

Designing for health - Guidance for designers

Tunnelling				Ref DfH012_17	No.
Potential health impacts to be considered by the designer:		Concept Stage <input type="checkbox"/>	Scheme Design Stage <input type="checkbox"/>	Detailed design Stage <input type="checkbox"/>	
Design Element	Health Hazard	Considerations	Possible Solutions	Linked to Ref No.	
Hand tunnelling and square works. Ground excavation and lining erection by hand.	Musculo-skeletal disease or work related upper limb disorder. Noise induced hearing loss. Hand Arm Vibration Syndrome.	Purpose of the tunnelling works – e.g. service installation or part of much larger tunnel. Simple alignment or complex structure. Size/diameter of service to be installed. Drive length. Access for tunnelling works – e.g. greenfield site or within live metro stations?	Avoid hand excavation by ensuring tunnel is large enough to allow use of mini excavator and/or mechanised tunnelling/pipejacking technique where possible. Avoid need for erection of lining by using pipejacking rather than segmental lining for small diameters. Comply with “Guidance for Designers - Internal dimensions for pipejacks and tunnels below 3m diameter and indicative drive lengths” published by		

			<p>BTS/HSE/PJA.</p> <p>Specify alternative tunnelling methodology such as use of sprayed concrete lining techniques.</p> <p>Follow BTS guidance on HAVS.</p> <p>Consider use of trenchless techniques such as directional drilling, auger boring etc.</p>	
	Heat strain	Avoid hand tunnelling in contaminated ground. Particularly avoid hand tunnelling requiring compressed air in contaminated ground.	If unavoidable consider task rotation, cool breaks,	
Sprayed concrete lining in soft ground or hard rock tunnels - concrete spraying	Dust related diseases such as COPD and silicosis resulting from the inhalation of inhalable and respirable dusts or respirable crystalline silica	Reduce dust emissions at source by mix design of shotcrete.	<p>Shotcrete mix design to minimise dust emissions.</p> <p>Use of wet shotcrete.</p> <p>Facilitate application by spray robot.</p> <p>Real time monitoring of dust levels.</p> <p>Use of extraction ventilation and de-dusting.</p> <p>Avoidance of secondary exposure.</p>	
SCL construction in soft ground. Breaking out of the lining concrete	Dust related diseases such as COPD and silicosis resulting from the inhalation of inhalable and respirable dusts or respirable crystalline silica		<p>Real time monitoring of dust levels.</p> <p>Use of extraction ventilation.</p> <p>Avoidance of secondary exposure.</p>	

Tunnelling in rock	Dust related diseases such as COPD and silicosis resulting from the inhalation of inhalable and respirable dusts or respirable crystalline silica. Noise induced hearing loss.		Use of hard rock TBM as alternative to drill and blast techniques? Use of extraction ventilation to control dust. Use of wet drilling or dust capture equipment on drill rigs.	
	Exposure to blast fume.		Selection of explosives to minimise fume. Extract ventilation to remove fume preferable to forced ventilation to dilute fume. Removal of personnel from tunnel during blasting operations. Provision of blast shelter in long tunnels.	
Hand tunnelling in rock	Hand Arm Vibration Syndrome. Noise induced hearing loss	Size of tunnel cross section required and length of drive. Access for plant and equipment.	Make tunnel large enough for mechanical drilling.	
Work in compressed air.	Acute or chronic decompression illness (Acute - Types 1 or 2 decompression	Is work in compressed air the preferred ground improvement technique? What can be done to minimise exposure pressure? Choice	Follow BTS "Guide to the Work in Compressed Air Regulations 1996" Dewatering, grouting, freezing or other	

Work in high pressure compressed air	sickness; Chronic – Dysbaric osteonecrosis). Barotrauma. Exposure to hyperbaric oxygen and nitrogen	of decompression tables. Ensure TBM is designed to allow for transfer under pressure if foreseeably required	ground improvement technique can be used. Provision of tool wear sensing techniques. Provision of tool inspection by inspection techniques. Provision of robotic tool changing. Use of atmospheric pressure tool changes from within spokes of cutterhead. Follow guidance in International Tunnelling Association Report 10.	
Disturbance of precast segmental concrete linings built before the 1990s	Exposure to asbestos in the form of cement impregnated asbestos fibre rope used for caulking joints	Asbestosis, mesothelioma	Avoid disturbing existing concrete linings. Asbestos survey.	
Disturbance of existing cast/ductile iron linings	Exposure to lead	Lead poisoning	Avoid disturbing existing cast/ductile iron linings and avoid hot work.	
Exposure to atmospheric contaminants and diesel engine exhaust emissions.	Exposure to oxides of carbon, oxides of nitrogen	Use of electrically powered plant.	Specify use of low emission engines with catalytic converters and particulate filters. Atmospheric monitoring and ventilation.	

Connection to existing sewers	Exposure to hydrogen supplied	Can connection be done with sewer dry?	Atmospheric monitoring and ventilation.	
Tunnelling in organic silts	Exposure to ammonia	Will grouting in the silts be required?	Atmospheric monitoring and ventilation.	
Tunnelling in carbonaceous rock	Exposure to carbon dioxide	What is the acidity of the groundwater? Is pyrites likely to be present?	Ensure adequate ground investigation. Atmospheric monitoring and ventilation	
Exposure to ionising radiation	Exposure to radon	Rock tunnelling in granitic and other rocks	Identify potential exposure levels from desk study and site investigation.	
Tunnelling in ground contaminated by current or former industrial processes, fuel storage etc.	Exposure to carcinogens, mutagens etc. through exposure to volatile organic compounds, polyaromatic hydrocarbons, total petroleum hydrocarbons, organic solvents, polychlorinated biphenyls, heavy metals etc.	Can tunnel alignment be altered to avoid contaminated ground?	Avoid tunnelling in contaminated ground. If unavoidable ensure ground investigation establishes the nature, concentration and spacial extent of contaminants in the soil and groundwater in terms of occupational exposure risk. Provide information on how risk to persons exposed can be mitigated including the use of PPE/RPE as a last resort.	
Tunnelling in ground contaminated by biological contaminants such as sewage, biological waste etc.	Biological infection including leptospirosis and water borne diseases	Tunnelling below leaking sewers or into existing sewers. Tunnelling below or adjacent to landfill sites	Identify occurrence of problem and nature and extent of contamination from desk study and site investigation. Information on sewer contents from sewerage utility. Information on landfill contents from Waste Disposal Authority. Alter alignment horizontally and/or	

			vertically to avoid contamination.	
Pre-grouting as ground improvement to facilitate tunnelling.	Exposure to grout chemicals leading to dermatitis, respiratory sensitization, atmospheric contamination	What are the likely health hazards arising from the grouts involved	Selection and specification of non-hazardous chemical grouts.	
Compensation grouting				
Ground freezing as ground improvement to facilitate tunnelling.	Hypothermia Atmospheric contamination from breakthrough of cold nitrogen gas	Choice of freeze agent – brine or liquid nitrogen	Warm clothing. Atmospheric monitoring and ventilation.	
<p>Information to go to contractor:</p> <p>Health hazards to be encountered, what the designer has done to mitigate them and the residual risks in terms of predicted exposure along with suggested mitigation measures.</p>				
<p>Information to go to H&S File:</p> <p style="text-align: right;">Use <input type="checkbox"/> Maintenance <input type="checkbox"/> Demolition <input type="checkbox"/></p>				

Further Information:

BS 6164 “Code of Practice for health and safety in tunnelling in the construction industry”

British Tunnelling Society “Guide to the Work in Compressed Air Regulations 1996”

British Tunnelling Society “THE MANAGEMENT OF HAND-ARM VIBRATION IN TUNNELLING - Guide to Good Practice”

British Tunnelling Society “OCCUPATIONAL EXPOSURE TO NITROGEN MONOXIDE IN A TUNNEL ENVIRONMENT - Best Practice Guide”

International Tunnelling Association/Br Tunnelling Society Compressed Air Working Group “Guidelines for good working practice in high pressure compressed air” ITA Report 10.

