

Working in Drainage Services Department Manholes Underground: A Critical Examination of Confined Space Safety Protocols in Hong Kong

¹Ir Dr Assoc Professor Samuel Kwok Piu LIP CEng, RPE, RCM, CPE, CBE, FCIBSE, FIMechE, FIE.Aust, FCABE, FHKICA, FCIPHE, MHKIE, MHKICM, MIET, MIFireE, MAIB, MASHRAE.,

²Dr. Wing Cheung TANG MCGI, CMgr, FCMI, FIMA, CPMC, FIMC

¹Founder and Managing Director of Lordray Engineering Company Limited

²Adjunct Professor of Spectrum International University College, Malaysia

DOI: <https://doi.org/10.51244/IJRSI.2026.1304000139>

Received: 18 April 2026; Accepted: 24 April 2026; Published: 07 May 2026

ABSTRACT

In the infrastructure of Hong Kong's Drainage Services Department (DSD), subterranean manholes provide many occupational hazards, such as toxic and flammable hydrogen sulphide (H₂S), oxygen-deficient environments, explosion risks, trench collapses, and illegal access. The Factories and Industrial Undertakings (Confined Spaces) Regulation mandates training, the designation of "Competent Persons", and permit-to-work systems; however, the manuscript contends that safety protocols may be qualitative rather than quantifiable, which restricts enforceability and renders decision-making reliant on judgement rather than established thresholds. This essential descriptive audit consolidates observational photographic data and procedural documentation within an international confined-space comparison framework. Research reveals that DSD manhole operations encompass essential control domains—permits, ventilation, personal protective equipment, atmospheric testing instruments, rescue apparatus, shoring, and perimeter control—however, the documented procedures are deficient in quantified atmospheric thresholds, performance benchmarks for ventilation and rescue timing, explicit protocols for communication failures, rationales for standardised inspection frequency, and uniform respiratory protection measures. The study additionally delineates methodological constraints that hinder causal assertions and advocates for a future mixed-method and quantitative monitoring architecture.

Keywords: confined space, Drainage Services Department, manhole, permit-to-work, occupational safety

INTRODUCTION

Background and Problem Significance

Manholes in the ground are an important but dangerous part of Hong Kong's sewage and drainage system. The Drainage Services Department (DSD) takes care of many manholes that let people get to sewers, storm drains, and combined drainage systems. These small spaces are not just bad places to work; they could also be deadly.

Sewage that collects in manholes is broken down by sulfate-reducing bacteria in an anaerobic process, which produces hydrogen sulphide (H₂S), a colourless, toxic, flammable gas that smells like rotten eggs at low concentrations. H₂S causes rapid olfactory fatigue, which means that workers can't tell when levels are dangerous after only a short time of being exposed. H₂S can cause immediate collapse and death within minutes at levels higher than 100 parts per million (ppm) (Aventaggiato et al., 2020).

At the same time, biological respiration and chemical oxidation use up the oxygen that is already there, making the air oxygenpoor. Normal air has about 20.9% O₂ in it. Workers' ability to think and move quickly goes down when levels drop below 19.5%. When levels drop below 16%, they quickly suffocate (McEwen, 2018). It's very dangerous to enter a manhole because of the flammable gas (H₂S has a lower explosive limit of 4.3% by volume), the confined space, the limited exit, and the possibility of the trench collapsing. The Labour Department (2025) says that accidents in confined spaces are always one of the top three causes of deaths on construction and utility sites.

Regulatory Context in Hong Kong

The Factories and Industrial Undertakings Ordinance (Cap. 59) and its subsidiary Confined Spaces Regulation (Chapter 59AE) are the main laws that govern work in confined spaces in Hong Kong. Section 4 of this rule says that no worker can enter a confined space unless they have been trained and named as a Competent Person. The rule also says that employers must give workers a valid permit to work before they can enter, do risk assessments, make sure there is enough ventilation, always keep an eye on the atmosphere, and make plans for emergency rescues (Labour Department, 2024).

Even with all these rules, accidents still happen. A review of DSD (2019) incident reports shows that there are problems that keep happening, such as not enough ventilation before entry, not enough gas monitoring, not using lifelines properly, and not enough shoring inspections. These patterns indicate discrepancies between documented protocols and practical application—discrepancies that this paper aims to elucidate and rectify.

Research Objectives and Research Questions

The following are the research objectives.

1. To conduct a critical analysis and comparison of DSD confined-space safety regulations for underground manhole entrance with worldwide standards.
2. To identify specific deficiencies in operational documentation—particularly if protocols are devoid of numerical thresholds or performance timing criteria.
3. To deliver evidence-based suggestions to enhance the measurability, enforceability, and resilience of safety controls.

To conform to a pivotal descriptive audit, the research questions must be congruent with qualitative evidence while also being operationally verifiable.

RQ1: To what degree do DSD manhole guidelines delineate quantifiable ambient thresholds for oxygen and H₂S (and flammability hazards)?

RQ2: To what degree do DSD procedures delineate performance criteria for ventilation time and duct positioning?

RQ3: To what extent do DSD procedures delineate the management of communication failures, the timing for initiating rescues, and the criteria for completing rescues?

RQ4: In what manner do DSD guidelines organise controls for structural integrity, specifically regarding shoring inspection frequency and perimeter control?

RQ5: Does the recorded practice exhibit uniform expectations for respiratory protection in the presence of H₂S risk?

Notwithstanding the presence of a permit-to-work system and the nomination of a Competent Person, accidents continue to transpire. The rationale is that safety relies not solely on procedural adherence (document compliance) but also on quantifiable performance metrics that mitigate ambiguity. The book primarily addresses the issue that ambiguous directives (such as adequate ventilation, test for toxic gases, or if no response) allow for diverse interpretations and heighten the risk of systematic underestimating.

LITERATURE REVIEW

International studies on safety in confined spaces give us standards by which we can judge DSD protocols. According to the United States Occupational Safety and Health Administration (OSHA, 2023), there are four basic requirements for entering a confined space that requires a permit: a written program, a permit system, continuous atmospheric monitoring, and rescue services on hand. The Health and Safety Executive (HSE) in the UK (2014) says that ventilation must be forced fresh air exchange at a rate that keeps O₂ levels above 19.5% and H₂S levels below 10 ppm (8-hour time-weighted average) or 15 ppm (short-term, 15-minute exposure limit).

There are still not many studies on how well ventilation works in manholes. McManus and Haddad (2019) showed that natural diffusion isn't enough to get rid of gas in vertical shafts deeper than 2 meters. Before entering, mechanical ventilation is needed for at least 10 to 15 minutes. Wang et al. (2018) recently discovered that flexible air ducts, such as those shown in DSD photographs, only allow for effective air exchange when the duct terminus is within 0.5 meters of the manhole bottom. This is a condition that is often not followed in practice.

The Construction Industry Council (2017) says that a Competent Person must check sheet iron and timber struts every day and that Form 5 certification must be done every week. But there hasn't been a published study that looks at how well DSD operations follow this rule.

Study Scope and Limitations

This paper relies on observational documentation and photographic evidence from specific DSD manhole locations in Hong Kong. There were no quantitative measurements of the atmosphere taken. There were no controlled ventilation tests done. There is no statistical analysis of the rates of accidents. All the pictures were taken during DSD work hours or from places that anyone could get to. There was no need for ethical approval because no people were involved, and all the workers who were photographed gave their consent by agreeing to work for the company.

The results may not be relevant to other confined spaces, such as water supply tunnels, culverts, electrical cable trenches, or manholes located outside of Hong Kong. Since the observations were made, protocols may have changed. Observed manholes may indicate conditions that are either better or worse than average. This paper delineates current protocols but does not evaluate their causal impact on accident rates.

METHODOLOGY

Research Design

This study utilises a qualitative descriptive design (Doyle et al., 2020) suitable for documenting and critically evaluating current occupational safety protocols. The design is based on observation and documents, not experiments.

Data Sources

Three different sources of information are used.

- (a) Photographic documentation: Ten pictures taken at four DSD manhole work sites in Hong Kong (Kowloon and New Territories) from January to April 2026. Pictures show safety gear, how the site is set up, and how things work.
- (b) Procedural documentation: Site supervisors gave us internal DSD safety guidelines and permit-to-work templates (redacted for privacy).
- (c) Regulatory references: The Hong Kong Labour Department's publicly available guidance documents and the Factories and Industrial Undertakings Ordinance.

Analytical Framework

Thematic analysis (Braun & Clarke, 2006) was used to look at photographs and procedural documents. Deductive codes were based on international confined space standards (OSHA, HSE). There were five main codes used:

- (a) Controlling the atmosphere (ventilation, gas monitoring, O₂/H₂S limits)
- (b) Getting in and out (winch, hoisting frame, lifelines)
- (c) Structural integrity (shoring, sheet irons, struts, Form 5)
- (d) Communication and rescue (two-person rule, surface-to-subsurface communication, emergency response)
- (e) Controlling the perimeter (rope net, water horses, barricades, and keeping people from getting in without permission)

Limitations of This Methodology

The author clearly states that this method cannot yield causal or generalisable results, which is an honest and necessary limitation. The ventilation system can't be objectively evaluated without quantitative atmospheric data, like levels of carbon monoxide, oxygen concentration, or particulate matter. In the same way, it does not know how good winch systems and emergency protocols are because there have not been any timed rescue drills to test deployment speed, equipment functionality, and crew response times. These are not small mistakes; they are big holes that make it impossible to scientifically test safety performance. So, this paper is more of a critical

safety audit than a controlled scientific study. It finds possible dangers, keeps track of current infrastructure, and points out areas of concern, but it cannot measure how well things work or predict what will happen in a real emergency. Readers need to keep this difference in mind as they read. As an audit, the work is good; as experimental research, it does not even come close to meeting the minimum standards.

FINDINGS

Overview of Observed Safety Protocols

Based on pictures and documents, DSD manhole operations in Hong Kong use the following safety measures. Italics are used to show direct quotes from procedural documents.

(a) Permit-to-work System: Before entering any of the operations we saw, everyone had to have a valid permit to work. "No worker shall enter a confined space without a valid permit issued by the Competent Person" and "Permit validity shall not exceed 24 hours" (DSD, 2019).

(b) Personal Protective Equipment (PPE) and Ventilation—Workers who went into manholes wore standard PPE, like hard hats, safety boots, gloves, and reflective vests. People did not always wear respiratory protection. Before people could enter, an electric blower fan with a yellow flexible air duct was set up to push fresh air into the manhole. Figure 1 shows a portable blower fan that is firmly attached to a flexible duct that goes down about 2 meters into a manhole to bring in fresh air or let out dangerous fumes. Figure 2 shows an emergency diesel generator on standby, clearly marked to show that it powers important equipment: blower fans for ventilation, a winch motor for lifting people or materials, and lights for safe work underground.



Figure 1: Blow fan and flexible air duct



Figure 2: Emergency diesel generator

(c) Atmospheric Testing -- Before and during entry, procedural documents say that poisonous gases (specifically H₂S) must be tested and O₂ levels must be measured. DSD (2019) said, "Use instruments to test for poisonous gases and see if the O₂ level is high enough". It did not, however, give any specific numbers for the thresholds. It did not say what "adequate" O₂ levels are (expected: >19.5%) or what H₂S levels are okay (expected: <10 ppm TWA).

(d) Two-Person Team and Rescue Equipment -- All the operations we saw had at least two people: one inside the manhole and one above ground. The worker on the surface stayed in touch with the worker below the

surface. Figure 3 shows an A-frame hoisting frame above the manhole that held a winch motor with a cable to drag an unconscious worker to the ground.

(e) Shoring and Trench Collapse Prevention --To keep the trench from collapsing, sheet irons were put around the manhole's edge and held in place with wooden struts (Figure 4). Every week, a safety officer had to check the trench and give out Form 5, which was posted at the site of the trench.



Figure 3: A frame with winch is set up

Figure 4: Barrier is fixed by metal trunking

(f) Perimeter Control and Unauthorised Access Prevention -- The sites we saw used a lot of barriers. For example, there were water-filled plastic barricades around the manhole perimeter, rope nets over the open manhole to keep people from falling in (Figure 5), and metal trunking through sheet irons to hold the barriers to the ground (Figure 4).

(g) Water Removal -- A submerged pump with a blue plastic hose was used to move sewage water from the manhole to ground surface drainage (Figure 6).



Figure 5: The manhole is barricaded by barriers

Figure 6: Submerged pump with blue plastic hose

Identified Gaps and Deficiencies

Based on comparison with international standards (OSHA, 2023; HSE, 2014; NIOSH, 2016), the following gaps were identified.

Gap	Observed DSD Practice	International Benchmark	Severity
No numerical gas thresholds	“adequate O ₂ ” (undefined)	O ₂ <19.5% triggers prohibition	High
No H ₂ S exposure limits	“poisonous gases” (undefined)	H ₂ S >10 ppm (TWA) requires action	High
No ventilation duration standard	“provide adequate ventilation” (no time specified)	Minimum 10–15 minutes pre-entry	Medium
No communication failure protocol	“if no response” – but no timeout specified	Communication check every 2 minutes; rescue within 4 minutes	High
No rescue time benchmark	“draw the unconscious worker to ground” – no speed requirement	Rescue must begin within 4 minutes (OSHA, 2023)	High
Weekly shoring inspection (Form 5)	“every week”	Daily inspection recommended (CIC, 2017)	Medium
Respiratory protection not consistently observed	None visible in photographs	H ₂ S >10 ppm requires SCBA or full-face respirator	Critical

The lack of specific atmospheric thresholds in the Drainage Services Department (DSD) procedural documents is a serious safety risk that could even cost lives. This gap exists on two levels that are related to each other: first, there are no numerical limits for certain dangerous gases and oxygen levels; second, there are no performance specifications for vague qualitative terms like "adequate ventilation."

Workers and supervisors do not have clear, measurable limits for oxygen (O₂) and hydrogen sulphide (H₂S), which means they don't have objective, actionable guidelines for two of the most important decisions about entering a confined space: whether to keep people out in the first place and whether to order an immediate evacuation once work has started. International standards, on the other hand, set clear goals. The United States Occupational Safety and Health Administration (OSHA, 2023) says that you can't go into a confined space that needs a permit if the oxygen level is less than 19.5% or more than 23.5%. The National Institute for Occupational Safety and Health (NIOSH, 2016) also sets a limit for H₂S exposure of 10 parts per million (ppm) as an 8-hour time-weighted average and 15 ppm as a short-term exposure limit of 15 minutes. If the levels go above these limits, the worker must either be removed or given respiratory protection that comes from a supply of air. Without these kinds of measurable benchmarks, a DSD worker who is told to look for "poisonous gases" or "adequate O₂" is in a very difficult situation. What value on the scale is "poisonous"? Is 10 parts per million of H₂S okay? Is it 50 ppm? Is 18.5% O₂ "enough"? The procedural document does not provide an answer. So, the choice to enter or leave is based on personal judgement, gut feeling, or undocumented local practice, all of which are known to consistently downplay risk in dangerous situations.

The phrase "adequate ventilation" can mean a lot of different things, and some of them could be dangerous, if it doesn't include a time limit, a volumetric air exchange rate, or a duct placement specification. One supervisor may deem two minutes of fan operation adequate, while another may necessitate twenty minutes. One worker

might put the flexible air duct just inside the opening of the manhole, while another might lower it to within 0.5 meters of the bottom. Empirical studies indicate that these distinctions are significant. Kallepalli, Johnson and Mattson (2021) found that natural diffusion alone takes more than 30 minutes to move gas even a little bit in a vertical shaft that is more than two meters deep. However, if the duct terminus is near the bottom, mechanical ventilation at a rate of 1,000 cubic feet per minute can exchange 90% of the air in 5–10 minutes. Wang et al. (2018) corroborated that flexible air ducts situated over one meter above the manhole floor led to inadequate gas mixing, creating a perilous stratum of H₂S or oxygen-deficient air at the base where the worker is positioned. Without a set time limit and rules for where to put ducts, DSD workers may not know that they are entering manholes that have not been properly or effectively ventilated.

The phrase "systematically underestimate required ventilation" needs to be explained in detail. Interpreting unclear safety instructions in a subjective way does not lead to random differences from a correct standard. Instead, it creates a systematic bias toward underestimating. This happens for three reasons. First, time pressure—supervisors and workers must finish maintenance tasks quickly because of operational pressures. The default time for ventilation becomes the shortest time that seems reasonable, not the best time based on engineering calculations. Second, atmospheric hazards are hard to see. For example, H₂S and oxygen deficiency are not dangerous until they get to levels that could kill you. H₂S induces olfactory fatigue rapidly, making it imperceptible by smell even at lethal concentrations (Ahmed, Yusuf & Khan, 2023). When there is not enough oxygen, people do not feel anything until their brain stops working and they pass out. Without alarms and quantitative monitoring, workers have no way to know if they are underestimating how much ventilation they need. Third, normalisation of deviance happens when not enough ventilation does not cause an accident that can be seen right away. Workers and supervisors wrongly think that the short amount of time was "good enough". Over time, bad practice becomes the norm. Quantified thresholds and required ventilation durations are the exact steps that will stop this systematic bias.

DISCUSSION

Interpretation of Findings

The DSD safety protocols that were observed include all the important types of control measures that are required by international standards, such as permits, ventilation, gas testing, rescue equipment, shoring, and perimeter control. This means that DSD has correctly figured out what the risks are of working on manholes. But without specific, measurable limits, these controls go from having objective safety standards to being subjective guidelines.

Think about testing the air. It is impossible for a worker to test for "adequate" O₂ without a number. Is 19.0% enough? How about 18.5%? International standards are clear: 19.5% is the lowest level of oxygen that can be breathed without supplied air (OSHA, 2023). Likewise, "poisonous gases" without acceptable exposure limits make it hard for workers to tell the difference between safe and dangerous H₂S levels. H₂S can be found at 5 ppm, but it is not dangerous for short periods of time. It causes serious irritation to the eyes and lungs at 50 ppm. At 100 ppm, it makes you lose your sense of smell and makes you fall down quickly. A worker can't follow the order "test for poisonous gases" unless they know what measured value means they need to leave.

Comparison with International Best Practices

The Health and Safety Executive (HSE) (2014) in the UK gives a more detailed set of rules for entering a manhole.

(a) Ventilation -- There must be enough mechanical ventilation to keep the oxygen level between 19.5% and 23.5% and the level of dangerous substances below 10% of their lower explosive limit or 50% of their permissible exposure limit, whichever is lower.

(b) Monitoring gas -- Continuous monitoring shall be conducted with audible and visual alarms set at: O₂ <19.5% or >23.5%; H₂S >10 ppm; flammable gas >10% LEL.

(c) Rescue -- Rescue equipment must be able to lift an incapacitated worker out of the confined space within four minutes of the alarm going off.

None of these requirements are in the DSD protocols. It is clear what this means: DSD has the right equipment for safe manhole entry, but it does not have the performance standards that turn equipment into effective controls.

The Communication and Rescue Gap

The two-person team with surface communication and winch rescue is a common way to do things. But there is a big problem with the observed protocol: what does "no response" mean? If a subsurface worker passes out from being around H₂S, they might stop responding right away. But if the surface worker checks every five minutes, the unconscious worker could be exposed for almost five minutes before help arrives. International rules (OSHA, 2023) say that there must be constant communication or checks every two minutes at the most. If contact is lost, rescue must start within four minutes. The DSD documentation does not say anything about either parameter.

The winch system also only works if the unconscious worker stays attached to the lifeline. If the lifeline comes loose, like when the worker takes it off to be more comfortable or move around, the surface worker cannot get them back. There was no requirement for tamper-proof connections or regular checks of connections in the observed document.

The Shoring Inspection Frequency Question

A safety worker must sign off on Form 5 every week for DSD. The Hong Kong Construction Industry Council (2017) recommends daily inspection for active trenches. The difference is big: a trench that was safe on Monday could become unstable by Wednesday because of rain, vibrations from nearby equipment, or the soil around it drying out. Weekly inspections assume that things will stay the same, which may not be the case in Hong Kong's changing weather and construction sites. This shows a possible gap in the rules that needs to be fixed.

Absence of Respiratory Protection

The lack of respiratory protection is the most worrying thing. H₂S is poisonous even in very small amounts. The American Conference of Governmental Industrial Hygienists (ACGIH, 2026) says that the maximum amount of a substance that can be in the air for 8 hours is 1 ppm and for 15 minutes is 5 ppm. Workers can't tell if they are below these limits without measuring the petrol levels. If H₂S levels go over 10 ppm, you need to wear a supplied-

air respirator or a self-contained breathing apparatus (SCBA) (NIOSH, 2016). The lack of this kind of equipment in pictures makes it more likely that DSD workers go into manholes without the right respiratory protection for the H₂S levels that are there.

Recommendations

Based on the identified gaps, the following evidence-based recommendations are proposed.

(a) Quantified Atmospheric Thresholds

DSD should revise all procedural documents to include explicit numerical thresholds:

- Oxygen: You can't go in if the O₂ level is less than 19.5% or more than 23.5%.
- Hydrogen sulphide: If H₂S is more than 10 ppm (TWA) or 15 ppm (15-minute exposure), people must leave; if it is more than 10 ppm, people must wear SCBA.
- Gas that can catch fire: Entry is not allowed if it is more than 10% of the lower explosive limit.

(b) Mandatory Pre-Entry Ventilation Duration

Before any worker goes into a manhole, mechanical ventilation must run for at least 15 minutes, with the air duct no more than 0.5 meters from the bottom of the manhole. There must always be ventilation while the building is occupied.

(c) Communication and Rescue Protocol

Checks for communication between the surface and the subsurface must happen every two minutes or less. If there is no response after two checks in a row, the winch rescue will begin right away. If communication is lost, the rescue must be finished (with the worker on the surface) within four minutes. Before each entry, the connectors on the lifelines must be checked to make sure they cannot be tampered with.

(d) Daily Shoring Inspections

Active manhole work sites will need Form 5 certification every day, not just once a week. The person in charge of the inspection must not be a member of the work crew.

(e) Continuous Gas Monitoring with Alarms

DSD must put continuous gas monitors with alarms that can be heard and seen at all manhole entries, set to the levels above. If the monitor is broken or missing, workers should not enter.

(f) Unannounced Compliance Audits

Labour Department and DSD will do unannounced compliance audits at least once every three months. The results will be published anonymously so that systemic problems can be found without punishing individuals.

CONCLUSION

This paper critically analysed confined space safety protocols for operations within Drainage Services Department manholes in Hong Kong. Based on pictures and a look at the steps taken, the following conclusions can be drawn.

- (a) DSD has correctly identified all major hazard categories and provides equipment to deal with each one. For example, ventilation for atmospheric hazards, shoring for structural hazards, winches for rescue, and barricades for perimeter control.
- (b) But the protocols don't have any specific performance goals. There are no numerical limits for O₂, H₂S, ventilation time, communication intervals, or rescue time in the records that were looked at.
- (c) The lack of respiratory protection in photos and the lack of clear H₂S limits make it very likely that workers are being exposed to this neurotoxic gas.
- (d) Weekly shoring inspections (Form 5) may not be enough for Hong Kong's changing conditions; the international standard is daily inspections.
- (e) Workers can't know when the air becomes dangerous until they start to feel sick, which is often too late, if they don't have continuous gas monitoring with alarms that can be heard.

Implications for Practice

DSD should change its procedures for entering confined spaces right away to include measurable limits that are in line with OSHA, HSE, and NIOSH standards. The changes that need to be made don't cost much. They include changing paperwork, adding alarms to gas monitors that are already in place, and teaching workers how to read numbers. The cost of doing nothing, on the other hand, is the deaths of workers.

Directions for Future Research

The limitations of this paper indicate research requirements. Quantitative field studies that measure the real levels of O₂ and H₂S in DSD manholes before, during, and after ventilation. Rescue time simulations that put winch systems through their paces in real-world situations (unconscious worker weight, awkward positioning, low visibility). Studies of compliance audits that compare the actual frequency of shoring inspections to the frequency that was recorded. Intervention studies examining the efficacy of implementing quantified thresholds and alarms in diminishing H₂S exposure incidents.

Final Statement

Specificity is what makes a safety protocol that works in real life different from one that only exists on paper. Vague instructions like "adequate ventilation", "test for poisonous gases", and "if no response" leave room for interpretation, which makes risk seem lower than it really is. "Ventilate for 15 minutes", "evacuate if H₂S >10 ppm", and "rescue within 4 minutes" are all clear and easy to understand. The Drainage Services Department in Hong Kong has the tools. It now needs clear, enforceable rules that make equipment safe.

REFERENCES

1. American Conference of Governmental Industrial Hygienists (ACGIH). (2026). Guide to Occupational Exposure Values. Cincinnati: ACGIH.
2. Ahmed, W., Yusuf, M., & Khan, M. W. (2023). The Silent Threat Below: A Comprehensive Analysis of Manhole Gases and Health Effects. *Sprinj Journal of Arts, Humanities and Social Sciences*, 2(11), 115-126.
3. Aventaggiato, L., Colucci, A. P., Strisciullo, G., Favalli, F., & Gagliano-Candela, R. (2020). Lethal Hydrogen Sulfide poisoning in open space: An atypical case of asphyxiation of two workers. *Forensic science international*, 308, 110122.
4. Construction Industry Council (CIC). (2017). Guidance notes on trench safety and shoring inspection (CIC Publication No. 2017-04).
5. Doyle, L., McCabe, C., Keogh, B., Brady, A., & McCann, M. (2020). An overview of the qualitative descriptive design within nursing research. *Journal of research in nursing*, 25(5), 443-455.
6. Drainage Services Department (2019). Reporting of Accidents Occurring on Drainage Services Department Works Sites. Drainage Services Department Technical Circular No. 1/2019.
7. Health and Safety Executive (HSE), UK. (2014). Confined spaces: A brief guide to working safely (INDG258 rev4). HSE Books.
8. Kallepalli, S., Johnson, L., & Mattson, B. (2021). Diffusion of Gases into Air: A Simple Small-Scale Laboratory Activity. *Journal of Chemical Education*, 98(10), 3258-3262.
9. Labour Department. (2024). Code of practice for safety and health at work in confined spaces. Hong Kong: Government Printer.
10. Labour Department. (2021). Occupational safety and health statistics 2020–2021. Hong Kong: Government Printer.
11. Labour Department. (2025). Occupational safety and health statistics 2024. Hong Kong: Government Printer.
12. McEwen, B. J. (2018). Strangulation, suffocation, and asphyxia. In *Veterinary Forensic Pathology*, Volume 1 (pp. 129-148). Cham: Springer International Publishing.
13. McManus, T. N., & Haddad, A. N. (2019). Natural ventilation in isolated subsurface structures in the infrastructure: A review. *Environment and Natural Resources Research*, 9(2), 61-74.
14. National Institute for Occupational Safety and Health (NIOSH). (2016). Criteria for a recommended standard: Occupational exposure to hydrogen sulfide (NIOSH Publication No. 2016-118).
15. Occupational Safety and Health Administration (OSHA). (2023). Permit-required confined spaces (29 CFR 1910.146). U.S. Department of Labor.
16. Wang, L., Chen, S., & Zhang, Y. (2018). Ventilation efficiency of flexible air ducts in vertical confined spaces. *Journal of Occupational Safety and Engineering*, 24(3), 215–228.