National Operational Guidance

Tunnel construction methods

The type of tunnel construction will present specific access, intervention and operational challenges, and specialist advice will be needed on the best way to proceed. There are three main tunnel construction methods.

Cut and cover

The simplest in tunnelling terms, cut and cover tunnels are constructed by digging a trench, forming the cast concrete tunnel walls and placing a concrete slab over the top. Excavations forming the cut can be deep and require special intervention considerations and controls.

Bored

As the name implies, these tunnels are completely surrounded by the ground. The tunnel is driven through the soil under the surface by mechanical, manual or explosive means. The excavation made to commence tunnel boring can be deep and require special access and intervention considerations and controls. The characteristics of the tunnel - single or twin bore - will also affect the intervention strategy, especially in terms of the intervention distance and dead end conditions during the construction process.

Immersed tube

Where a tunnel is to cross beneath a body of water, an immersed tube tunnel may be selected as an alternative to a bored tunnel. This type of tunnel is usually made of reinforced cast concrete rectangular sections, which are constructed in a casting basin, sealed at both ends, then floated out, sunk and joined to the previous underwater section by gaskets. The tunnel sections are normally laid in a trench on the river or sea bed and, once in place, a rock protection layer is placed over the top of the tunnel sections to protect them.

Access to the casting basin is normally via a series of tiered access roads. One end of the casting basin is fitted with a caisson to prevent the ingress of water until the basin is flooded. The flooding of the casting basin, floating out and towing, sinking and joining of the sections underwater are extremely specialist operations, which fall outside the normal scope of fire and rescue service operations. The fire and rescue service could, however, be asked to provide water safety assets to assist during a waterborne incident.

Pre-planning and familiarisation

All underground structure incidents have the potential to present the fire and rescue service with a range of challenges owing to their physical nature and potentially limited access. To ensure adequate emergency response preparedness, site inspection visits will be essential to familiarise and prepare all responders likely to attend and make an intervention in these environments during construction or when completed.

The construction of an underground structure may present additional challenges and necessitate temporary procedures and intervention strategies because not all planned infrastructure may be in place. Site visits will provide crews with awareness about access points, rendezvous points (RVPs), holding/strategic holding areas, equipment loading areas, intervention points and water supplies. They will also enable the more specialist construction arrangements to be seen, such as tunnel boring machines (TBMs), spoil extraction and supply train systems.

Many natural underground structures across the UK, particularly those not mapped or used by leisure groups, may never have been visited by inspection personnel. In the case of an emergency response to such a structure, fire and rescue services should seek specialist advice and co-operation from organisations with more knowledge and experience of similar environments.

Planning

An assessment of the work site, operating activities and associated risks is a crucial element of the information gathering and planning process, and full consultation with the contractor and infrastructure manager must take place to establish specialist activities and ways of working. All responders should be given the opportunity to contribute to the planning process to enable a robust and inclusive emergency plan to be developed.

As part of developing the emergency plan, the contractor and infrastructure manager must be informed of any services deemed necessary to support an intervention by the fire and rescue service or other responders. When assessing support service requirements, the appropriate legislation and application guidance must be reviewed to ensure full compliance and provision. Information gathered during the planning process will be used to determine a number of important factors and to:

- Establish a pre-determined attendance of sufficient weight of attack that will fulfil all initial intervention requirements and enable a safe system of work to be implemented
- Identify the need for the provision of fixed installations or specialist equipment
- Identify the need for specialist team support provided by the contractor or infrastructure manager
- Identify the need for specialist team support from the fire and rescue service
- Consider the need to develop crew intervention plans

Any plans made during the construction phase must be kept under constant review and revised to reflect the ongoing construction process. Once the transition between construction and commissioning occurs, plan review and revision will need to be determined in accordance with the fire and rescue service premises risk management model, which will set the risk level and inspection frequency. All partner agencies must be involved in the final planning process.

Special access arrangements

It is particularly important that fire and rescue service personnel are made aware of special access arrangements, such as the access to the bottom of an excavation for a cut and cover tunnel, the launch chamber for a bored tunnel or the casting basin for an immersed tube tunnel. Access from the 'top site' to the 'pit bottom' will be strictly controlled and a 'red tally' system will normally be employed to account for those below ground. Access to the bored tunnel may require additional safety and access controls, including the contractor providing training and issuing self-contained breathing apparatus (SCBA) to all visitors to comply with health and safety requirements.

During a tunnel construction phase, access to underground areas and tunnel workings is subject to strict access and egress controls, in accordance with Health and Safety Executive (HSE) requirements and varies according to the type of tunnel construction method. The most complicated access is to cut and cover constructions or where an underground chamber has been constructed for assembling and launching a tunnel boring machine. The cut and cover or chamber floor slabs can be many metres below the top site access level.

Access to the below ground workings for these tunnel types is not normally by road or rail but via lifts and scaffolding staging and steps, with access control at top site level. Access control is the entry point for those wishing to go to the lower levels or 'pit bottom'. The control system can be manual, can use an emergency tally system (where a token allocated by the contractor is handed in and retained at the control building, then retrieved by the user on exit), or can be an electronic system (where an ID tally or card is swiped and logged when the user enters or leaves a controlled area).

For railway tunnels, transporting fire and rescue service personnel and equipment must be discussed and intervention methods agreed with the infrastructure manager, the train operating companies and the regulator (Office of Road and Rail) at the earliest opportunity. This will enable access and intervention arrangements to be incorporated in the tunnel emergency plan.

When developing the emergency plan, intervention plans and procedures, transporting crews will be a key consideration because it is not possible for crews to intervene and carry heavy equipment into long tunnels. The length of the tunnel, access and intervention points should be considered, along with the services provided to support an intervention, such as track trolleys or using trains to convey personnel and equipment into the unaffected tunnel. The design of the tunnel will dictate the type of intervention method to be used, and whether access should be from the tunnel portal, intervention shafts or via cross-passages from the non-incident tunnel to the incident tunnel.

For most cut and cover and tunnel boring machine launch chambers, below ground excavations and structures are constructed using linked concrete piling to form a diaphragm wall, or interlinked steel sheet piling, which is driven into the ground. Both methods normally use horizontal concrete or steel beams to prevent the side walls and end sections from collapsing inwards. As part of the excavation process, edge protection will be provided to prevent falls from height and to prevent vehicles from falling into the excavation.

Training

Fire and rescue services should consider conducting training exercises at underground structure sites that present significant risks, whether they are complete or under construction. Where possible, training exercises should include other responders to ensure greater inter-agency awareness and understanding. Following completion and during the normal running phase, training should focus on the designed use of the structure and the incident type associated with that use.

During the construction phase, exercises, drills and joint working with the contractor's specialist teams will need to be arranged with the principal contractor at the earliest possible opportunity. It would be unusual for a contractor to have their own on-site fire and rescue team(s) unless required for a particular activity, such as working in a confined space.

Contractor's staff or engineers may have specialist knowledge that could help guide fire and rescue service crews when attending machinery entrapment incidents.

When planning training exercises, consideration should be given to a number of procedures. These include arrival, access to below ground areas, equipment and personnel loading, transfer arrangements, intervention tactics, and specialist procedures such as confined space, tunnel boring machines and high-voltage electricity.

Training during the construction phase should address all incident types that could be encountered. These include fire, explosion, structural collapse and entrapment, machinery entrapment, hazardous materials and incidents involving heavy plant and equipment, the tunnel boring machine (TBM) and high-voltage electricity.

Work in compressed air (Pressurised atmospheres)

During the construction and refurbishment of tunnels and subsurface infrastructures, compressed air can be used to manage ground water and to stabilise the face of the excavation. The nature of compressed air working has changed significantly over the years to reflect developments in tunnelling technology and techniques. Long periods of work in compressed air chambers using hand excavation techniques have ceased to be the norm, as the majority of underground structures are constructed using tunnel boring machines (TBM) or other methods. This has resulted in much lower levels of exposure to pressurised working environments.

Exposure to compressed air is now generally limited to periodic but short excursions into the cutting head of a tunnel boring machine (TBM) for inspection and maintenance. Given the relative rarity of compressed air tunnelling work, the emergency services will have little or no experience of dealing with hyperbaric emergencies. Such operations are specialist in nature and are not activities that normally involve fire and rescue services, other than to provide support and assistance to specialist teams.

The contractor in charge of the pressurised working operations should assist the fire and rescue service in planning its response to an on-site emergency. That assistance will extend to providing equipment and training facilities. Emergency exercises should be undertaken early in the works period and at intervals of not more than 12 months thereafter. The contractor in charge should work with the emergency services to allow them to undertake simulations and joint exercises to improve their ability to respond to emergencies.