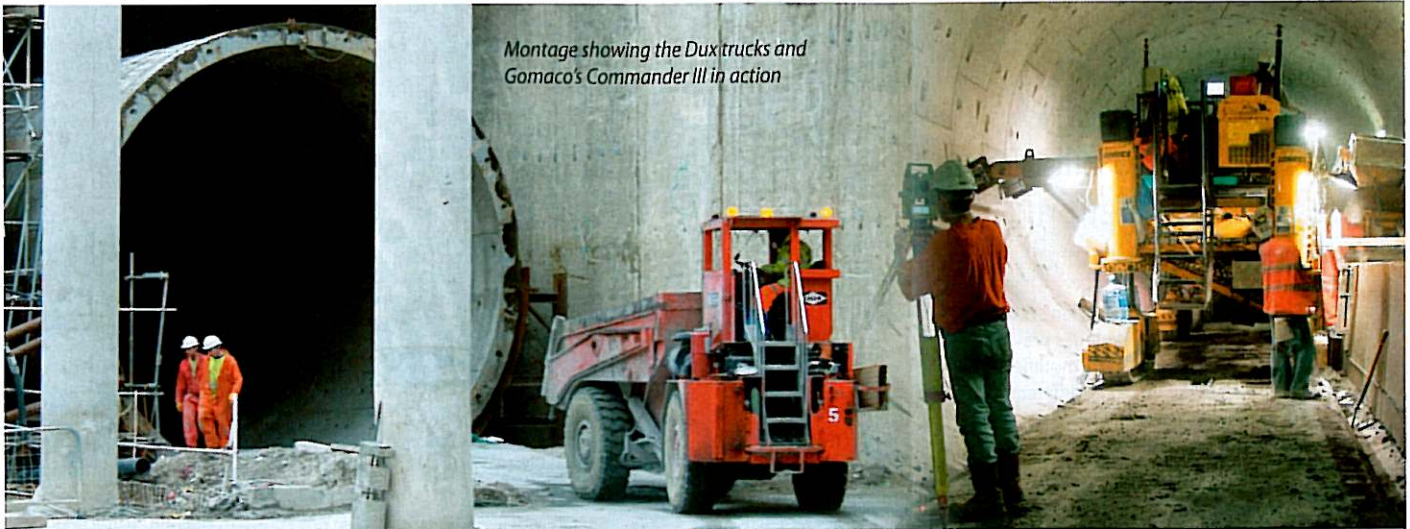
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Montage showing the Dux trucks and Gomaco's Commander III in action

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some of the main Olympic stadia.

Work on Contract 220 began four years ago when two 7.5 km tunnels (7.15 m id) were bored out.

Two 8.2 m-diameter Kawasaki TBMs drove the tunnels on this contract section. The first unit set off from its launch chamber at Stratford at the end of August 2002 (*World Tunnelling*, September 2002, pp298-299) and completed its drive in early 2004.

Bill Brundan, tunnel agent for the Nishimatsu-Cementation Skanska Joint Venture responsible for building the new railway tunnels at Contract 220, explained: "We liked the idea of slipforming because it would be quick and would drastically reduce the number of men needed for the operation. But we needed to find someone with the expertise to help carry out the work. Gomaco introduced to us Peter Davidson and Peter was involved from a very early stage, and jointly we chose the subsidiary plant and equipment and ironed out all the methods. Peter has certainly been a vital part of the paving operation."

TESTING THE PAVER

But would the concrete walkways stick and stay standing on the circular walls of the tunnel? The JV members were sceptical, and they had limited experience slipforming concrete and working with slipform pavers. The Dutch carried out this type of work successfully on their Botlek tunnel and a similar system was starting up on Contract 240 using another subcontractor – Cobeton, of The Netherlands (*TTC*, March 2005, pp30-32). Even so, they decided early on to have Peter Davidson and his Gomaco Commander III paver carry out trials to see if they could slipform the project.

Mr Brundan explained: "Before we decided to go paving, we did a number of trials. We actually built dummy tunnels on the surface where we erected some segments to imitate the tunnel and we used a Commander III to do extensive trials to see if it was possible. We tested the reinforcement, the dowels, the ways of getting the concrete to stick to the wall. We wouldn't make the decision to pave until we'd confirmed in our minds that it was physically possible. The trials clearly showed it would work."

Peter Davidson and his crew then got the go-ahead to slipform the three different applications.

Mr Davidson said: "You learn early on

that you have to be very patient when working on a tunnel project. When we started this project, we had no tunnel experience, but we're very good at logistics, road paving, batch plants and production."

Four of the tunnels and most of the equipment, batching plant, and tunnel portals were in the Stratford Box, an area being built as the new Stratford International Station for the high-speed passenger rail line that will travel through Contract 220's two new tunnels.

Initially, the equipment was used to pave the main trackbed. The tracks on the Commander III had to be built to tilt up to 35° to accommodate the tunnel's curvature. Another challenge in paving the tunnel's trackbed included slipforming over a 9.8 in (250 mm)-diameter ducting pipe.

"We laid the pipe just in front of the paver and connected everything up as we went," John Crouch, Mr Davidson's foreman, said. "There has been some 2,500 lengths of ducting and we managed to come up with simple methods to allow the ducts to be put in without stopping or delaying the paving process."

"The trackbed's running surface is about 2.5 m wide," he added. "It was laid in a circular tunnel so in the centre of the tunnel it's about 600 mm deep."

Mr Davidson said: "We decided in the early days that the only way to take this contract on was to do everything. If we had other people fixing pipes or

steel for us, they'd just hold us up. We connect all the pipes and services as we go, so there's no extra finishing work, no jack-hammering or cleaning out of anything."

During one stretch of slipforming the trackbed, the Commander III ran 10.5 days straight, 24 hours a day without stopping. During that time, Mr Davidson's crew laid down 7.5 km of trackbed covering the entire length of one tunnel.

Phase One of the C220's CTRL's concrete slip-forming project was complete. The next phase involved slipforming two different types of walkway: an evacuation and a maintenance type.

Mr Brundan said: "The walkways are more challenging because the horizontal surface and the vertical surface are varying all the time depending on the tunnel alignment or tunnel cant. That means that the walkway can go from a 1.5 m width on the top surface down to about a 1.1 m width. It varies all the time."

The hydraulic mould is capable of expanding or contracting up to 500 mm on both its top plate and sideplate. It was tricky at first, getting the walkway to follow the curving tunnel profile while maintaining line and level. The outside line of the finished wall will only be 50 mm away from the high-speed trains that will soon be running in the tunnel.

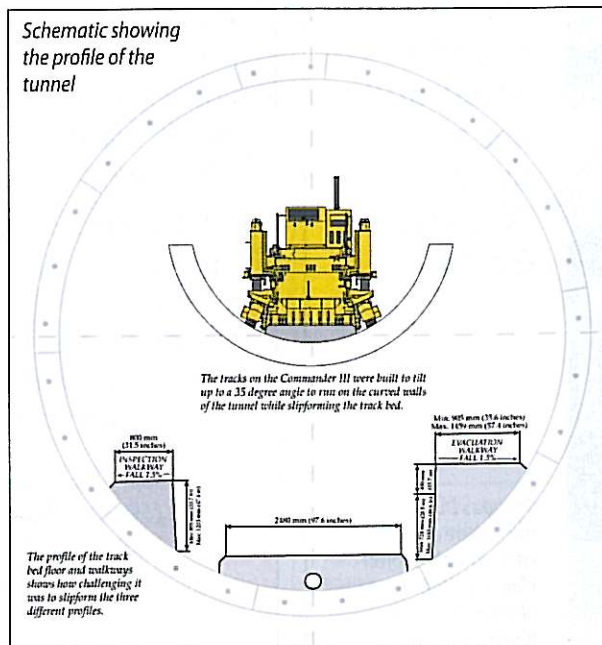
Mr Davidson said: "The walkway at its largest was 1.6 m high and 1.5 m wide and that's a fair block of concrete that attempts to push that paving machine off the wall."

Mr Brundan added: "We have a hydraulic jack system with wheels that come from the body of the paver to the opposite wall of the walkway we're paving. With the considerable variation of the tunnel alignment and the cant, the wall goes all over the place. There's really no straight lines in that tunnel and our system helps to make everything stable and keeps the walls standing upright."

Ductwork and piping also have to be dealt with in the walkways, just like the trackbed. Finishing work on those is carried out directly behind the paver. Nothing is left behind for completion at a later date.

Concrete is delivered to the paver by trucks, specially manufactured by Canada's Dux Machinery. Each truck carries 6.1 m³ and everything that enters the tunnel is in a preset sequence. Two crossing bridges or ramps are strategically placed at certain points to allow the trucks to pass. The top of each ramp is 700 mm off the floor to allow

Schematic showing the profile of the tunnel



enough width for two trucks to pass each other inside the tunnel.

The Dux trucks were chosen early on in the project planning phase because of their shape and hauling capacity. The Dux drivers dump their load of concrete into a large skid as fast as possible. A 13 t excavator, with a shortened boom to work in the tight tunnel conditions loaded the concrete into the hopper in front of the Commander III.

The maintenance walkway itself is 800 mm wide and 1,203 mm tall. Its high production exceeded everyone's expectations. "We've achieved up to 600 m in a 12-hour shift on the smaller wall," Mr Crouch said. The rate of paving increased as the end of the tunnel was neared.

The walkway was poured in 3,000 m sections with a 1,500 m stagger in between. The walkway has to be slipformed in these shorter segments to accommodate the ramps and concrete delivery. Once one walkway is in place, there is no room to place the crossing ramps.

Finishing work behind the paver was kept to a minimum. No joints or curing compound were required because the tunnel is the perfect drying environment for concrete. It maintains a steady temperature and a dry environment.

Mr Brundan said: "Production was fantastic. We

put down a phenomenal amount of concrete in a 24-hour period. If we had gone the traditional hand-forming method, we would have perhaps managed outputs of about 50-100 m/d, at best. There's really no comparison. The time we've saved and also the manpower we've saved has been considerable."

Another time-saving area of the project involved use of the Leica stringless guidance system instead of traditional stringline. Tunnel conditions do not favour normal stringline use, plus the manpower needed to set up the line would have been considerable.

Mr Brundan continued: "We couldn't use stringline because we wouldn't have had enough surveyors to set it and get it all ready in time. We used a 3-D system when we were boring the tunnels and it was a natural step to use a stringless 3-D system on the paver. Leica manufactures a very good system and I don't think we could have done it any other way."

Sitting just outside the two tunnel entrances is Davidson's twin-shaft mixer, Compactor batch plant. It can produce up to 157 yd³ (120 m³) of concrete per hour.

"It mixes the dry concrete that a lot of other plants would have struggled with," Mr Brundan said. "It's a plant that has plenty of capacity and it gives us high outputs and high production."

The mix design itself is very dry with both 0.4 in and 0.8 in (10 and 20 mm)-sized limestone, two types of sand, a super-plasticiser and an air-entrainment agent.

"It's a very dry concrete and very hard to handle," Mr Brundan said. "You couldn't handle it by hand or with shovels, but the Commander III is obviously ideal for it. The machinery that we selected for this project has all been unbelievable," Davidson said. "The Commander III has run the last six months, seven days a week, 24 hours per day. It just keeps going and going. The production we're getting right now is just out of this world."

The tunnel work that, despite its challenges, Davidson and his crew are ready to take on again.

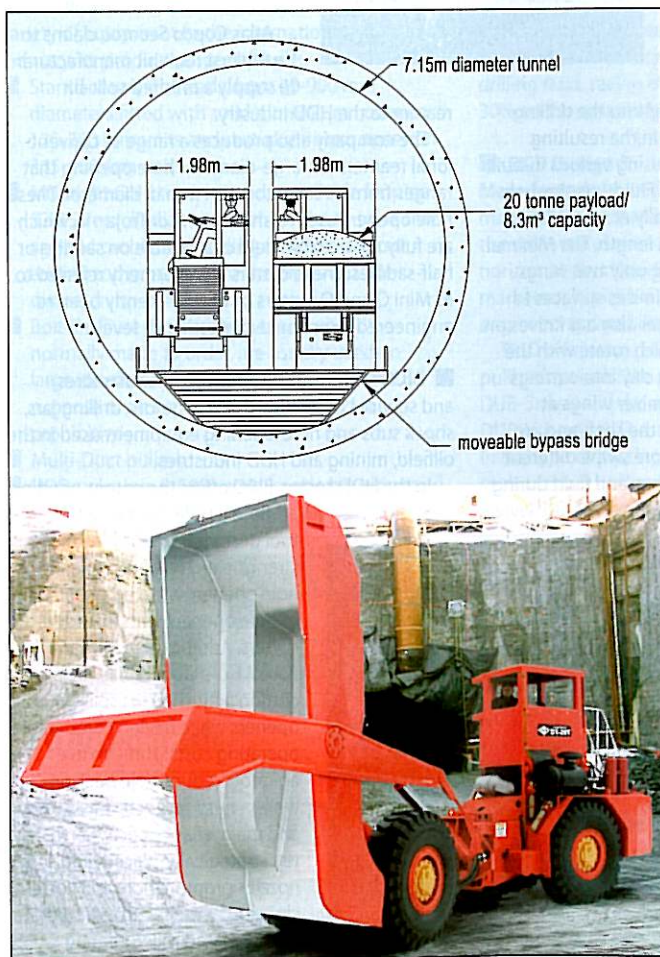
"We'd go anywhere in the world to work on another tunnel," Mr Crouch said without hesitation. "It's interesting work, you can plan your jobs and you don't have to worry about the weather. Once you're set up, you just go."

Slipforming was completed in the September quarter of 2004, finishing this part of the CTRL contract two months ahead of schedule. In under six months, Davidson and his crew slipformed almost 75 km of tunnel railbed and walkways.

"The tracks on the Commander III had to be built to tilt up to 35° to accommodate the tunnel's curvature"

Acknowledgements

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