Charlton Hayes Interceptor Sewer & Drop Shaft

providing a sewer connection to a 2,200 property development via a 30m deep shaft in a dense residential area

Wessex Water received an application under Section 98 of the Water Industry Act to provide sewerage to a development of 2,200 new residential properties, 66,000m^2 of commercial buildings and a hotel on the former Filton Airfield in Bristol. The Frome Valley Relief Sewer (FVRS), an existing sewer tunnel crossing the north of Bristol, was constructed in 1993 to relieve sewer overloading and to provide sufficient capacity to take the additional flows from this scale of future development. The FVRS extends from the east of Bradley Stoke (near the M4 motorway) to the west of Patchway (near the M5). The FVRS has a length of 4km, diameter of 1.8m and the primary challenge for this scheme was the depth, reaching 30m in the vicinity of the required connection. After a comprehensive review, use of the two nearest existing shafts was deemed unsuitable due to their locations. Thus, a new shaft connection was required.

Charlton Hayes shaft
Courtesy of Lewis Civil Engineering

The scheme

The Charlton Hayes Interceptor Sewer and Drop Shaft scheme was divided into two separate projects with specific specialist teams to develop the optimum solution for the off-site wastewater infrastructure, as follows:

- 30m deep drop shaft to discharge flows in the existing Frome Valley Relief Sewer.
- 1km long, 650mm diameter, interceptor sewer to connect the Charlton Hayes development site to the new shaft, and provide additional future sewerage capacity to the surrounding area.

Wessex Water appointed Mouchel to undertake the design of the new drop shaft and Mott MacDonald for the design of the new gravity sewer. The construction of both the sewer and the shaft was undertaken by Lewis Civil Engineering.

Team challenges and considerations

One of the biggest challenges faced by the project team was the proposed connection point on the FVRS. The two nearest existing shaft locations were 1km apart and each posed significant difficulties in terms of location and accessibility. One is located in the centre of the Patchway housing estate while the other is located in the centre of an interchange for the A38 on the opposite side of a deep railway cutting. These factors would have overly hindered the incoming sewer installation.

Options were limited, with the alignment of the FVRS needing to coincide with a feasible construction space. However, a single site existed within the play area of an existing Nursery and Youth Centre. It would provide a confined site and present its own logistical issues, but with comprehensive planning and close consultation with the town council and community groups would provide a viable location for both the shaft and the incoming sewer route.

Full depth shaft construction - Courtesy of Lewis Civil Engineering

Launch pit for laser guided auger under major highway route Courtesy of Lewis Civil Engineering.

The interceptor sewer

A hydraulic analysis of the catchment was carried out by Wessex Water to ensure that, while satisfying the immediate requirements of the Section 98 requisition, capacity benefits could also be realised for the existing (combined) sewer network by connecting it into the new interceptor sewer.

Challenges facing the project team included the ground conditions and logistics of working in busy highways between the development and the proposed discharge point. Contaminated ground, varying rock levels, and the need to cross several arterial access routes with imposed highways working restrictions posed the challenges alongside the H&S considerations of working within this urban environment. The project team engaged with all stakeholders to develop the preferred route that balanced constructability with design criteria, cost, programme and risk implications.

Stakeholder consultations, including local businesses, community groups, highways authority, emergency services, the public library, local town council, bus companies and residents, were all undertaken to assess the impacts of the works and plan mitigation measures. An evening public meeting was held so residents could view proposals and ask questions.

Early contractor involvement from Lewis Civil Engineering took place throughout the design stage to advise on constructability and allow realistic commercial estimates to be developed alongside various options. Their involvement ensured a 'right first time' approach providing essential confidence during all stakeholder consultations. Effective collaboration between the designers of both sewer and shaft, with particular attention to incoming gradients and connecting details, provided efficient continuity between the separate construction projects.

Throughout all design and construction stages, Wessex Water's Environmental Services team conducted screening assessments and advised on mitigation measures and monitoring plans, providing full support to the project team.

As well as the above ground constraints, bore hole investigations and pre-construction trial holes had indicated changing rock levels along the route and proved the location of numerous service crossings including culverts/high pressure oil pipelines and both HV gas and HP gas mains.

The final route took into consideration all of the above factors and made use of the less disruptive laser guided auger construction technique for significant road crossings and garden areas where depth, services or third party constraints dictated.

The drop shaft

Once the proposed site had been identified, the precise line, level and condition of the FVRS needed to be validated. A number of walk-through surveys were undertaken so the relative positions of the existing tunnel and potential shaft location could be set out on the surface. The various options for the shaft location, diameter and associated connection details could be developed as well planning the layout of the combined working area and site compound.

Health and safety was the primary driver for the design development phases of the project. Consideration needed to be made not only to the construction techniques and diameter of the proposed shaft but fundamentally whether an off-line solution with a heading across to the tunnel was preferable to an on-line solution directly onto the crown of the tunnel.

Initial discussions were focused on the flows within the existing tunnel and the difficulties these may introduce when designing and constructing the connection detail. High flows and periodic surcharging of the tunnel would cause internal pressures and make a low connection point difficult, as well as determining the time of connection. Flow monitors were installed immediately upstream to allow the design team to understand the range and nature of flows that could be expected and the construction team to monitor 'real time' flow levels during the planning and completion of the physical connection.

The initial walk through survey confirmed record drawings that showed that the tunnel was built using a segmental system aligned with timber pegs. Although revolutionary at the time, this system was found to be no longer manufactured. With limited information available on its design and therefore likely performance under loading if disturbed, the decision was made to construct the shaft off-line.

A 6m long, 1.2m^2, reinforced concrete heading was required to be constructed in 800mm stages between the base of the 30m deep shaft and the back of the existing 1.8m diameter tunnel lining. Removal of the remaining ground within the final stage would be completed in narrow vertical strips, thereby minimising the area of tunnel lining left exposed and unsupported at any one time. Once complete, the reinforced concrete heading would provide a fully supporting and enclosing structure around the location of the final break through into the tunnel.

Lewis Civil Engineering chose to construct the shaft by underpinning using Buchan shaft liners. Selecting the shaft diameter was a key decision. Whilst knowing that a 5m diameter shaft was technically possible and anything greater would provide no final operational benefit, the project team felt that this was insufficient to provide a safe working environment.

A 7.5m diameter shaft was selected following careful consideration of plant sizes to be used; access restrictions; necessary dewatering and ventilation hosing; and muck skip clear lifting zones. As well as mitigating the risk of crushing injury, the increased cost implications of procuring the larger shaft segments was later proven to be offset by increased production rates as a consequence of the increased working room.

The possible need to dewater the shaft of large amounts of ground water during construction posed a further challenge within this residential environment. Careful consideration was given to the route of a temporary overland pipeline that could be deployed at short notice if needed. Statutory land entry notices were served in advance on landowners and sections of pipe installed under roads in early preparation. These mitigating measures were aimed at reducing costly construction delays if the risk was realised.

To control flows during the 30 meter fall from the incoming surface sewer, a 450mm diameter stainless steel vortex drop pipe and energy dissipation unit (EDU) were installed down the side of the shaft. This allows low flows to fall with a vortex movement while high flows fall in a traditional manner. The EDU is located at the base of the shaft at the bottom of the drop pipe and reduces vibration and scour effects. It is contained behind a 1.4 metre high weir wall to ensure it remains permanently submerged. A penstock is located in an upstream manhole immediately before the drop shaft to allow isolation of flows should maintenance be required.

Public relations

The site compound was bounded by a number of residential properties, local amenities and a busy day nursery and youth centre. The wider residential environment surrounding the interceptor sewer works required an integrated and sympathetic traffic management plan.

Local councillors were kept informed of weekly progress with email reports while house owners were informed of planned works in their area through regular letter drops and advance warning

Construction in progress - Courtesy of Lewis Civil Engineering Ltd

Construction in progress - Courtesy of Lewis Civil Engineering Ltd

leaflets. School children from the youth centre were invited to visit the construction site and given a brief presentation on the need for the scheme in order to encourage the next generation of engineers.

Innovation

The ground conditions encountered provided the opportunity for new construction methods to be used and innovative materials to be trialled. Fluctuating rock level led to the introduction of a recently developed no-dig technique termed Pilot Driven Rock Auger.

This enabled four sections of the interceptor sewer to be driven at depths up to 7m through limestone areas. The technique allows pipes to be installed through strong rock whilst maintaining tolerances acceptable for gravity pipelines. This remains one of the few schemes within the UK where this technique has been used to date.

Areas of contaminated ground and aggressive soils precluded the use of concrete pipe in certain areas, and the design team therefore specified the use of Aquaspira pipe. This steel reinforced polyethylene pipe met both the resistivity characteristics required while providing a robust pipe for the client.

Conclusion

Wessex Water's early engagement of the delivery team on these combined £3.5m projects allowed every aspect from concept to completion to be carefully considered and planned. The result was an efficient delivery of two challenging projects within a densely populated area on time and within budget whilst minimising the impact on the surrounding public.

The editor and publishers would like to thank Wessex Water and Lewis Civil Engineering for providing the above article for publication.

(Above) Site stripping (Below) Site compound following establishment. A secure and self-contained site was required
Courtesy of Lewis Civil Engineering