Guidance Notes on Safety and Health of

Hand-dug Tunnelling Work

Safety at work

Occupational Safety and Health Branch
Labour Department

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1. Introduction

1.1 Hand-dug tunnel is one of the trenchless methods for tunnel construction, and the working environment of which is generally poor. The risks of hand-dug tunnelling work, including soil collapse in tunnel, inundation due to ineffectiveness of waterproof grouting, and possible emission of toxic gas or occurrence of oxygen deficiency during excavation, etc. are comparably high. Hand-dug tunnelling work is therefore a relatively high risk operation. According to the industrial accident statistics, construction of hand-dug tunnels has caused a number of serious and fatal accident cases.

1.2 In view of the relatively higher risks associated with the construction of hand-dug tunnels than the other tunnelling methods, this set of Guidance Notes ("GN") particularly sets out the restrictions on the adoption of hand-dug tunnels, and urges the duty holders to avoid using this method for construction of tunnel.

1.3 When the hand-dug tunnelling work is unavoidable, the proprietors or contractors responsible for or involved in such work shall provide and maintain a safe system of work, and take appropriate safety precautionary measures for the tunnelling work, including carrying out task-specific risk assessment, identifying associated potential hazards, and formulating safety control measures and working procedures, in order to ensure the safety of workers working in the tunnels.

1.4 The GN aims to provide practical guidance to proprietors, contractors and workers engaged in hand-dug tunnel construction work, and

enhance the occupational safety and health ("OSH") awareness of the relevant stakeholders. Workers participating in hand-dug tunnel construction work or underground utility laying works and other personnel involved in the work should also read the contents of the GN thoroughly to avoid the occurrence of accidents.

1.5 The GN should be read in conjunction with the publications issued by the Labour Department ("LD"), such as "Code of Practice Safety and Health at Work in Confined Spaces", "A Brief Guide to the Factories and Industrial Undertakings (Confined Spaces) Regulation", and "Safe Work in Confined Spaces", etc. Apart from these publications, reference should also be made to the relevant national/international standards.

1.6 The GN provides relevant guidelines on the safety and health of hand-dug tunnelling work in accordance with the provisions of the Factories and Industrial Undertakings (Confined Spaces) Regulation ("F&IU(Confined Spaces) Reg."), but does not modify or supplement in any way the legal effect and interpretation of any laws including the Factories and Industrial Undertakings Ordinance (Chapter 59), the Occupational Safety and Health Ordinance (Chapter 509) and their subsidiary legislation. The provisions of these Ordinances and any regulations or Codes of Practice issued thereunder will prevail over the GN in the event of any contradiction or inconsistency.

2. Scope of Application and Definitions

2.1 The GN mainly focuses on the tunnelling work for laying underground utilities or their associated works, and is applicable to tunnels of which the part constructed by hand-dug method from either end is 2.5m or above in length and 3m or below in internal diameter/height. The duty holders carrying out other tunnelling works should comply with the relevant requirements of this GN where practicable.

2.2 The GN focuses on the OSH matters in respect of tunnel construction using hand-dug method and those working in the hand-dug tunnels to safeguard the OSH of the workers involved in the hand-dug tunnelling work. The GN does not cover the OSH matters of all the relevant work at the worksites.

2.3 This GN adopts the following definitions:

"**approved breathing apparatus**" means a breathing apparatus of a type approved by the Commissioner for Labour (the "Commissioner") under section 12 of F&IU(Confined Spaces) Reg. The notice of approval of these apparatuses will be published in the Gazette.

"**certified worker**" means a person -

(a) who has attained the age of 18 years; and

(b) who holds a certificate issued by a person whom the Commissioner has authorized to certify workers as being competent to work in a confined space.

"**competent engineer**" means an engineer who has valid registration with the Engineers Registration Board in the Geotechnical or Civil discipline (and also in the Structural discipline if structural works are required), with a minimum of 5 years of experience in site investigation, design and construction of trenchless or underground excavation works.

"**competent person**" means a person (except paragraphs 5.2.6.4 and 5.2.10.2) -

(a) who has attained the age of 18 years;

(b) who is either -

(i) a safety officer registered under the Factories and Industrial Undertakings (Safety Officers and Safety Supervisors) Regulations; or

(ii) a person who holds a certificate issued by a person whom the Commissioner has authorized to certify persons as being competent to prepare risk assessment reports; and

(c) who has at least one year's relevant experience, after obtaining the registration or certification referred to in paragraphs (b)(i) or (ii), in assessing risk to the safety and health of workers working in confined spaces.

"**confined space**" means any place in which, by virtue of its enclosed nature, there arises a reasonably foreseeable specified risk, and without limiting the generality of the foregoing, includes any chamber, tank, vat, pit, well, sewer, tunnel, pipe, flue, boiler, pressure receiver, hatch, caisson, shaft or silo in which such risk arises.

"**hand-dug tunnel**" means a tunnel which is constructed by manual excavation with the use of hand-tools or portable power-operated tools driven by electrical, mechanical, hydraulic or pneumatic means, including "pipe jacking" with man-entry, the use of prefabricated segments to conduct excavation works or "heading method" for tunnel construction.

"**heading method**" means in the process of constructing a hand-dug tunnel which would involve the erection of successive frames supporting the surrounding ground, but excluding "pipe jacking" or the use of prefabricated segments to conduct excavation works.

"**risk assessment report**" means an assessment and recommendations carried out by a competent person in accordance with section 5 of F&IU(Confined Spaces) Reg.

"**specified risk**" means a risk of -

(a) serious injury to any person at work arising from a fire or explosion;

(b) the loss of consciousness of any person at work arising from an increase in body temperature caused by, for example, heat stress in the work environment;

(c) the loss of consciousness or asphyxiation of any person at work arising from gas, fume, vapour or the lack of oxygen;

(d) the drowning of any person at work arising from an increase in the level of liquid; or

(e) the asphyxiation of any person at work arising from a free flowing solid or the inability to reach a respirable environment due to entrapment by a free flowing solid.

3. Legal Requirements and Responsibilities

3.1 The Factories and Industrial Undertakings Ordinance ("FIUO") and its subsidiary regulations stipulate the legal responsibilities of the proprietors and contractors (including employers) conducting construction work at industrial undertakings, including construction, erection, installation, reconstruction, repair, maintenance, renewal, removal, alteration, improvement, dismantling, or demolition of any water, electrical, gas, telephonic, telegraphic, tunnel, etc. in respect of the safety and health of workers at work.

3.2 The FIUO also stipulates general duties on proprietors and contractors (including employers) with regard to safety and health at work of employees at industrial undertakings, including the provision and maintenance of plant and systems of work that are, so far as is reasonably practicable, safe and without risks to health of workers, and provision of all necessary safety and health information, instruction, training and supervision.

3.3 Every person employed at work shall comply with the general duties of person employed as stipulated under the FIUO, which include taking reasonable care for the health and safety of himself and of other persons who may be affected by his acts or omissions at work; and as regards any duty or requirement imposed on a proprietor of the industrial undertaking or contractor for securing the health and safety of person employed at the industrial undertaking co-operating with him so far as is necessary to enable that duty or requirement to be performed or complied with.

3.4 The Construction Sites (Safety) Regulations ("CSSR") made under the FIUO is applicable to construction work and construction sites including tunnel excavation work. According to CSSR, a contractor who undertakes construction work shall, within 7 days after the commencement of the work, furnish in writing to the Commissioner the information of the relevant construction work unless at the date of commencement of the work the contractor has reasonable grounds for believing that the work will be completed in a period of less than 6 weeks from that date, or not more than 10 workmen are or will be employed on the work at any one time.

3.5 Paragraph 3.4 above is also applicable to contractors of term contracts. Relevant contractors shall furnish the Commissioner with the information on the construction work involved in the relevant term contracts including the locations of particular sites, the dates of commencement of the work, etc., within 7 days after the commencement of the work. The LD will not accept a blanket notification that covers certain area(s) across the territory and the whole contract period as a valid notification.

3.6 According to the Factories and Industrial Undertakings Regulations ("FIUR") Part IIA, every person employed to work underground tunnelling operations is required to undergo statutory medical examinations before he/she enters into the tunnel to commence work. Statutory medical examinations including general examination and chest X-ray can be performed by any registered medical practitioners who are conversant with such examinations.

3.7 The examining doctor responsible for carrying out the statutory medical examinations will certify whether the person employed to work underground is medically fit for tunnelling work and forward a copy of medical examination reports to LD for certification of fitness to work. A worker is not allowed to commence work in hand-dug tunnel unless the Senior Occupational Health Officer of LD has issued the certificate to the proprietor. Please refer to FIUR for further information about requirements of medical examinations.

3.8 In addition, the F&IU (Confined Spaces) Reg. stipulates responsibilities and specific duties of proprietors, contractors, competent persons and certified workers undertaking work in confined spaces including tunnel work. For details, please refer to "A Brief Guide to the Factories and Industrial Undertakings (Confined Spaces) Regulation", "Code of Practice Safety and Health at Work in Confined Spaces" and "Safe Work in Confined Spaces" published by the LD.

3.9 Apart from the above legislation, the Factories and Industrial Undertakings (Lifting Appliances and Lifting Gear) Regulations, the Factories and Industrial Undertakings (Loadshifting Machinery) Regulation, the Factories and Industrial Undertakings (Protection of Eyes) Regulations, the Factories and Industrial Undertakings (Noise at Work) Regulation, the Factories and Industrial Undertakings (Electricity) Regulations, etc., are also applicable to hand-dug tunnelling work. Reference can be made to brief guides to the relevant legislation, codes of practice and guidance notes published by LD for the relevant legislative requirement(s).

4. Restriction on Adoption of Hand-dug Tunnels

4.1 In general, the methods for laying of underground utilities or conducting associated works can be divided into “open-cut trench method” and “trenchless method”.

4.2 The open-cut trench method is to excavate a trench from the ground surface to a certain depth for laying underground utilities. After laying the utilities, the trench will be backfilled.

4.3 The trenchless method for construction of an underground tunnel involves the adoption of different techniques, such as pipe jacking, use of prefabricated segments to conduct excavation works, tunnel boring machine, horizontal directional drilling and heading method. These methods involve less ground excavation and reduce the disturbance to road users and people nearby, and are therefore used for underground utility works.

4.4 Apart from adopting different techniques as mentioned in paragraph 4.3 above, the mode of operation of trenchless method for the construction of underground utility tunnels can be divided into two categories, i.e. “without man-entry” and “with man-entry”, during the tunnelling construction process. The trenchless method without man-entry mainly uses mechanical means, such as the tunnel boring machine and pipe jacking, for tunnel construction. In general, workers are not required to enter the tunnel for manual excavation during tunnel excavation. The trenchless method with man-entry can be further sub-divided into two types. The first type involves the use of mechanical means and

manual digging work, such as pipe jacking or the use of prefabricated segments such that workers would carry out manual excavation within a metal shield head. The second type refers to tunnels constructed by "heading method" in that the hand-dug tunnel is constructed solely through manual digging operation. Both types require workers to work inside the tunnel under construction.

4.5 Apart from the technical factors, the safety and health hazards to workers should be the prime consideration in selecting the construction method for underground utility works during the design and planning stage. The following factors should be considered in the design and planning stage of an underground utility project in order to safeguard the safety and health at work of the workers concerned:

- The advantages/disadvantages and the hazards to workers of different practicable construction methods;
- Particular conditions of the work site, such as distribution and conditions of existing underground utilities, groundwater level and geotechnical conditions;
- Existing buildings, structures and utilities nearby;
- Site layouts; and
- Excavation methods, ground supporting methods, etc.

4.6 From the OSH point of view, having workers to work in a confined space should be avoided, especially in the tunnel construction work for underground utilities where extensive manual work is involved. The high risks posed to workers working in such a confined and congested working environment are foreseeable. Any failure in the safe system of work can lead to fatal consequences. Hence, detailed design and

planning should be undertaken to avoid having workers working in confined spaces or keep such work to a minimum.

4.7 When considering the tunnel construction method during the design and planning stage, the following guiding principles should be followed as far as practicable –

(a) The open-cut trench method should be accorded top priority;

(b) Only when the open-cut trench method is not practicable, such as where it is necessary to cross a railway, river or seawall, or there exists a structure, the trenchless method without man-entry can be adopted;

(c) Only when neither the open-cut trench method nor the trenchless method without man-entry is practicable, such as where it is impracticable to construct a shaft for assembling and/or retrieving machines and to change the tunnel route at the same time, the trenchless method with man-entry using mechanical equipment and providing a metal shield head at the excavation face can be used (Photo 1) with a view to reducing the risks to workers in the tunnel;

Photo 1 - A tunnel constructed by use of prefabricated segments

(d) Only when none of the above-mentioned open-cut trench method and trenchless methods is practicable, such as where it is necessary to change the excavation route due to unexpected underground obstacles or uncharted utilities encountered during the tunnel excavation, comparable sharp turns in the tunnel, and geological problems together with the limitation of ground surface areas, heading method can be resorted to as the construction method for underground utility tunnel (Photo 2).

Photo 2 - A tunnel constructed by heading method

4.8 Under general circumstances, tunnel construction by using the heading method is not suitable for site environments with the following conditions (including but not limited to):

(a) High groundwater level;
(b) Close to seawall or river wall;
(c) Tunnel under landfill area;
(d) Tunnel crossing river or close to sea;
(e) Insufficient cover between tunnel and ground surface;
(f) Close to laid asbestos cement mains;
(g) Close to pipeline with damage or leakage;
(h) Tunnel location congested with other underground utilities; and
(i) Close to gas station, hospital or facility likely to discharge large amount of hot water or chemical fluid.

Under the above circumstances, duty holders should consider using other safer tunnel construction methods, or changing the tunnel route

or depth so as to meet the requirements for ensuring the workers' safety and health.

4.9 If, in accordance with paragraphs 4.7 and 4.8 above, the use of heading method to construct the entire tunnel or part thereof is unavoidable, the length of the entire tunnel, or the part of the tunnel to be constructed by heading method, should be as short as possible. A shaft, means of egress or an open trench should be provided to the tunnel constructed by heading method for every 25m or less. If the entire tunnel is constructed by heading method, the total length of the tunnel should not exceed 50m. If only part of the tunnel is constructed by heading method, each continuous section of the tunnel constructed by heading method should not exceed 50m; and the accumulated total length of the parts of the tunnel constructed by heading method should not exceed 50m or 5% of the total tunnel length, whichever is longer. If the included angle inside the tunnel reaches 110^{o} or below (Please refer to Figure 1), an additional shaft or means of egress should be constructed at the turning point as safe means of escape. The work involving the heading method should, as far as practicable, be conducted from both ends of the tunnel in order to reduce the emergency escape distance. The tunnel constructed by heading method should maintain a minimum clear height and clear width of 1.8m and 1.4m respectively.

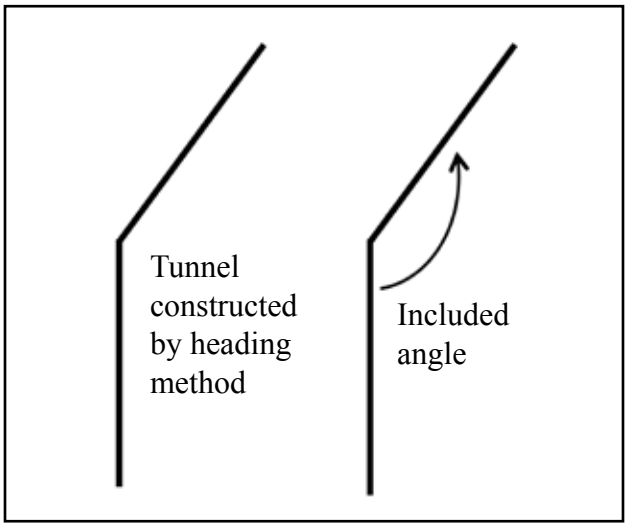

Figure 1 - Plan view showing the included angle of a tunnel constructed by heading method.

4.10 Taking into account the particular conditions of different work locations, more than one construction method may be adopted in the construction of a tunnel. Before deciding to adopt the heading method for the construction of a tunnel or part thereof, the proprietor or contractor should follow the guiding principles and order of priorities set out in paragraphs 4.7(a) to (c) to determine the tunnel construction method(s) to be adopted, and should assess and confirm that the conditions mentioned in paragraph 4.8 do not exist in the surroundings of the work site.

4.11 With regard to the size and length of hand-dug tunnels constructed by methods other than the heading method, please abide by the guideline titled "Tunnelling and Pipejacking: Guidance for Designers" published by the Pipe Jacking Association, the British Tunnelling Society and the Health and Safety Executive, UK or other equivalent national/ international standards.

4.12 In the design and planning stage of a project, the project client and project designers (including design consultant) should be involved and other relevant parties should also be consulted. Reference should be made to the requirements of relevant government departments and national/international standards. The method(s) to be used for the construction of the tunnel should be specified in the tendering documents in accordance with the GN. If it is a "Design and Build Contract", the project client, project designers (including design consultant where applicable) and contractors should review the design of the tunnel to confirm its compliance with the requirements of the GN including the guiding principles stipulated in paragraph 4.7. Before the commencement of work, relevant duty holders, including contractors, should carefully re-examine and approve the construction method of the relevant tunnel.

4.13 The proprietor or contractor should from time to time review the tunnel construction method. When other safer and practicable methods are available, use of the heading method should be avoided for tunnel construction.

5. Safe System of Work and Safety Precautions for Construction of Hand-dug Tunnels

5.1 Safe System of Work

Avoidance of hand-dug tunnels should always be the foremost consideration. However, if adopting such method is truly confirmed that it is inevitable and is applied under appropriate conditions, the proprietor or contractor shall establish a safe system of work, which consists of the risk assessment, the method statement, and the implementation, supervision and review of the safe system of work prior to the commencement of any associated work. The method statement and the safe system of work should be formulated and endorsed by the proprietor or contractor responsible for the work with reference to the advice and recommendations of the project engineer, competent engineer, competent person and other relevant personnel. In particular, both written and verbal information and instruction should be provided to all personnel involved before the hand-dug tunnelling work commences.

5.1.1 Risk assessment and method statement

5.1.1.1 Prior to any hand-dug tunnelling work, the proprietor or contractor responsible for the work should appoint a competent engineer and a competent person to carry out a risk assessment to identify all the associated hazards, particularly the “specified risks”. The competent engineer and competent person should, on the basis of the risk assessment results, recommend necessary precautions which should be taken before and during the hand-dug tunnelling work so as to ensure the safety and health of the workers concerned.

5.1.1.2 The risk assessment should identify the hazards to the workers entering, leaving or working in the tunnel, as well as the others in the close proximity who may be affected by the work to be carried out. Key factors such as existing ground conditions, groundwater level, underground utilities, design of ventilation, surcharge on surface, effects of adverse weather, overheating, fire, explosion and potential sources of inhalation of harmful gas, vapour, dust or fumes and the hazards inherent in the work, the proposed work method, the plant, materials and the design or construction of the tunnel itself should all be taken into account. Consideration should not be limited to hazards inside the tunnel, but also those stemming from the other plant, processes and operations in the vicinity, such as inadvertent contact with or damage to the utilities nearby during the work.

5.1.1.3 Before carrying out the risk assessment, all information about the vicinity of the workplace should be gathered so as to facilitate the identification of all potential hazards. For example, the updated information about the underground utilities should be gathered from the relevant government departments and utility companies. Information on the geotechnical and geological conditions and groundwater table should be obtained by means of site investigations. Whenever any uncharted utility or water seepage from an existing utility pipe is found during excavation, the work should be suspended immediately and a fresh risk assessment should be carried out in order to identify the relevant potential hazards, summon assistance from relevant authorities and devise corresponding measures.

5.1.1.4 The risk assessment report should include the risk exposure level of all the persons involved as well as the safety precautions to be taken. It is also necessary to consider and specify the size, number and distribution of tunnel entrances, the number of workers who can remain safely in the tunnel, and the problems and efficiency of the evacuation or rescue operation. The competent engineer and competent person should submit the report to the proprietor or contractor. All relevant records should also be retained for future reference and review.

5.1.1.5 For the risk assessment and permit-to-work system in connection with confined spaces, references should be made to paragraph 5.2.1 of this GN and the "Code of Practice Safety and Health at Work in Confined Spaces".

5.1.1.6 Upon identifying the hazards and making relevant recommendations on the safety precautions in the risk assessment report, the proprietor or contractor should formulate method statements in relation to the hand-dug tunnelling work.

5.1.1.7 The method statements should include details of all relevant processes, work procedures, risk control measures, requirements for the associated equipment, and qualifications and training of the workers, etc. The proprietor or contractor should implement a permit-to-work system in respect of some high risk work and working environments (such as confined spaces, hot work and work on electrical equipment).

5.1.1.8 Relevent calculations and drawings should be provided for the design of temporary works, and the relevant data should be checked and verified by a competent Independent Checking Engineer ("ICE") whose qualification should be equivalent to that of a competent engineer.

5.1.1.9 The tunnelling work should be properly phased according to the practicable construction schedule to avoid being thrown into disarray by the simultaneous conduct of myriads of work of different nature at the same location.

5.1.1.10 Before the work commences, the proprietor or contractor should take all reasonably practicable steps and measures, including the conduct of a detailed underground utility survey (such as using utility locators and making trial pits), to confirm the alignment and depth of the existing underground utilities. The relevant utility companies and government departments should be consulted on the necessary precautions to be taken and be informed of the work to be carried out and its schedule. Continuous assessment of the latest working environment and the actual condition of the tunnel should also be carried out by the competent engineer and competent person during the work to avoid any inadvertent contact with or damage to other utilities in the proximity.

5.1.1.11 Unless otherwise required, a safety clearance (of at least 1.5 times the diameter, height or width, if applicable, of the tunnel) between the tunnel and other underground utilities (such as water pipes and drains) should be maintained so as to avoid any inadvertent contact with or damage to the utilities in the proximity, thereby leading to

the associated hazards. Nevertheless, the safety clearance may be suitably adjusted after assessment by the competent engineer and competent person, with detailed consideration of various factors such as the construction facilities nearby, ground conditions, and the accuracy and reliability of the technique/equipment used.

5.1.2 Implementation

5.1.2.1 The protection of the safety and health of workers engaged in hand-dug tunnelling work relies not only on the development of a comprehensive safe system of work, but also its thorough implementation by duty holders. To ensure full compliance with the safe system of work, the proprietor or contractor should provide sufficient and necessary information, instruction and training to all personnel directly or indirectly involved in tunnelling work, including workers engaged in tunnelling work or in the close proximity, supervisor, management staff, standby person and all members of the rescue team to ensure that they have sufficient knowledge and safety awareness in respect of the tunnelling work.

5.1.2.2 Duty holders should take sufficient and suitable steps to ensure that all safety precautions stated in the risk assessments, permit-to-work systems and method statements are effectively and continuously implemented and maintained. Emergency preparedness for all hazardous situations should be put in place with the conduct of regular emergency drills, for the sake of ensuring that all relevant personnel are familiar with the emergency procedures, enhancing their safety awareness, and continuously reviewing and improving the relevant arrangements.

5.1.3 Supervision

5.1.3.1 To ensure the effective implementation of the safe system of work, an effective monitoring and control system should be established and implemented. A supervisor with sufficient relevant knowledge, experience and safety awareness should be assigned to supervise the tunnelling work.

5.1.4 Reviewing

5.1.4.1 The risk assessments and the associated working arrangements should be regularly reviewed in a timely manner. A review should also be conducted whenever any circumstances during work indicate that the risk assessments and/or the associated working arrangements are no longer valid, or where there has been a significant change in the condition of the work relevant to the assessments and working arrangements. Whenever necessary, such as the discovery of an unknown obstacle, a fresh risk assessment should be conducted.

5.1.4.2 Whenever any significant change or abnormality in the working conditions, particularly air quality, ground conditions or groundwater table, etc., is observed or where adverse weather conditions which will cause potential hazards to the safety and health of workers are anticipated, the work should be immediately suspended with the workers evacuated. A thorough review on the risk assessments and the associated work arrangements should subsequently be carried out. Resumption of work should not be allowed unless the site condition is confirmed to be safe.

5.2 Safety Precautions

Apart from the common hazards found in confined space, the workplaces of hand-dug tunnels are usually associated with limited and restrictive space with regard to the access thereto, work therein and egress therefrom, thus entailing higher risks than those of general construction works. The following are some of the safety precautions to be formulated and implemented by the proprietor or contractor for the prevention of common hazards in hand-dug tunnelling work. The proprietor or contractor should also establish and adopt adequate effective safety measures against the other hazards (such as lifting operations, moving plant, fall of persons or falling objects) by making reference to relevant legislation, codes of practice and guidance notes.

5.2.1 Risk assessment and permit-to-work system for work in confined spaces

5.2.1.1 The implementation of "Permit-to-work system" is an essential part of a safe system of work for confined space work. The responsible proprietor or contractor should implement a "Permit-to-work system" pertaining to the risk assessment for working in confined spaces. The proprietor or contractor may set out in a "Permit-to-work certificate" the work to be done and items to be checked before entering a confined space and the necessary precautions to be taken to ensure safety and health at work in the confined space.

5.2.1.2 The proprietor or contractor should, after receiving a risk assessment report completed by the competent person, verify that

the risk assessment report has covered all the matters referred to section 5(2) of F&IU(Confined Spaces) Reg. He may then issue a "Permit-to-work certificate" to the certified workers engaged in confined space work.

5.2.1.3 Entry into a confined space for work should be permitted only after the issue of a valid "Permit-to-work certificate" by the proprietor or contractor. Such "Permit-to-work certificate" should specify the location (the conditions and characteristics of the confined space) and type/nature of work to be done, and state:

(a) that all necessary safety precautions in relation to the hazards identified in the risk assessment report have been taken; and

(b) the period during which workers may remain safely in the confined space. In addition, the "Permit-to-work certificate" should also include:

(i) results in the risk assessment report completed by the competent person;

(ii) effectiveness of the isolation and withdrawal from service;

(iii) results of cleaning and purging of facilities in the confined space;

(iv) results of the atmospheric testing;

(v) a list of personal protective equipment ("PPE"); and

(vi) other safety precautions.

5.2.1.4 Reference should be made to the "Code of Practice Safety and Health at Work in Confined Spaces" for the requirements, details and record of the "Permit-to-work certificate".

5.2.2 Tag in/tag out system

5.2.2.1 The number of persons staying in the tunnel should, as far as reasonably practicable, be kept to a minimum. However, it is not appropriate to work alone.

5.2.2.2 A "tag in/tag out" system for hand-dug tunnelling work should be implemented to record the persons entering and leaving the tunnel. Common practices include erecting a notice board for keeping the Construction Industry Safety Training Certificates (commonly known as "Green Cards") / Certificates of Certified Worker, etc. of the persons entering the tunnel, and maintaining a register for recording their entry and exit time.

5.2.2.3 Such system provides crucial information for the supervisor, standby person and rescue team to monitor the compliance with the requirement on the prescribed number of workers who can safely remain in the tunnel and to ensure the effective execution of the emergency plan in case of need.

5.2.3 Access, egress and passageway

5.2.3.1 Safe access to and egress from the tunnel, passageway and emergency escape route should be properly planned and clearly marked to ensure the safety and health of workers under all circumstances.

5.2.3.2 The size, number and distribution of access and egress points should be assessed individually on the basis of the activities to be carried out and the number of persons involved. Due consideration

should be given to any possible difficulties in entering the tunnel and conducting rescue operations from the tunnel.

5.2.3.3 More than one safe access and egress point should be arranged for workers in the tunnel as far as practicable. In considering to regulate the movement of vehicles, materials and workers at the access and egress points, these access and egress points should be:

(a) properly planned and clearly marked to prevent the safety and health of the workers and other personnel involved from being endangered;
(b) of reasonably good design and construction;
(c) properly illuminated;
(d) free from hazards of falling objects;
(e) non-slippery and unobstructed to facilitate prompt evacuation and rescue from the tunnel whenever necessary;
(f) not less than 60cm in width for all pedestrian passageways of tunnels using the heading method. For tunnels using other construction method(s), the width for the passageways should also be not less than 60cm as far as practicable. Walking in a tunnel should be prohibited while a winch haulage is in operation, unless the walkway is adequately protected; and
(g) fitted with suitable safety hoops for every fixed access ladder rising 3m or more from the lower working platform or ground level to the top rung. The spacing between the hoops should not exceed 1m. In addition, the top of the ladder should be at least 1m above the upper working platform to serve as a handrail. Its topmost safety hoop should also be located at the level of 1m above the upper working platform.

5.2.3.4 For work to be carried out on or adjacent to roads, road closure and temporary traffic arrangement ("TTA") measures including warning signs and lights, guarding and safety clearance zone should be designed to the satisfaction of the relevant authorities.

5.2.4 Air monitoring

5.2.4.1 A risk of atmospheric hazards is inherent in hand-dug tunnelling work. The purpose of air monitoring is to confirm whether hazardous air impurities are present in an underground tunnel so as to decide and set out the related safety precautions necessary for hand-dug tunnelling work.

5.2.4.2 Air monitoring should be conducted by a person with appropriate training and experience. It includes pre-entry atmospheric testing and atmospheric monitoring during work by air monitoring equipment. Reference should be made to the "Air Monitoring in the Workplace" published by LD for more information about the basic principles and methods of air monitoring in workplaces for air impurities hazardous to health.

5.2.4.3 Air monitoring does not end with a pre-entry test. Since atmospheric conditions of a workplace within the hand-dug tunnel can change rapidly or contaminants may be produced during work processes, it is necessary to perform continuous air monitoring to ensure that the air quality in the tunnel remains acceptable throughout the work. Portable type multi-gas monitoring equipment with an audio-visual alarm should be provided to each worker for continuous air monitoring. A re-entry test should be

conducted before any worker re-enters the tunnel if all the workers have temporarily left the tunnel. In fact, re-entry test and pre-entry test should be performed in exactly the same manner and should be considered to be equally important. In case the alarm of air monitoring equipment is activated or any other indication of danger is observed, workers must leave the confined space immediately according to the emergency procedure.

5.2.4.4 The following are some important points on the use of air monitoring equipment specifically for conducting pre-entry tests in hazardous environments and confined spaces:

(a) Only properly maintained and calibrated equipment should be used for atmospheric testing;

(b) The most common configuration for a multiple-sensor gas monitor is one that displays readings on levels of oxygen, combustible gas, hydrogen sulphide and carbon monoxide. One should never assume that the hazardous gases present are limited to these gases. Different or additional air monitoring equipment, such as dust monitors, other hazardous gas monitors or organic chemical monitors, are required for testing other hazardous air impurities if a competent person considers that such hazardous air impurities may be present in the hand-dug tunnel;

(c) The air monitoring equipment should be of the explosion-proof type;

(d) The air monitoring equipment should have an audio-visual alarm device which would alert workers in the hand-dug tunnel when any indication of danger is detected;

(e) The proper functioning of the air monitoring equipment should be tested, i.e. to conduct functional or bump test, before use according to the manufacturer's instructions;

(f) The atmosphere in the hand-dug tunnel should, as far as practicable, be tested by using remote sampling probes and sampling lines connected to direct-reading equipment placed outside the hand-dug tunnel;

(g) The atmosphere around the working position of the person carrying out air monitoring should be tested first to ensure his safety and health during air monitoring;

(h) In general, testing for oxygen should be performed first because some gas sensors are oxygen-dependent and may give unreliable readings in oxygen-deficient situations. Even though it may still be sufficient for survival, any depletion of oxygen should be further investigated;

(i) As the hazardous gas may not be evenly distributed, air monitoring should be performed from the top to the front end of the hand-dug tunnel to cover different positions of the hand-dug tunnel and different depths of the shaft pit. If it is not feasible to horizontally extend the sampling probe and sampling line connected to the air monitoring equipment to the front end of the hand-dug tunnel, the proprietor or contractor should place remote control type air monitoring equipment at different and suitable locations (including different working locations and the excavation face) in the tunnel. Sampling for a few minutes at each location is required as there will be a time lag for the gas to be pumped from the sampling probe to the air monitoring equipment through the sampling line;

(j) The results should be recorded with the time and location of the air monitoring in the risk assessment; and

(k) Air monitoring must be conducted again when there is any potential change in the atmospheric conditions.

5.2.4.5 Combustible gas or vapour can cause fire or explosion. Using chemicals or performing gas welding or flame cutting operations in a hand-dug tunnel could have fire or explosion risks. An oxygen-enriched environment increases the risks of fire or explosion. Combustible materials that may not burn in room air can ignite easily and burn fiercely in an oxygen-enriched environment. The oxygen content in the hand-dug tunnel should not exceed 23%.

5.2.5 Ventilation

5.2.5.1 The hazards of oxygen deficiency or exposure to hazardous gas may be present in the hand-dug tunnel (reference should be made to the "Prevention of Gas Poisoning in Drainage Work" published by LD for further information). Therefore, effective mechanical ventilation should be installed for supplying sufficient respirable air to workers and removing air contaminants in the tunnel.

5.2.5.2 The tunnel ventilation equipment should be designed and installed by a person with suitable training and experience.

5.2.5.3 The schedule of inspections, tests and maintenance of the tunnel ventilation system should be clearly stipulated to ensure its effectiveness.

5.2.5.4 The air supply rate of the ventilation system should be determined by taking into account the work processes, such as welding, drilling and grouting, which will consume oxygen and contaminate the atmosphere. It is therefore necessary to provide adequate air change to remove the hazardous substances released and maintain sufficient air supply.

5.2.5.5 If local exhaust ventilation is installed to control the air contaminants in the tunnel, the hood opening should be close to the source of contaminants to ensure the effectiveness of the local exhaust ventilation and reduce the risk of inhaling air contaminants by workers.

5.2.6 Ground support

5.2.6.1 In-rush of free flowing solid is one of the serious hazards in hand-dug tunnels. In order to ensure the stability of the ground and minimise ground settlement/movement at all times, due consideration should be given to:

(a) providing continuous and adequate support and consolidation (such as applying advance grouting at the excavation face and suitable grouting along the lining) before and during excavation; and

(b) for the heading method, providing the top support with sufficient strength in advance and excavating as little soil as possible to maintain its self-supporting features safely until temporary or permanent support has been provided.

5.2.6.2 Major considerations in designing the ground-support system should include:

(a) the size, depth and shape of the tunnel;
(b) the method and speed of digging and lining;
(c) the stiffness and water tightness of the lining system;
(d) the groundwater table;
(e) the structural geology;
(f) the proximity of other underground utilities and structures; and
(g) the influence from other facilities in the vicinity, e.g. surcharge and vibration by moving vehicles on the road surface.

5.2.6.3 The proprietor or contractor should arrange surveys and regular inspections at the excavation face and in the proximity of the tunnel by a competent engineer so as to detect the potential risks associated with the ground conditions and groundwater as early as possible.

5.2.6.4 According to CSSR, every part of the excavation or earthwork shall be examined by a competent person at least once in every period of 7 days after the commencement of the hand-dug tunnelling work and issued with a weekly report in the approved form to ensure that they are safe and secure.

5.2.7 Inundation

5.2.7.1 In-rush of water is another serious hazard in hand-dug tunnels. The construction of hand-dug tunnels below groundwater table should be avoided as far as practicable. During hand-dug tunnelling work, the surrounding underground water of the tunnel should be managed in one or more of the following ways:

(a) arranging sufficient number of water pumps to dewater the ground inside the tunnel and/or the surrounding groundwater of the tunnel; and

(b) excluding water in-rush by ground treatment, compressed air or sealed lining.

5.2.7.2 In order to minimise the hazards associated with the underground water, as far as practicable, suitable grouting should be applied during hand-dug tunnelling work. Additional grouting should also be applied immediately after other temporary and permanent supports have been erected to enhance the stabilization and consolidation of the ground and prevent excessive in-rush of water. Besides, sufficient number of spare water pumps should be provided.

5.2.7.3 Suitable life buoys or life jackets attached to an independent lifeline should be provided at the strategic locations on the site (e.g. in the vicinity of the excavation face) for ease of evacuation and rescue of the workers inside the hand-dug tunnel. All reasonable steps should be taken to ensure that all the workers make proper use of the life buoys or life jackets provided.

5.2.8 Illumination

5.2.8.1 Adequate illumination is essential for workers to work and move around safely in the hand-dug tunnel. It also allows workers to easily see and recognise the hazards present in the workplace. However, too strong illumination may not only cause eye fatigue and have adverse effects on the eyes, but the glare effect or strong contrast may affect visibility and cause accidents.

5.2.8.2 The lighting system in the underground tunnel should be of waterproof type and fixed at suitable locations to provide illumination and reduce glare or shadow. Portable lighting devices (e.g. handheld torches or head lamps) should only be used in some exceptional conditions.

5.2.8.3 Where portable lighting devices are used, a management system should be put in place and facilities should be provided for their proper storage, charging, distribution, use and maintenance. For potentially explosive atmospheres, the portable lighting devices should conform to the explosion protection requirements.

5.2.8.4 Where it is foreseeable that potentially explosive gas may enter the hand-dug tunnel, the lighting system should conform to the explosion protection requirements so that evacuation can be undertaken with adequate illumination upon detection of potentially explosive atmospheres in the underground tunnel.

5.2.8.5 The presence of dust or mist in the atmosphere can also have a very significant effect on illumination. Under these conditions, the illumination in the tunnel should be increased accordingly.

5.2.8.6 Uniform illumination should be provided in the hand-dug tunnel.

5.2.8.7 Lighting equipment should be installed at suitable positions to minimise the vulnerability to damage, taking into account the installation and repair requirements. Regular repair and maintenance, including inspection and cleaning, should be carried out to ensure the effectiveness of the lighting equipment.

5.2.8.8 High-intensity lighting equipment should have diffusers and screening and installed at suitable positions to reduce the glare effect of strong light falling within the normal field of vision of the workers. In case there is a strong light falling within the normal field of vision, workplace illumination should be increased to reduce the lighting contrast.

5.2.8.9 Independent emergency lighting should be installed along the escape route and at the entrances and exits.

5.2.9 Electricity

5.2.9.1 Common sources of electric hazard associated with hand-dug tunnelling work included underground power cables, electrical plant, equipment and tools involved in the work.

5.2.9.2 References should be made to the "Code of Practice on Working near Electricity Supply Lines" published by the Electrical and Mechanical Services Department and other relevant legislation and guidance notes to eliminate the hazards associated with underground cables.

5.2.9.3 Given the humid environment in the tunnel, prevention of electric shock is of paramount importance. To eliminate the hazards associated with the electrical plant, equipment and tools involved in the hand-dug tunnelling work, the following should be ensured:

(a) except for the water pumps, ventilation blowers and arc welding equipment, the rated voltage of all portable electrical tools and the power supply within the tunnel should not exceed 110V a.c.;

(b) all switchboards should be securely locked and can only be accessible to authorised registered electrical workers;

(c) the power supplying circuitry used within the tunnel should be provided with a suitable residual current device to prevent electric shock;

(d) all electrical plant, equipment and tools should be designed to be adequately waterproof, dustproof, explosion-proof (where applicable) and double-insulated/earthed to prevent any harmful effects caused by ingress of water and dust;

(e) all electrical plant, equipment, tools and their associated cables and connections should be properly located and protected (e.g. fixed along the side wall of the tunnel at an elevated position) against the weather, possible in-rush of water and moving winch; and

(f) all plant, equipment, tools and exposed utilities should be regularly checked and maintained to ensure that they are in safe working order.

5.2.9.4 To ensure safety before, during and after long holidays, the following measures should be adopted as far as practicable before long holidays:

(a) shutting down all unnecessary generators and other power sources;

(b) disconnecting all unused electrical plant, equipment and tools from power source except those essential provisions such as lighting equipment and temporary traffic signs and removing them from the tunnel;

(c) properly storing and protecting all electrical plant, equipment and tools against the possible adverse weather;

(d) ensuring that all switchboards are securely locked and can only be accessible to authorised registered electrical workers; and

(e) conducting a thorough check on all electrical plant, equipment and tools by registered electrical workers before resumption of work and keeping a written record.

5.2.10 Noise

5.2.10.1 High noise level in the work environment can distract concentration, cause difficulties in oral communication and even cause accidents. Long term exposure to excessive noise can cause permanent hearing damage. Construction plant, such as drillers and rock breakers, frequently create very loud noise level.

5.2.10.2 If workers are exposed to a high noise level in the working environments, proprietors or contractors should appoint a competent person according to the Factories and Industrial Undertakings (Noise at Work) Regulation to carry out a noise assessment and devise a noise reduction plan. Engineering control measures should first be adopted to reduce the noise at the source. Such measures include the use of machines with less noise, installation of anti-vibration materials, muffler or silencer, removal of machines with a high noise level from places with more workers, installation of sound absorbing materials or sound barriers.

5.2.10.3 If it is not possible to reduce the noise to an acceptable level, approved ear protectors must be worn.

5.2.10.4 Proprietors or contractors should provide workers exposed to a high noise level with information about noise hazards to hearing, and instruction and training about the proper way to use the ear protectors.

5.2.11 Heat and humidity

5.2.11.1 Workers engaged in hand-dug tunnelling work are at a higher risk of suffering heat stroke, especially on summer days with high temperature and humidity. To prevent heat stroke, proprietors or contractors should arrange a suitable assessment of the risk of heat stress at the workplace and, based on the assessment results, adopt effective preventive measures. For details of the assessment of the risk of heat stress, reference should be made to the "Risk Assessment for the Prevention of Heat Stroke at Work" and "Prevention of Heat Stroke at Work in a Hot Environment" published by LD.

5.2.11.2 To assess the risk of heat stress, the following risk factors should be taken into consideration, including temperature, humidity, heat radiation, air movement, workload, clothing and acclimatization. A combination of these factors can cause adverse health effects ranging from heat syncope to heat stroke. Common signs of heat stroke include high body temperature, thirst, headache, fatigue and lethargy, clammy skin, no sweating, paleness, confusion, muscle cramps and loss of consciousness.

5.2.11.3 To reduce the risk of heat stroke for workers working in a hand-dug tunnel, the following preventive measures should be implemented in the workplace:

(a) providing adequate ventilation in the workplace;
(b) using appropriate ventilation equipment, e.g. portable fans, to increase the air movement;
(c) eliminating, isolating or relocating sources of hot air;
(d) exhausting hot air out of the workplace;
(e) setting up suitable screens to reflect radiant heat away from the workers;
(f) where practicable, rescheduling the work to cooler periods in the daytime and cooler locations;
(g) arranging more frequent rest breaks;
(h) providing sheltered rest areas near the work locations;
(i) providing drinking water and reminding the workers to drink more water;
(j) providing mechanical aids for workers to reduce physical demand on them;
(k) re-organising the work to reduce intensity and pace of bodily movement of the workers;
(l) allowing time for acclimatization starting with a lower workload or shorter working duration, and gradually increasing the workload or duration over a number of days; and
(m) reminding workers to pay attention to their health conditions and providing training for workers to enhance their awareness of early symptoms of heat stroke.

5.2.12 Dust and chemicals

5.2.12.1 During the construction of hand-dug tunnels, processes involving drilling, breaking and crushing of rocks will generate silica dust.

Besides, dry cement for use in processes such as grouting, concreting, transporting and tipping of spoil could produce excessive dust in the tunnel.

5.2.12.2 Exposure to excessive silica dust for prolonged period can lead to silicosis - a disease with lung fibrosis causing difficulty in breathing. The risk of suffering from silicosis is high in the construction of hand-dug tunnels with poor ventilation.

5.2.12.3 In addition to the existence of dust hazards in the hand-dug tunnels, toxic gas, vapour and fume may be released from a variety of processes, machinery and chemicals, including welding, painting, and using adhesives and thinners.

5.2.12.4 Exposure to such toxic gas, vapour and fume may cause adverse health effects to the workers. The extent of harmful effects depends on the toxicity and concentration of the gas, vapour and fume. Some can overcome the workers quickly while others can have long-term health effects.

5.2.12.5 To reduce the workers' exposure to silicosis and chemical contaminants, proprietors or contractors should take the following control measures:

(a) using water suppression to reduce the dust level;
(b) using safer substitutes or less volatile chemicals;
(c) improving the work process or equipment to reduce the emission of dust or toxic chemical contaminants;
(d) providing adequate ventilation in the workplace;

(e) applying local exhaust system at source to effectively remove dust and chemical contaminants such as gas, vapour and fume; and

(f) wearing suitable impervious protective gloves to avoid direct contact with the chemicals.

5.2.12.6 If, and only if, the dust level and chemical contaminants cannot be adequately controlled by any combination of the measures mentioned above, proprietors or contactors should provide appropriate and adequate respiratory protective equipment ("RPE") to the workers and ensure that the RPE is properly worn.

5.2.12.7 Proprietors or contractors should provide workers with information about the health effects of silica dust and chemical contaminants, as well as instruction and training on the proper procedure for wearing RPE.

5.2.12.8 Proprietors or contractors should also take suitable measures to maintain and store the RPE to ensure its effectiveness.

5.2.13 Biological hazard

5.2.13.1 The workers in underground hand-dug tunnel may be exposed to biological hazard from the bite of rodents or pests. Infection from bacteria or virus is not impossible if the workplace has been contaminated.

5.2.13.2 To protect workers from biological hazard, proprietors or contractors should:

(a) remind workers of the importance of good personal hygiene;
(b) inform workers of the importance of first aid treatment to prevent infection through wounds and cuts;
(c) tidy up the sites and keep refuse (such as lunch boxes and cans) in closed containers; and
(d) appoint professional pest and rodent control contractors to carry out pest and rodent control in the workplace whenever necessary.

5.2.14 Manual work

5.2.14.1 Physically demanding manual work such as handling of heavy items, prolonged use of hand tools, standing, kneeling, stooping, crawling or sustaining a static working posture, may cause musculoskeletal disorders. Hand tools with poorly designed handles will further increase the risk of injuries.

5.2.14.2 Proprietors or contractors should provide a properly planned and designed workplace to minimise injury of workers caused by conveyance work. This includes the design of work system, plant, equipment and containers used in the workplace as well as workstation layout. Prior to conducting conveyance work, employers must carry out risk assessments in accordance with legislation to identify the risks associated with such work in the workplace and take suitable protective and prevention measures. For details, reference should be made to “A Guide to Part VII of the Occupational Safety and Health Regulation (Manual Handling Operations)” published by LD.

5.2.14.3 Risk assessment should be conducted to assess the risk of prolonged manual work to ensure that suitable measures are taken, such as the provision of mechanical tools and protective elbow guard or kneelet to reduce the risks induced by overexertion of the body, hand and forearm and prolonged kneeling to work. Suitable work rest arrangements for workers can also relieve fatigue.

5.2.15 Fire prevention and hot work

5.2.15.1 Burning, welding, gas cutting and other hot work are inherently hazardous. They not only create hazards of fire, but also lead to emission of toxic gas, vapour, dust or fume, causing deficiency of oxygen, raising the atmospheric temperature, etc. Hot work should be prohibited in hand-dug tunnelling work as far as practicable. However, when hot work is necessary, a hot work permit system should be drawn up detailing the precautionary measures to be taken. For example:

(a) all electrical plant, equipment and tools that are likely to give off sparks or become hot should not be installed or used in areas where combustible substances exist;

(b) the quantity of gas cylinders stored should be kept to a minimum as far as practicable;

(c) all combustible substances in the proximity should be removed, and all workpieces should be checked to ensure that no residues of any combustible substances left on them;

(d) continuous monitoring of the atmospheric temperature and air quality, and good ventilation should be maintained;

(e) proper fire-fighting installations (e.g. suitable fire extinguishers and fire blanket) should be provided and maintained, and the access to the fire-fighting equipment and

emergency escape route should be kept free from obstruction; and

(f) proper training and emergency drills should be provided to all personnel involved.

5.2.15.2 No hot work should be allowed in the tunnel unless a hot work permit is issued.

5.2.15.3 Smoking and naked light should be prohibited in the tunnel and shafts, on the surface within the site and near the outlets of any exhaust fans used for ventilation. Relevant warning notices should be displayed in the corresponding conspicuous places of the tunnel. If naked light is necessary, a hot work permit system and relevant safety measures should be implemented and hot work permit should be granted in advance.

5.2.15.4 Reference to the "Code of Practice Safety and Health at Work for Gas Welding and Flame Cutting" and "Code of Practice Safety and Health at Work for Manual Electric Arc Welding" published by LD should also be made for the other relevant requirements.

5.2.16 Monitoring devices

5.2.16.1 Continuous monitoring of the working conditions in hand-dug tunnels is of paramount importance for the immediate execution of evacuation and rescue plans in case of emergency. The following safety measures should be adopted as far as practicable:

(a) establishing a monitoring system for the groundwater level and the movement and settlement of the adjacent ground, utilities, other structures, etc;

(b) installing a water level alarm which gives out warning signals whenever the water level has reached a height of 10cm at any position inside the tunnels;

(c) installing a closed-circuit television ("CCTV") system or providing mobile real-time inspection camera to continuously monitor the internal environment and the proximity of the excavation face of the hand-dug tunnels (Photo 3);

(d) providing fire detection devices to detect the possible outbreak of fire if hot work (including the use of naked light, etc) is necessary;

(e) testing the air and temperature again by a competent person before allowing workers to re-enter the tunnel each time after all workers have left the hand-dug tunnel;

(f) providing every worker working inside the hand-dug tunnel with a portable type of multi-gas monitoring equipment with audio-visual alarm to continuously monitor the air quality nearby the worker; and

(g) providing every worker working inside the hand-dug tunnel with a personal distress alarm (motion sensor) (Photo 4) to give out alerting signals to others when the worker remains motionless for a certain duration.

5.2.16.2 Whenever any significant change or abnormality in working conditions causing potential hazards to the safety and health of workers is observed, the proprietor or contractor should immediately activate the emergency plan, suspend the work, arrange evacuation and rescue of workers, and report to the relevant government departments in accordance with the emergency plan.

Resumption of work should not be allowed until the site condition is confirmed safe.

5.2.16.3 Besides, at least one standby person should be assigned to station outside the tunnel throughout the operation to monitor the real-time surveillance system and maintain communication with the workers inside. The standby person should also keep in view other factors such as adverse changes in the weather and displacement of ground and materials. The standby person should alert the workers inside the tunnel, call immediate evacuation and summon assistance once the hazard is discovered.

Photo 3 - Closed-circuit television ("CCTV") system

Photo 4 - Personal distress alarm (motion sensor)

5.2.17 Use of personal protective equipment ("PPE")

5.2.17.1 PPE should be considered as a last resort in case of emergency. In order to accord maximum protection to the workers, PPE should be provided and properly used only when all other engineering and administrative safety and health precautions have been proved to be impracticable. Examples of common and suitable PPE in hand-dug tunnelling work are:

(a) safety helmet with chin strap;

(b) safety goggles, hand shield or face screen;

(c) portable lighting device (for emergency use);

(d) reflective safety vest;

(e) safety harness attached to independent lifeline (if it is recommended in the risk assessment report);

(f) safety gloves;

(g) safety shoes; and

(h) escape-type breathing apparatus (See paragraph 6.4 for details).

5.2.17.2 All PPE provided should conform to the relevant legal requirements and the respective national/international standards. The proprietor or contractor should also ensure that all workers make proper use of the PPE provided. All the PPE should be properly stored, taken care of and maintained. Damaged PPE should be immediately replaced without being used further.

6. Emergency Preparedness

6.1 Emergency Plan

6.1.1 When an emergency occurs, emergency preparedness is vital to making an efficient and adequate response to rescue the persons concerned from the safety and health hazards. All the possible emergencies should be identified with their effects and impacts evaluated, and an emergency plan should be drawn up. The emergency plan should include the following elements:

(a) setting priority of the possible emergencies;

(b) reporting to the relevant government departments and public emergency services (e.g. the Hong Kong Police Force ("HKPF") and the Fire Services Department ("FSD"));

(c) alerting all the personnel involved;

(d) providing escape and rescue procedures and routes;

(e) forming a standby rescue team consisting of a sufficient number of trained team members; and

(f) providing equipment and materials as required (including the proper use of safety harnesses and independent lifelines, life buoys, safety baskets, etc. in case of emergency).

6.1.2 When devising the emergency plan, reference should be made to the relevant legislation and the requirements of other authorities, particularly the F&IU (Confined Spaces) Reg. Immediate suspension of work, and evacuation and rescue of workers must always be accorded with the highest priority in case of emergency.

6.2 Alert and Communication Systems

6.2.1 Sufficient alert and communication systems (including walkie-talkie and intercommunication system) (Photo 5) should be provided to ensure the effectiveness of the emergency plan. In particular, effective communication between the workers inside the tunnel and the standby person and supervisor on the ground should be maintained throughout the period when the hand-dug tunnelling work is being carried out. An audio-visual alarm system should be provided for the workers inside the tunnel to alert the others on the ground, and vice versa, in case of emergency.

6.2.2 The standby person and supervisor on the ground should not enter the tunnel even in an emergency. They should remain stationed outside the tunnel and summon the assistance of the standby rescue team and public emergency services (e.g. HKPF and FSD). They should stay outside the tunnel and brief the rescue personnel and the public emergency services on the circumstances of the emergency upon their arrival.

Photo 5 - Intercommunication system

6.3 Safety Baskets

6.3.1 Hazards in hand-dug tunnelling, such as toxic gas, vapour, dust or fume, deficiency in oxygen and increase in body temperature, may result in the loss of consciousness of workers in the tunnel. Proprietors or contractors should therefore provide at least one safety basket and suitable carrying tool for prompt withdrawal of injured workers from the tunnel in case of emergency (Photo 6).

6.3.2 The carrying tool should be placed near the excavation face to facilitate the prompt transportation of the injured worker from the excavation face to the entrance of the shaft. The safety basket should be placed at a strategic location of the entrance of the shaft to facilitate the transportation of the injured worker from the tunnel to the ground. The safety basket and carrying tool should be kept in good working condition and be readily available for use.

Photo 6 - Safety basket

6.4 Escape-type Breathing Apparatus

6.4.1 If the hand-dug tunnelling work does not involve underground pipework, and the competent person has not recommended the use of approved breathing apparatus in the risk assessment report, each worker engaged in hand-dug tunnelling work should be provided with a set of escape-type breathing apparatus (air supply type self-rescuer) for emergency escape purpose. The escape-type breathing apparatus can supply the workers with air or oxygen for a sufficient period of time for them to escape.

6.4.2 Escape-type breathing apparatus is portable type for emergency escape and is normally carried by users on a belt at waist. The quality of the air or oxygen content of the escape-type breathing apparatus should be of breathable type.

6.4.3 Proprietors and contractors should provide adequate information, instruction, training and supervision to employees equipped with escape-type breathing apparatus at work to ensure that the escape-type breathing apparatus are properly worn and used.

6.4.4 Proprietors and contractors should take suitable measures to inspect, maintain and store the escape-type breathing apparatus to ensure their effectiveness.

6.5 Emergency Drill

6.5.1 Emergency drills should be conducted regularly to ensure that all the personnel involved are familiar with the emergency procedures and to enhance their safety awareness and preparedness. In general, the drills should include the following:

(a) Evacuation drill for all the personnel involved: This is to enable all the personnel to familiarise themselves with the emergency procedures, communication system, escape routes and exits, safe assembly point, PPE, etc. and to test the effectiveness of emergency procedures and evacuation plan, as well as the sufficiency and suitability of emergency facilities provided; and

(b) Rescue drill for emergency and rescue team: This is to test the capability of the emergency and rescue team in their rescue duties, such as report and command duties, first aid, rescue, use of emergency facilities, etc.

6.5.2 Observations made during the drills should be recorded for identification of deficiencies and continuous improvement to the emergency plan.

7. References

1. Occupational Safety and Health Ordinance, Chapter 509
2. Factories and Industrial Undertakings Ordinance, Chapter 59
3. Factories and Industrial Undertakings Regulations, Chapter 59A
4. Construction Sites (Safety) Regulations, Chapter 59I
5. Factories and Industrial Undertakings (Lifting Appliances and Lifting Gear) Regulations, Chapter 59J
6. Factories and Industrial Undertakings (Protection of Eyes) Regulations, Chapter 59S
7. Factories and Industrial Undertakings (Noise at Work) Regulation, Chapter 59T
8. Factories and Industrial Undertakings (Electricity) Regulations, Chapter 59W
9. Factories and Industrial Undertakings (Safety Officers and Safety Supervisors) Regulations, Chapter 59Z
10. Factories and Industrial Undertakings (Confined Spaces) Regulation, Chapter 59AE
11. Factories and Industrial Undertakings (Loadshifting Machinery) Regulation, Chapter 59AG
12. Code of Practice Safety and Health at Work for Gas Welding and Flame Cutting, Labour Department

13. Code of Practice Safety and Health at Work for Manual Electric Arc Welding, Labour Department

14. Code of Practice Safety and Health at Work in Confined Spaces, Labour Department

15. A Brief Guide to the Factories and Industrial Undertakings (Confined Spaces) Regulation, Labour Department

16. Air Monitoring in the Workplace, Labour Department

17. Safe Work in Confined Spaces, Labour Department

18. Risk Assessment for the Prevention of Heat Stroke at Work, Labour Department

19. Prevention of Gas Poisoning in Drainage Work, Labour Department

20. Prevention of Heat Stroke at Work in a Hot Environment, Labour Department

21. A Guide to Part VII of the Occupational Safety and Health Regulation (Manual Handling Operations) , Labour Department

22. Code of Practice on Working near Electricity Supply Lines, Electrical and Mechanical Services Department

23. Code of Practice for the Lighting, Signing and Guarding of Road Works, Highways Department

24. Approved Code of Practice – Safe Work in Confined Spaces, Health and Safety Executive, UK

25. Avoiding Danger from Underground Services, Health and Safety Executive, UK

26. BS 6164:2011, Code of Practice for Health and Safety in Tunnelling in the Construction Industry

27. Control of Trenchless Works Carried out by Non-government Utility Undertakers Affecting Public Roads, Highways Department

28. Tunnelling Code of Practice 2007, The State of Queensland (Department of Justice and Attorney-General), Australia

29. Tunnels under Construction Code of Practice 2006, WorkCover New South Wales, Australia

30. Safety Manual, Drainage Services Department

31. Tunnelling and Pipejacking : Guidance for Designers, Pipe Jacking Association, British Tunnelling Society and Health and Safety Executive, UK

8. Enquiries and Complaints

Enquiries

If you wish to enquire about this GN or require advice on OSH matters, please contact the Occupational Safety and Health Branch of LD through:

Telephone : 2559 2297 (auto-recording service available outside office hours)
Fax : 2915 1410
E-mail : enquiry@labour.gov.hk

Information on the services offered by LD and on major labour legislation is also available on our website at http://www.labour.gov.hk.

For details on the services offered by the Occupational Safety and Health Council, please call 2739 9000.

Complaints

If you have any complaint about unsafe workplaces and work practices, please call the LD's OSH complaint hotline at 2542 2172. All complaints will be treated in the strictest confidence.

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