**Limehouse Link**

Linking The Highway in the west to the Isle of Dogs at Westferry Road and North Quay in the east, the £255 million Limehouse Link tunnel is the largest underground road built by cut and cover techniques. The seven year project required considerable skill and ingenuity by the teams involved from the London Docklands Development Corporation (LDDC), Balfour Beatty/AMEC joint venture and Sir Alexander Gibb & Partners to overcome the many unique challenges presented. Several major problems were encountered during the 42 month construction period, but co-operation between the parties allowed the section between The Highway and Westferry Road to be completed on schedule and to North Quay, five and a half months ahead of time.

**Choosing the route**

Set up by Government in 1981, the LDDC was given the task of breathing new life back into the capital city's run down and derelict port areas. This was to be done by attracting new homes, new businesses and jobs, as well as new community and leisure facilities, and by improving the existing homes, businesses and facilities. From the beginning it was recognised that new opportunities could only be generated if access to the area was dramatically improved. The existing road system had little or no spare capacity and there would have to be major improvements in the public transport network. In addition to promoting and part funding the Docklands Light Railway, the LDDC set about improving and building new local roads to meet the needs generated by an estimated eight million square feet of development on the Isle of Dogs. However, by the mid 1980s, the success of London Docklands in attracting thousands of new homes for sale and rent and new commercial developments, including a single development of 12 million square feet on Canary Wharf, had brought about a radical rethink on the infrastructure needed in the area.

By mid 1986, the LDDC Board had approved the Docklands highways strategy - a series of new and improved roads, stretching from Wapping in the west to Beckton in the east. Major upgrades and extensions were also being proposed for the Docklands Light Railway. To the west, the new roads needed to pass through densely populated areas, presenting the engineers with a complex set of problems. A solution was found, after extensive consultation and debate, in a new underground road built by the cut and cover technique from the top down - the Limehouse Link.

Options, including new surface roads and widening of existing roads, had been considered but were rejected as they involved the demolition of large numbers of properties. The route chosen for the 1.8

---

**Diagram:** Limehouse to Leamouth

1. Limehouse Link
2. Westferry Circus and associated road improvements
3. Poplar DLR
4. Canary Wharf East Dock
5. Cotton Street East Dock
6. Prescot Road Disused
7. Prescot Road Flyover
8. East India Dock
9. Limehouse Crossing

This is a general guide only; for further details please contact the LDDC. The information is based on the LDDC's plans as at the date of publication, but the proposals remain subject to change.
kilometre Limehouse Link minimised the number of properties that needed to be demolished, and joined together pieces of derelict and under-used land, minimising the effect on the local area.

In November 1986, Sir Alexander Gibb & Partners were appointed to undertake the detailed design. In July 1988, planning permission was granted and, following a public inquiry in November 1988, the Secretary of State for the Environment and the Secretary of State for Transport confirmed the compulsory purchase orders, associated road closure orders and conservation area consents.

A challenging design

Designing the Limehouse Link proved to be a real challenge:

- Designing the route to the top down method within the physical constraints.

- A grade separated junction, with slip roads giving access to Westferry Road, had to be situated part way along the tunnel length.

- Existing docks and waterways had to be restored during construction and navigation rights maintained. This required the tunnel lid to be up to eight metres below ground level along much of the route.

- It had to be designed so that buildings, several storeys high, could be built over the tunnel.

- The route crosses a number of existing main roads. These were to be maintained during construction together with all the services, such as gas, water and electricity mains, buried underneath.

- The ground conditions were particularly difficult for deep excavation, with water retained under pressure deep in the soil.

Key design features include the services buildings which house the exhaust fans—an integral part of the tunnel portals.

Contract award

The LLDC invited tenders to construct the scheme from leading UK and European civil engineering companies in December 1988, for submission in May 1989. After a detailed review of the bids, the £171 million tender (estimated then at £220 million at 1993 prices) was awarded on 20 September 1989 to a joint venture of Balfour Beatty Civil Engineering Limited and Fairclough Civil Engineering Limited (who in 1992 took the name of its parent company AMEC).

The joint venture submitted an alternative design in the Limehouse Basin which proposed construction from the ‘bottom-up’. Not only did this save money, but it also allowed the section between The Highway and Westferry Road to be completed 12 weeks earlier than required in the tender.

Early days

Work started on 20 November 1989 marked by the then Prime Minister The Rt Hon Margaret Thatcher, MP driving the first test pile for the cofferdam in Limehouse Basin. Driving trials had to be undertaken to validate the joint venture's cofferdam design of tubular piles to retain the Victorian viaduct which carries the Docklands Light Railway to the north of the Basin. Early trials were also commenced on; the large diameter bored piles; the system to dewater the ground during construction; and diaphragm walling, the method of building the tunnel walls. The dewatering trials indicated that the wells were extremely difficult to design and install so the joint venture opted to undertake its construction itself, rather than subletting this work.
Building from the top down

After installing the diaphragm walls (figure 1) to the first 100 metre section, the roof was excavated between the walls some eight metres below original ground level. To meet the LDDC's requirements of avoiding disruption to local roads, spoil was hauled along the line of the works and, in some instances, concrete was pumped up to one and a half kilometres. The diaphragm walls were propped using large tubular struts (figure 2) to prevent movement to the adjacent buildings and the roof slab constructed beneath. At this stage, movement to the diaphragm walls was so small that only a fraction of the anticipated prop load was experienced. Openings were left at about 50 metre intervals in the roof slab to give access for construction below.

After reducing the water level in the soils beneath the London Clay, the tunnel was excavated using backhoe excavators and tracked front-end loaders a further 10 metres below the underside of the roof. Initially to keep the walls apart, tubular struts were installed (figure 3). As part of the Balfour Beatty/AMEC redesign, these were later removed using a technique which mobilised the soils natural strength whilst minimising the construction time of the base slab. Close monitoring of the walls was necessary to ensure only acceptable movements were being encountered and was aided by re-detailed, the base slab construction to reduce the size and weight of the steel reinforcement. These alterations enabled the joint venture to average 10 metres per week of tunnel construction to each of the five construction faces - over twice the planned output of four and a half metres.

Environmental awareness

Hundreds of homes and businesses line the route of the Limehouse Link requiring exceptional consideration and care both in the design and detail of the road and its construction. The LDDC required the contractor to use barge transport for delivery and removal of construction material and spoil.

To ship the three and a half million tonnes of materials and spoil, to and from the site, a 200 metre purpose, built wharf was built on the river frontage at Dundee Wharf along with a chain of wharves at Greenwich, Dagenham, Purfleet and East Tilbury.

It is estimated that this eliminated 90,000 truck journeys on local streets over the contract period, an average of 90 trips a day. Most of the concrete for the tunnel was mixed at the on-site plant and pumped to where it was needed, saving a further 60,000 truck journeys.

The underground route immediately reduced the long-term effect on the local area. The LDDC carried out noise protection measures next to the portals for a number of properties, including the installation of secondary glazing and specified silencing of the tunnel ventilation system so that the fans were barely audible at night.

Noise and vibration limits during construction were determined by an agreement under section 61 of the Control of Pollution Act, negotiated by the LDDC with the London Borough of Tower Hamlets. Part of the agreement provided for secondary glazing to many properties along the route.
Selected properties were also to be vacated temporarily, allowing diaphragm walling and piling to continue over a greater period per day. Balfour Beatty/AMEC had to control their activities very carefully to keep within these agreed limits and to use the most practical and efficient methods to reduce disturbance to the local community. Where possible they employed plant runs from mains electricity and the most modern machines available and staff received special training. Regular meetings were held with the local community and the local authority. The works were also closely monitored by the LDDC which employed its own environmental consultant.

**Bottom up in the basin**

During the tender, the joint venture radically re-thought the original construction methods and proposed a design and construct alternative in the Limehouse Basin, building the tunnel from the bottom up (figure 4). This involved the construction of a working platform using sea dredged sand pumped into place from the river following removal of silt from the Basin. A cofferdam using the largest sheet piles available (Larssen 6) and large diameter steel tubes were then installed and the sand fill and clay between the walls removed. The walls were propped using tubular struts (figure 5), the lower of which was installed after excavation to base slab level using the observational technique adopted in the top-down construction.

The tunnel box, designed by Robert Benaim, was constructed at 10 metres a week, using purpose made steel shuttering to the base and walls and a lightweight travelling soffit form for the roof (figure 6).
All wired up

To keep the tunnel clean and safe, ventilation, lighting and traffic management systems have been installed. Computer controlled from the services building at Westferry Road, these facilities are linked to the police traffic control centre at Blackwall, along with the nearby Blackwall and East India Dock Link tunnels. The ventilation system continually checks the levels of exhaust fumes within the tunnel. If the fume level rises, jet fans on the roof of the tunnel are started, accelerating the air to the axial fans in the service buildings which in turn expel the air into the atmosphere. Sensors outside the tunnel control the levels of five banks of lights at the entrance reducing the 'blackhole' effect on a bright day. Traffic sensors and cameras check the traffic flow to reduce delays and give early warning of incidents, with a full emergency telephone system available for public use. The emergency services radios remain fully functional inside the tunnel due to the 'leaky feeder' system which has been installed.

Integrated management

Unavoidable delays in the early part of the contract led the contractor and LDDC to agree revisions to the contract, designed to ensure completion on schedule. It involved the contractor employing additional resources and redesigning part of the works. Any cost savings resulting from design changes were shared with the LDDC.

To improve its responsiveness to problems and ability to make swift decisions, the LDDC integrated its management with Gibb to undertake the supervising officer’s role of providing design details and changes, and approving the construction works.

This produced considerably closer liaison between the contractor and client than traditionally exists in UK construction.

Another key initiative developed was to review and resolve, at 90 day intervals, all problems that could potentially delay the completion date of the works. As a result of agreements between the LDDC and the contractor, as well as this problem solving procedure, the Limehouse Link between The Highway and Westferry Road opened on time and the section to North Quay five and a half months early.
Opening the way

The Limehouse Link, part of the private Docklands highway network, was planned and designed in three years - half the time of other similar schemes. It opened on schedule, on 17 May 1993, at an agreed cost of about £255 million. This represents a fairly unique achievement in the UK construction industry.

Key statistics

<table>
<thead>
<tr>
<th>Materials</th>
<th>Concrete 25,000 m³</th>
<th>Reinforcement 49,000 t</th>
<th>Excavated material 790,000 m³</th>
<th>Dredged silt 104,000 m³</th>
<th>Marine backfill 380,000 m³</th>
<th>Diaphragm walling 41,000 m²</th>
<th>Tunnelling cladding 67,000 m²</th>
<th>Electric cabling 250,000 m</th>
<th>Jet fans 60</th>
<th>CCTV cameras 60</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Note 97 per cent of all materials were supplied and manufactured in the UK)

<table>
<thead>
<tr>
<th>Plant</th>
<th>Cranes over 60t 26</th>
<th>Excavators - large 16</th>
<th>Excavators - small 10</th>
<th>Dump trucks 12</th>
<th>Concrete batching plant - capacity 190 m³/hr</th>
<th>Fork lift trucks 10</th>
<th>Tracexcavators 6</th>
<th>Mobile cranes 9</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Labour</th>
<th>Joiners 60</th>
<th>Steelfixers 75</th>
<th>Plant operators 110</th>
<th>Concrete finishers 110</th>
<th>Pipe layers 20</th>
<th>Electricians 15</th>
<th>Fitters 15</th>
<th>General operatives 220</th>
<th>Lightermen and sailors 50</th>
<th>Trainees and apprentices 18</th>
</tr>
</thead>
</table>

(Note: Approximately five million manhours have been expanded directly on this project)

<table>
<thead>
<tr>
<th>Staff</th>
<th>Contractor 185</th>
<th>Client 15</th>
<th>Consultant supervisor staff 80</th>
<th>Designers 95</th>
<th>Sub-contractors 145</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Final value: approximately £255 million</td>
<td>Duration - 193 weeks (completed 23 weeks early)</td>
<td>Form of contract - GC works 1, edition 2 (modified)</td>
</tr>
<tr>
<td></td>
<td>Method of measurement: CESMM and SMM6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>