

# PLANNING HEALTH AND SAFETY RISK MANAGEMENT FOR UNDERGROUND WORKS

ITA Working Group n°5

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**AITES**

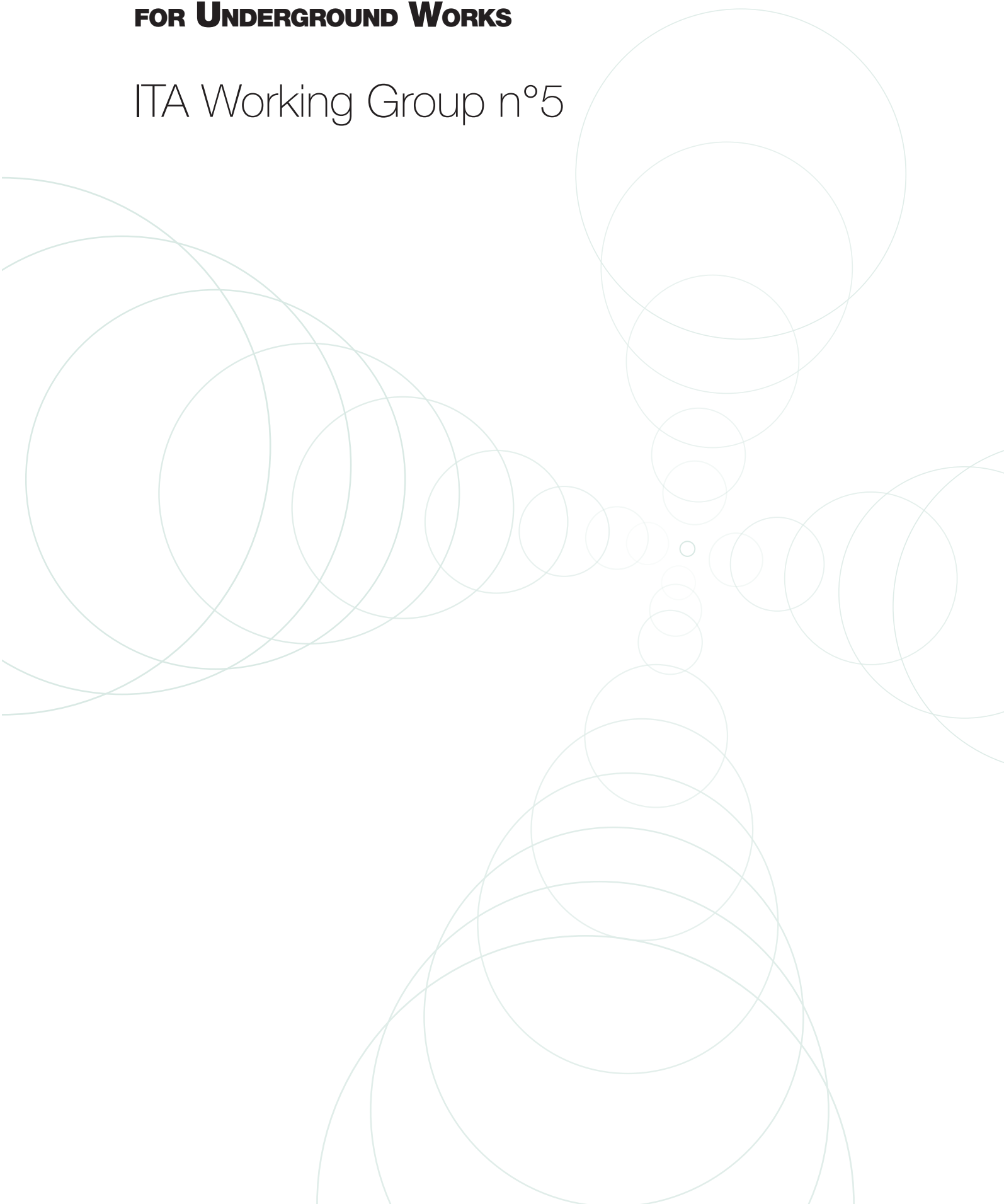
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INTERNATIONAL TUNNELLING  
AND UNDERGROUND SPACE  
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### FOREWORD

It is considered necessary that client organisations are prominent in establishing the context for the management of health and safety risks associated with underground project construction. With such risks properly highlighted and prioritised, tenderers should be able to provide sufficient resources with their tenders in order to construct the works safely and contribute to the overall success of a project.

This guide has its origins from discussions held at the WTC in Naples May 2019 of a perceived 'gap' in the guidance available relating to the planning of underground projects.

Accordingly, WG5 decided to commence a set of guidelines that focussed on the role of the client organisation and good practise from the earliest stages of project conception to procurement of physical works contractors in order to address this 'gap'.

The document has been developed with the beneficial input of several members of WG5 and peer reviewers and their contributions are gratefully acknowledged.

### SCOPE AND OBJECTIVES

1. To identify hazards<sup>1</sup> and constraints<sup>2</sup> imposed by the design, construction, operation and maintenance, refurbishment and de-commissioning of underground assets that give rise to reasonably foreseeable risks to health and safety.
2. To ensure that identified health and safety risks are either eliminated or managed in a systematic and integrated way from the initial stages of a project, until completion, through operations, asset refurbishment and de-commissioning.
3. To implement safety assurance measures with regular and thorough audits that demonstrate compliance with pre-defined risk criteria.
4. With the above objectives achieved, demonstrate that residual risk levels<sup>3</sup> for underground health and safety are as low as reasonably practicable.

<sup>1</sup>Hazards and risk sources are interchangeable terms in this document

<sup>2</sup>Such constructability and/or maintainability constraints are a key obligation for designers in a 'safety in design' process.

<sup>3</sup>Risk levels after controls have been applied

## >> DEFINITIONS

### COMPETENCY

It is considered essential that each person involved in the project is competent to carry out their role and that each organisation involved in the project should ensure that their employees or agents are competent to carry out the work required of them. Competency may be assessed by consideration of relevant experience and skill, development training and academic qualifications and/or certifications.

Given the critical role of the client during the design development and procurement stages, the client (definition below) should have or procure technical and contract management competence appropriate to the nature and scale of the project and only select competent designers and constructors.

For the purposes of this guidance document a competent person is a person who has the relevant knowledge, experience and skill to carry out a task required by the project. During construction a competent person is also a person who can recognize hazards associated with a task and has the ability and authority to mitigate those hazards.

### CLIENT AND/OR CLIENT ORGANISATION

- The final owner of the project to be constructed and/or the procurer of goods or services including design services whether a public entity or a private agency or developer, and responsible for:
  - The information issued to design or construction tenderers as “works information”.
  - The adequacy and suitability of designs prepared by or on behalf of the Client. The Client should assess the competency of Designers and define the risk management requirements for design quality assurance. For example, the Client should define the requirements for independent design checks particularly for complex excavations with significant consequences, such as excavation collapse.
  - The adequacy and suitability of construction methodologies and organisation proposed by contractors during the tendering phase.
  - The supervision of all parties (designers, contractors and other technical services) during the construction and the commissioning of the project.

- The creation and maintenance of a project-wide risk and safety culture for all stakeholders.
- Responsible for the project-specific risk management.
- Responsible for the project-specific health and safety management.

### DESIGNER

- The individual/organization appointed to undertake the planning and design process and defining the limits of the design and the observations and monitoring necessary to validate the design assumptions. Different designers may be appointed for different stages of the design process. It is noted that significant design activities may be undertaken by Clients, particularly at the early stages of project planning, e.g., alignment selection, statutory approvals and by Contractors for both temporary and permanent works.
- Responsible for being competent in their area of practise as applied to the design (and safe construction thereof) and conversely not practising outside their area of competency and adhering to the code of ethics of their practice.

### CONTRACTOR

- The organization contracted by the Client to construct the project, i.e., to carry out or manage construction work.
- Responsible for the adequacy and suitability of designs prepared by or on behalf of them, covering temporary works designs and especially any component of design verification through construction, e.g., observational methods, NATM/SCL (refer CIRIA reports R185, C580 & C760).<sup>4</sup>
- Responsible for Risk Management Plans.
- Responsible for the provision of competent personnel for construction.

### PLANT AND EQUIPMENT MANUFACTURERS AND PROVIDERS

Providers of mechanical and electrical plant for the construction of a project on either a hire or purchase basis

### EMERGENCY SERVICES

Police, Fire and Ambulance and other emergency services that may be involved in an emergency response.

Input from the public emergency services and utility providers during the project planning stages pre-tender is recommended as is input from experienced contractors and specialist plant and equipment designers and suppliers.

### COLLABORATION

It is considered best practice that all parties to a project cooperate to achieve and maintain safe places of work.

### ‘REASONABLY PRACTICABLE’

Given the long asset life expectancy, the methods for assessing risks, risk control measures and the criteria for risk acceptability for underground assets may change. Most commonly, as a guide to good practice, a risk control measure is considered reasonably practicable, if the resource in terms of cost and time and risks of implementation are not grossly disproportionate for the level of benefit achieved.

The definition of gross disproportionality should be defined by the client risk management framework (although ultimately this would be decided by a Court). It is suggested, by way of guidance, that if the costs of the risk control measures are less than an order of magnitude greater than the potential costs of the consequences of inaction then they are reasonable in order to minimise the risk.

Therefore, the objective of any risk assessment should be to establish and document a sufficient level of risk mitigation, in situations where hazards cannot be eliminated, from assessing the following: (a) the risk mitigation level can be achieved, (b) potential consequences have been assessed against costs, effort or other disadvantages of risk mitigation measure implementation to establish why only the proposed risk mitigation measures will be undertaken and no others) and (c) is acceptable to all those that may be affected by the risk being realised.

<sup>4</sup>For designs that are prepared by third parties, i.e. the client or the clients designer (and not by or on behalf of contractors) it is recommended that contractors should critically review the designs in relation to health and safety (and other) risks to establish their view of the suitability and adequacy of the designs presented for the project works. Neither a commercial advantage or disadvantage should be created if potential risk reduction measures are identified by the contractors, especially if as a result of inadequate health and safety and constructability risk assessments by the client and their agents in the tender reference design.

## >> INTRODUCTION

1. The planning of underground construction, underground asset operations and maintenance, and underground asset refurbishment requires rigorous management of risks. This is because there is generally a higher level of risk within confined spaces and associated with the use of plant and equipment underground. Therefore, such activities are likely to fall outside of 'business as usual' oversight for client organisations that do not regularly undertake underground construction or maintenance.

2. The most effective risk management methods are those that implement the hierarchy of controls of Figure 1 below. Therefore, decisions that enable or preclude the use of 'elimination' (that is 'eliminating' risks) may be made early in the project life cycle and this raises the significance of the Client's role in health and safety risk management. Clients should acknowledge that by fixing the alignment and dimensions of the underground asset, often as part of statutory consent procedures and property acquisition, they force the contractor to incur risk, which the contractor cannot eliminate/avoid in accordance with hierarchical risk management principles shown in Figure 1. This aspect also emphasizes the importance of establishing that a reference design for the underground assets is safe to construct, maintain and operate, prior to tendering.

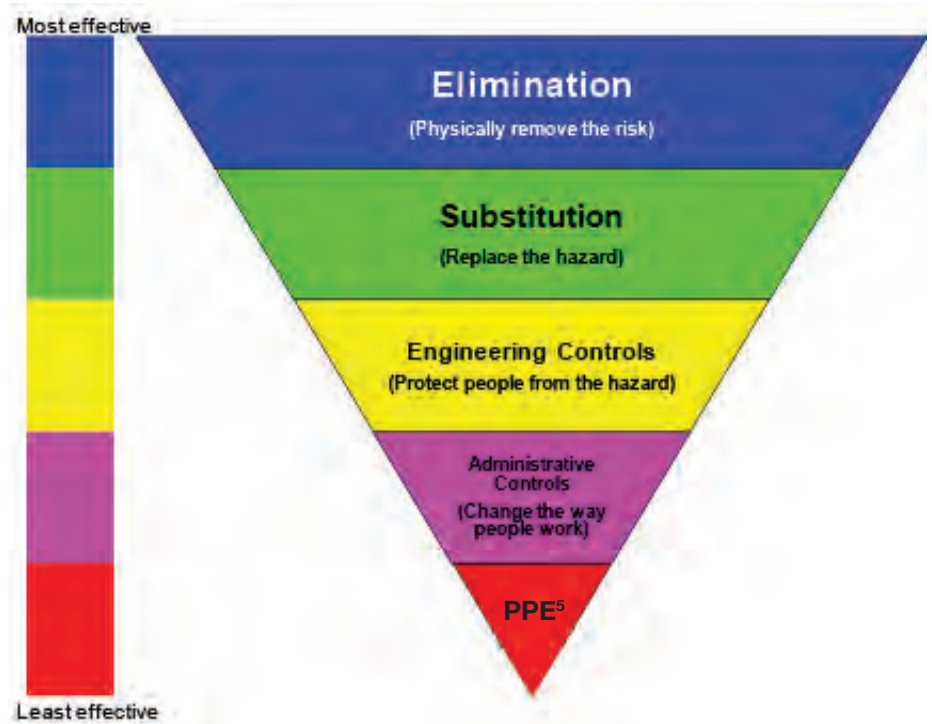


Figure 1. Hierarchy of risk management principles.

<sup>5</sup>PPE : Personal Protective Equipment

## >> GENERAL RECOMMENDATIONS

1. Client organisations should establish a health and safety risk management framework for proposed or existing underground assets ('assets') in accordance with current guidance and good practice, technological trends, local, national and international standards, regulations and requirements through design, construction and operational lifecycles. Accordingly, the WG recommends adopting the risk management principles of ISO 31000. This process should require the client to assess their own competence for procuring, operating and maintaining underground assets and, if necessary, supplement their corporate experience with personnel experienced in underground design and construction, procurement, risk management and operation and maintenance.

2. At each design stage, including concept design and particularly prior to tendering, clients should conduct a health and safety review (HSR), and use risk registers to record the following items: (i) safety and health issues identified during the design reviews and actions taken; and (ii) risks that cannot be removed through design changes. (iii) primary responsibility for risk ownership. The HSR risk register should be a live document which will be updated as and when new risks are identified.

3. Client organisations should implement and maintain oversight of health and safety processes for activities undertaken by them or on their behalf by formal review throughout design phases for the assets and throughout construction, operations and maintenance or whenever design changes are made (recommended by ISO 45001)

4. At all design and construction stages, where risks cannot be eliminated by design, they should be managed by the implementation of risk controls described in risk management plans. It is recommended that such residual health and safety risks be reduced as far as reasonably practicable

5. Designers should allow for constructability

constraints in undertaking their design, constraints which arise as a consequence of working in the underground environment.

6. Contractors having assessed and accounted for the health and safety risks that cannot be eliminated by the reference design (or an equivalent alternative), are placed in control of the worksite and should manage the residual worksite risks. It is recommended that the acceptance of these risks is explicitly done through risk registers incorporated into the construction contract.

## >> RECOMMENDATIONS FOR TENDERING

1. Client organisations should assess the competence of design organisations in addressing constructability in the underground environment when selecting professional advisers. It is recommended that only experienced underground design firms are used.
2. Client organisations should assess the competence of construction organisations in appropriately eliminating and effectively managing health and safety risks. Key areas that should be requested in the Tender for underground construction include provision of a Temporary Ventilation Management Plan and an Occupational Health and Hygiene Management Plan. A Ventilation Engineer and Occupational Hygienist should be nominated by the constructor in the Tender schedules.
3. Client organisations should assess and evaluate the health and safety risks associated with proposed assets prior to releasing tender documentation for construction, rehabilitation, or maintenance. The principal objective of this evaluation should be the identification of foreseeable risks throughout the lifecycle of the assets against a defined level of acceptability in accordance with the risk management framework established by the client organisation under the general recommendations above.
4. In order to produce the evaluation, the health and safety risks associated with alternative design options and alternative construction methodologies should be compared and evaluated.
5. Client organisations should prepare reference designs, requirements and risk assessments for:
  - Geotechnical conditions
  - Construction methodologies and processes to be used, given the constraints provided by the reference design (e.g. mined tunnelling, cut and cover, drill and blast, or tunnel boring machines used to construct the asset)
  - Any schedule constraints of the client requiring the need to select underground construction activities to be performed in parallel
  - Temporary ventilation during the construction of shafts and underground working areas
  - Ventilation, electrical and electro-mechanical installations for construction, operation and maintenance stages
  - Personal Protective Equipment (PPE) assessments and
  - Incident and Emergency plans for fire and other emergency scenarios in conjunction with local emergency services and provide this information to tenderers. An objective of the reference design should be to establish that the scheme can be constructed and maintained safely.
6. Client organisations should require tenderers to use the hierarchy of controls throughout their works planning and operations. This may preclude certain methods of working that may be acceptable above ground and may also require the use of specialised plant and engineering technologies to ensure that certain risks are managed using higher-order controls<sup>6</sup>.
7. Client organisations should incentivise innovation to improve health and safety risk management offered by the client organisation reference design (scheme). The client organisation reference design provisions should be considered as minimum requirements for compliance and should be in full compliance with all relevant local laws, regulations and rules.
8. Client organisations should allow adequate time for the interactive assessment and comparative evaluation of the health and safety risk management proposals by all tenderers prior to finalising construction and/or operations or maintenance contracts.
9. Experience suggests that proper attention to the management of health and safety risks is generally indicative of a superior risk management culture within an organisation. Therefore, it is in the interest of client organisations that superior health and safety risk management features of a tender are positively acknowledged during client organisation assessments of the quality of tendering parties corporate experience and tender submissions.
10. Client organisations should consider the use of BIM<sup>7</sup> and other digital technology and processes as a means of identifying hazards, associated risks and their mitigation.
11. Client organisations should require tenderers to provide health and safety assessments (reviews) to accompany their tenders. Client organisations should require such assessments to include all risk sources (hazards) listed below as a minimum.

<sup>6</sup>For example, the use of positive air pressurised, enclosed and sealed cabins for mined tunnelling to protect mined-tunnelling operators.

<sup>7</sup>Building Information Model



## >> PROMPT FOR RISK SOURCES FOR RISK ASSESSMENTS<sup>8</sup>

- Ground conditions including contamination, groundwater conditions and inundation risks<sup>9</sup>
- Exceptionally adverse weather
- Methods of working<sup>10</sup>
- Lighting conditions
- Occupational Noise
- Environmental Noise
- Vibration
- Manual handling
- Fatigue and shift patterns
- Heat/cold
- Biological hazards
- Ambient temperatures
- Natural and artificial ventilation
- Tunnel transport
- Offsite spoil transport, and the associated hazards with heavy vehicle safety
- Pedestrians in the tunnel
- Existing structures
- Unexploded Ordnance (UXO)
- Adjacent infrastructure including utilities<sup>11</sup>
- Electrical power installations and stored energy
- Mechanical and electrical equipment used, including TBMs. Particular attention should be made to the assessment of the suitability of general construction plant to be used for underground working (both for static installations and moving plant)
- Concurrent worksite activities, especially walkways and moving plant risks
- Underfoot conditions ('slips, trips and falls')
- Materials and material handling
- Lifting and lowering operations
- Working at heights
- Fire risks, from natural gases, natural and introduced materials, and plant
- Toxic or explosive gases
- Hyperbaric working
- Explosives
- Worksite layout and the potential for flooding
- Access and egress to the construction or worksite
- Demolition<sup>12</sup>
- Incident and emergency management for the activities
- Naturally occurring and combustion gases
- Respirable crystalline silica
- Naturally occurring asbestos
- Diesel exhaust emissions
- Welding fumes and gases
- General dusts from excavation, spoil handling or generated through subsequent asset construction or maintenance processes, e.g., drilling, grinding or application of sprayed materials.
- Use of chemicals, resins, grouts.
- The placement of concrete and concrete formwork
- UV radiation
- Radon gas and Ionizing Radiation
- Radioactivity
- Mental health and wellbeing
- Living conditions if projects require remote worksites
- Shift patterns and travel to work
- "Social" risks and discrimination
- Are there any other foreseeable hazards and risks?

<sup>8</sup>Note that not all risk sources will occur on a project and the list may not provide exhaustive list of risk sources

<sup>9</sup>Have the geotechnical conditions for the project been sufficiently investigated? Are geological features present that may cause health issues, such as contaminated ground, asbestos, heavy metals, etc.? Generally, the adoption of a Geotechnical Baseline Report (GBR) process as per ASCE guidelines should enable enhanced geotechnical risk identification and thereby management through preparedness, by adopting suitable methods and controls in advance. It is preferable that tenderers are given the opportunity to ask for or to undertake further Geotechnical Investigation.

<sup>10</sup>Are there alternative construction methods that can eliminate or reduce health and safety risks?

<sup>11</sup>Should underground utilities or underground structures be de-commissioned and removed or re-located or retained in-situ?

<sup>12</sup>Demolition of existing buildings in urban areas is increasingly common and can add considerable complexity in terms of risk sources to health and safety planning. Given the focus of tunnelling contractors on tunnelling risk management, it is recommended that such activities be undertaken by demolition specialist firms in advance of the main tunnelling works.

## >> REFERENCES

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- 5) COUNCIL DIRECTIVE 92 / 57 / EEC of 24 June 1992 on the implementation of minimum safety and health requirements at temporary or mobile constructions sites (Eighth individual Directive within the meaning of Article 16 (1) of Directive 89/ 391 /EEC)
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