CONSTRUCTION INDUSTRY COUNCIL
建造業議會

生命第一 LIFE FIRST

REFERENCE MATERIAL ON HOLE MANAGEMENT

www.cic.hk

Version 1
Nov 2022

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Preface

The Construction Industry Council (CIC) is committed to seeking continuous improvement in all aspects of the construction industry in Hong Kong. To achieve this aim, the CIC forms Committees, Task Forces and other forums to review specific areas of work with the intention of producing Alerts, Reference Materials, Guidelines and Codes of Conduct to assist participants in the industry to strive for excellence.

The CIC appreciates that some improvements and practices can be implemented immediately whilst others may take more time for implementation. It is for this reason that four separate categories of publication have been adopted, the purposes of which are as follows:

Alerts	The Alerts are reminders in the form of brief leaflets produced quickly to draw the immediate attention of relevant stakeholders to the need to follow some good practices or to implement some preventive measures in relation to the construction industry.
Reference Materials	The Reference Materials are standards or methodologies generally adopted and regarded by the industry as good practices. The CIC recommends the adoption of the Reference Materials by industry stakeholders where appropriate.
Guidelines	The Guidelines provide information and guidance on particular topics relevant to the construction industry. The CIC expects all industry stakeholders to adopt the recommendations set out in the Guidelines where applicable.
Codes of Conduct	The Codes of Conduct set out the principles that all relevant industry participants should follow. Under the Construction Industry Council (Cap 587), the CIC is tasked to formulate codes of conduct and enforce such codes. The CIC may take necessary actions to ensure compliance with the codes.

If you have read this publication, we encourage you to share your feedback with us. Please take a moment to fill out the Feedback Form attached to this publication in order that we can further enhance it for the benefit of all concerned. With our joint efforts, we believe our construction industry will develop further and will continue to prosper for years to come.

Abbreviations

BIM	Building Information Modelling
DfMA	Design for Manufacture and Assembly
DfS	Design for Safety
LD	Labour Department
MEWP	Mobile Elevating Working Platform
NB-IoT	Narrow Band-Internet of Things
PPE	Personal Protective Equipment
PTW	Permit-to-Work
QR	Quick Response
RFID	Radio Frequency Identification
SWP	Safe Work Procedure
UAS	Unmanned Aircraft Systems
VR	Virtual Reality

1. Introduction

The Construction Industry Council (CIC) is committed to creating a workplace that is safe and healthy, and has been organizing many functions and events to heighten the awareness of workers and the personnel involved in health and safety in the past. The “Life First” campaign was launched recently aiming to (i) raise safety standards on site; (ii) enhance safety awareness of the stakeholders in the construction industry; and (iii) urge them to take up their respective roles and responsibilities to enhance construction safety and "Say No to Danger".

From 2020 to 2021[1] , 5,641 industrial accidents including 41 fatal cases occurred in the construction industry, of which 8% and 37% respectively involved “fall of person from height”. This included cases of “fall of person from hole”.

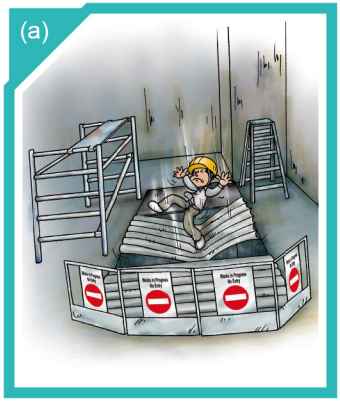
The risks of fall of person from hole arise when workers work near a hole made in a floor slab for erection and installation of service facilities, such as service risers and pipe ducts, etc. This also includes cases when workers work near fragile panel/ceiling void and lift shaft. It is necessary to take steps to manage the risks of fall of person from hole, in order to reduce the number of accidents in the construction industry in Hong Kong.

In this reference material, the need for managing the risks of fall from hole, and the procedures for managing the risks are given. Examples of control measures for fall from hole, and the technology applicable to the hole management, are included. Reference has been made to the Standard and Guidance Report on E&M Service Risers and Pipe Ducts produced by Gammon (2019) in preparing this reference material.

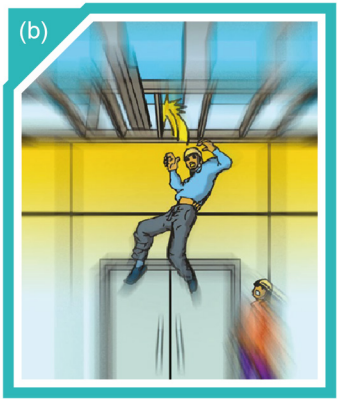
1. https://www.labour.gov.hk/common/osh/pdf/OSH_Statistics_2021_en.pdf

2. Need for Managing Risks of Fall from Hole

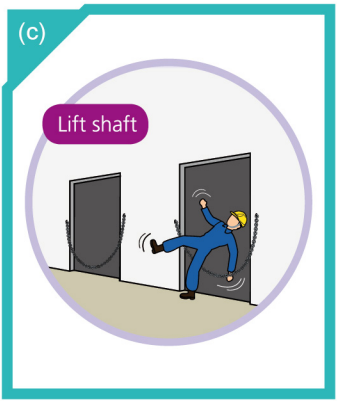
Falling from height is a major cause of death and serious injury in the construction industry in the Hong Kong workplaces. In 2020, there were 216 industrial accidents including 7 fatal cases involving "fall of person from height" in Hong Kong[1]. These numbers also included cases of "fall of person from hole". There are hazards when workers are working at height in different situations. Focus is placed on managing the risks of fall for workers from floor opening, fragile panel / ceiling void and lift shaft in this reference material, as shown in Figure 1.



Fall from floor opening



Fall from fragile panel/ceiling void



Fall from lift shaft

Figure 1 - Typical Height Hazards

As an example, in a fatality case given in LD (2018a)[2] , a worker working near a floor opening in the upper floor plant room inadvertently stepped on the metal sheets covering the floor opening, and fell a vertical distance of 7 m to the floor below when one of the corrugated sheets gave way, as shown in Figure 1(a).

Electrical and air conditioning improvement works were carried out in the plant rooms of a railway substation. An air duct passing through the floor between the upper floor plant room and the lower floor plant room was dismantled. A floor opening of 3 m x 1.8 m was exposed. One piece of metal sheet and two pieces of corrugated sheet were used to cover the floor opening.

The deceased person and his supervisor were working in the lower floor plant room. The deceased person was asked to get a tool from the workers working in the upper floor plant room. The deceased person got the tool from a worker working near the floor opening in the upper floor plant room. He inadvertently stepped on the metal sheets covering the floor opening and fell when one of the corrugated sheets gave way.

The size of the metal sheets and corrugated sheets provided was smaller than that of the floor opening. The sheets were placed over the opening across the shorter side. The sheets were not securely fixed and could be easily displaced. Temporary barriers were erected on the front side of the floor opening, but not on the remaining three sides. No warning notice was posted to indicate the presence of the floor opening.

This accident could have been avoided if the floor opening had been properly covered, the materials used for covering the floor opening had been of adequate size, sound construction and securely fixed in position to prevent displacement, and a warning notice had been prominently displayed in the upper floor plant room to warn workers of the danger of falling through the floor opening.

2. LD (2018a). A Casebook of Occupational Fatalities Related to Renovation & Maintenance Works.

3. Procedures for Managing Risks of Fall From Hole

3.1 Planning of Works

The commitment of the top management and good planning ahead can help minimize the risks of fall from hole.

Prior to commencement of works, a competent person should be appointed to lead and form a team to work out the strategy for the hole management and operations. This competent person could be the Project-in-charge.

The Project-in-charge should lead the project team members, including engineer(s), frontline management, safety officer, safety supervisors, etc., to conduct a task-specific risk assessment to identify all potential hazards associated with the work near holes, taking into account the nature of the work and the working environment.

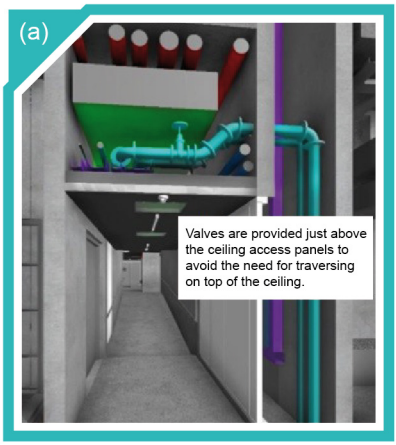
The following circumstances should be considered in the evaluation of risks of works near hole in the assessment:

(a) location and size of holes;
(b) site environment and constraints;
(c) access to the site and holes;
(d) nature of work, and details of the items[3] installed through the hole;
(e) method of hoisting and erection of the items through the hole;
(f) works sequence;
(g) plant / equipment / personnel needed;
(h) activities affecting or affected by the works; and
(i) duration of the works, etc.

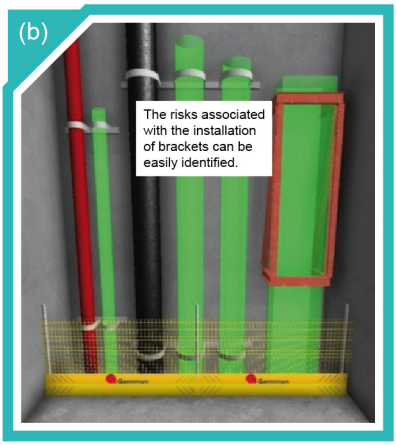
3. These include type of materials, height, size and weight of the items, etc.

Based on the risk assessment, the team should review the works holistically covering the whole sequence of the works involved (e.g. access and movement of plant / equipment to the position for installation, method of hoisting and erection of the components, etc.), and adopting a design for safety[4] (DfS) approach, produce a work plan to eliminate the risks at source, e.g. by eliminating working near the hole, minimizing manual handling and erection work near the hole, etc. For example, a permanent access, and access to services within the E&M service riser for final testing, commissioning, rectification of defects, etc., should be included in the design (Figure 2(a)).

In assessing the design option that is the best suited to eliminate the risks at source, BIM 3D can be used which is able to give a good evaluation of the construction sequence, relationship between working time and space, validation of construction planning, interaction between workers and machineries, safety, etc. (Figure 2(b)).



Provision of easily accessible location for T&C, repair and future maintenance works.

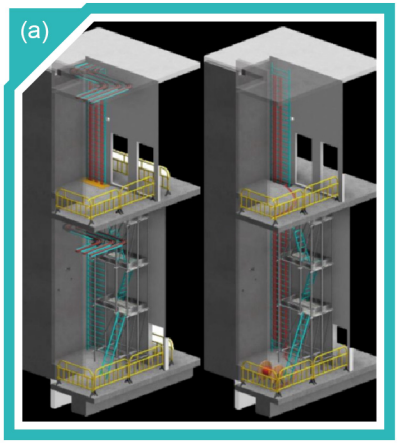


Application of BIM 3D to identify potential safety hazards and plan in advance safety measures required before commencement of works.

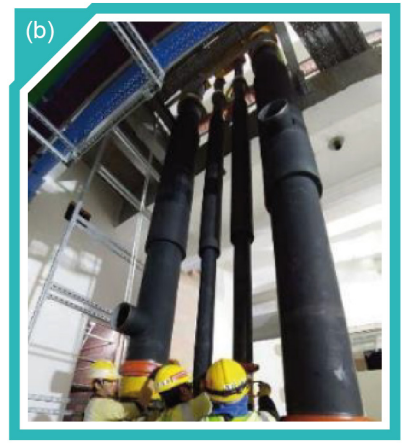
Figure 2 - Elimination of Risks in Planning of Works

4. The principle of "Design for Safety (DfS)" is to bring the consideration of the actual potential hazards and risks to each project to the forefront of a designer's work. Designers can quantify the risk and develop a framework within which design, specification, and planning of project and operation activities can either be used to prevent such hazards materializing or be employed to mitigate their effects. Safe Design is the most effective risk control measure which is achieved by eliminating the hazards at source (after DEVB).

The method of hoisting and erection of the components will have a bearing on the planning of works. For example, if traditional installation method is used, good planning of the arrangement and positions in the use of metal scaffolds, supporting hanger, temporary cover, etc., is needed (Figure 3(a)). On the other hand, if DfMA / modular installation method is used, features, such as edge protection, safe working platforms, etc., can be built into the module design (Figure 3(b)), and the riser module can be installed prior to and independently of the erection of block walls of the riser shaft.



Traditional installation method:
Good planning of the arrangement in the use of metal scaffold and supporting hanger, and the works sequence is needed.



DfMA / modular installation method:
Riser module can be installed prior to and independently of the erection of block walls of the riser shaft; and additional features, e.g. edge protection, safe working platforms, etc., can be built into the module design

Figure 3 - Effect of Installation Method on Planning of Works

If it is not practically reasonable to eliminate the risks at source, then the team should make use of the engineering / administrative control measures to control the risks. Some of control measures used include:

(a) hole cover; guardrail and wire mesh fencing; temporary steel gate / steel door;
(b) temporary means of access for installation;
(c) fall restraint / fall arrest system, etc. when it is impracticable to adopt control measures set out in(a) and (b) above.

A *Hole Management Plan*[5] showing the details described in Items (a) to (i) above should be prepared, as shown in Figure 4. The types of control measures used for each respective hole, installation status of the measures, the persons responsible and their contacts should be included. Appropriate documents, including method statement, a step-by-step sequential procedure, "Hold Point" control procedure, etc. should be prepared. The *Hole Management Plan*, including the installation status of the measures, should be reviewed and updated regularly during operation to account for the changes made. The revised plan and documents should be conveyed to the relevant parties promptly.

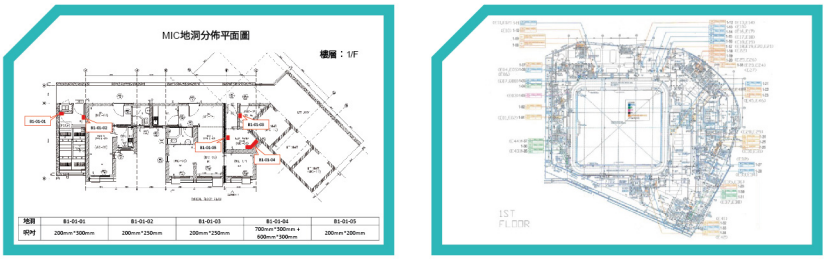


Figure 4 - Hole Management Plan

Other responsibilities of the team during planning of the works include:

(a) provide the workers concerned with the necessary safety information, instruction and training to ensure that they are familiar with the safe working methods and procedures and safety measures;
(b) develop and implement an effective monitoring and control system to ensure that the safety measures are strictly followed;
(c) provide the necessary safety measures (e.g., safety harness, anchor points, independent lifelines, fall arrest systems) on site;
(d) review and revise, if necessary, the safe working methods and procedures with contingency plans to cope with the changing working environment;
(e) investigate incidents arising from the implementation of the hole management requirements and take any necessary preventive / corrective actions following an incident or in the identification of a risk or hazard;
(f) talk with workers to identify safety hazards; and
(g) explore use of the technologies given in Section 5 to help planning and make improvements.

5. TA Hole Management Plan is a holistic plan in which location and size of holes, nature of work, details of the items installed through the hole, control measures used for each respective hole, installation status of the measures, the persons responsible and their contacts, etc., are shown. The plan should be developed during planning of the works, and reviewed regularly during the works to account for the changes made during operation.

3.2 Operation

During operation, the team should review the risk assessment regularly to monitor the effectiveness of the hole management implementation and check if changes to the control measure arrangements are needed in response to changes in the actual site conditions, works sequence, mobilization of plant / equipment for the work, activities affecting or affected by the works, etc. The team should stop the operations if the implementation deviates from that shown in the Hole Management Plan and control documents.

The following actions may be taken after the review: (i) refining the control measures used for the work; (ii) upgrading type of materials for the hole covers / fencing; and (iii) providing more supervision personnel to cover the hole management implementation.

Other responsibilities of the team during operation include:

(a) provide a debriefing to the workers involved to ensure that they understand the process, and the proper use of the safety measures on site;
(b) monitor and check the implementation of the control measures on site;
(c) check that risk owners are assigned to oversee the implementation of control measures;
(d) review and revise installation methods and work processes, and identify hazards in response to the changing working environment; and
(e) check that an effective communication arrangement for giving and receiving instructions among different parties and used by the workers working near holes is in place.

A workflow for managing the risks of fall from hole is given in Appendix A.

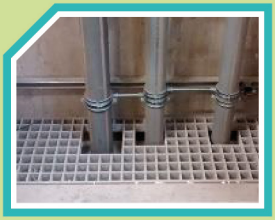
4. Examples of Control Measures for Fall From Hole

Some examples of control measures for fall from hole are given in Figure 5. A checklist of the control measures is given in Appendix B.

Control Measures	Examples of Measures
Providing Hole Covers / fencing to Openings	To prevent fall from holes, covers should be provided. The covers used should be (i) so constructed as to prevent fall of persons, materials and articles; (ii) clearly and boldly marked to show their purposes; and (iii) be securely fixed in position. The type of covers used depends on the size of the opening, as follows: (a) For small size openings (300 mm to 500 mm), metal covers, plywood covers or Bondek decking system are used. The metal covers should be 5 mm thick minimum with stoppers, and the plywood covers should be 18 mm thick minimum plywood boards or planks with stoppers. For the Bondek decking or equivalent proprietary system, the covers should be securely fastened to prevent workers from removing it and falling through the opening. Warning notices should be displayed as an alert to workers in all types of covers provided. (b) For medium size openings (500 mm to 1000 mm), guard-rails[6] or wire mesh fencing with toe-boards is used.

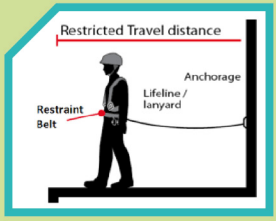
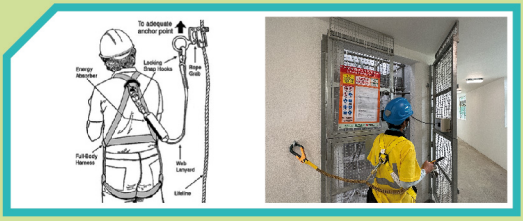
6. For guardrails and infills, the following should be specified:
   (i) top guard rails should be fixed at a height of 900 to 1150 mm;
   (ii) intermediate guard rails should be positioned at a height of 450 to 600 mm;
   (iii) working behind guard-rails shall be prohibited;
   (iv) toe boards should not be less than 200 mm in height; and
   where there is a risk of falling materials and tools, an infill such as brick guards, netting or a proprietary panel system should be used (Note: The use of infill panels is required on all loading towers or platforms where loose materials are stacked).

Control Measures	Examples of Measures
Providing Hole Covers / fencing to Openings	c) For large size openings (larger than 1000 mm) (e.g. lift shaft), temporary steel gate / steel doors are used. The temporary steel gates / steel doors provided should be (i) able to protect fall of person and falling objects; (ii) kept closed at all times (using padlock or other closing mechanisms); and (iii) provided with Warning Notices displayed prominently on the door. When use of temporary steel gates / steel doors is not practicable, a temporary barriers system, such as scaffold tube and fittings and wire mesh fencing can be used to control access. Fiberglass / GRP grating or permanent concrete infill can be used as permanent decking. The fiberglass / GRP grating can be installed easily within mechanical and electrical service riser vents and smoke risers. The following factors should be considered in the selection of decking: (i) rigidity and stiffness; (ii) loading capacity; (iii) electrical conductivity; (iv) anti-slip; (v) adaptation to suit duct / services risers passing through the opening; and (vi) fire resistance requirement.  Metal / plywood cover  Bondek decking

Control Measures	Examples of Measures
Providing Hole Covers / fencing to Openings	 Guardrail  Wire mesh fencing  Temporary steel gate / steel door  Fiberglass / GRP grating  Permanent concrete infill

Control Measures	Examples of Measures
Providing Temporary Means of Access for Installation	The following safe means of access should be provided when work at height is needed: (a) Metal scaffolds. The works sequence and the need for adapting / modifying / partly removing the scaffold during installation should be considered in the scaffold design. The scaffolds used should be reviewed regularly to ensure that the layout is suitable for the installation and they are always accessible. For non-typical scaffolds and scaffolds over 10 m high, advice from a scaffold expert on the scaffold design should be sought. (b) Mobile elevating work platform (MEWP) and access platforms. The use of MEWP are subject to the safe working procedures given in LD (2007)[7]. (c) Podium steps / manual telescopic platform. In case of restricted working space, podium steps / manual telescopic platform and similar equipment are used, following the guidelines given in CIC (2016)[8].  Metal scaffolds  Mobile Elevating Work Platform  Access platform

7. LD (2007). Guidance Notes on Safe Use of Power-operated Elevating Work Platform.
8. CIC (2016). Guidelines on Work-Above-Ground Safety.

Control Measures	Examples of Measures
Providing Temporary Means of Access for Installation	 Step platform  Telescopic platform
Providing Fall Restraint / Fall Arrest System	A fall restraint system is a travel restraint system which restricts the movement of the worker and to prevent him from approaching an unprotected edge on a building or structure. The system consists of a restraint belt or harness that is connected by a lifeline / lanyard to a suitable anchorage point or a static line. A fall arrest system is a system that is designed to stop the fall as it is happening. It includes a full-body harness, energy absorber, lanyard, anchorage points, etc.  Fall restraint system  Fall arrest system

Control Measures	Examples of Measures
Managing work at height	Work should be organised so that there is no inference between work among workers as this may increase risk to themselves or others. For example, tasks should be sequenced so that different trades are not working above or below each other at the same time. The work should be planned so the work is not carried out from a ladder. Overhead works are strictly prohibited. The Permit-to-work (PTW) system can be used when the opening is larger than 1000 mm, e.g. lift shafts. A safety alert system via NB-IoT (Narrow Band-Internet of Things) can be included in the PTW system (see Section 5). This safety alert system will provide a real time alert signal to a central monitoring platform, when there is malpractice and entry of trespassers, leading to a workflow for follow-up action.

Figure 5 - Examples of Control Measures for Fall from Hole

5. Technologies Applicable to Hole Management

Notwithstanding the implementation of control measures set out in Chapter 4, different types of technologies are available to facilitate the hole management. The hierarchy of technological controls is shown in Figure 6.

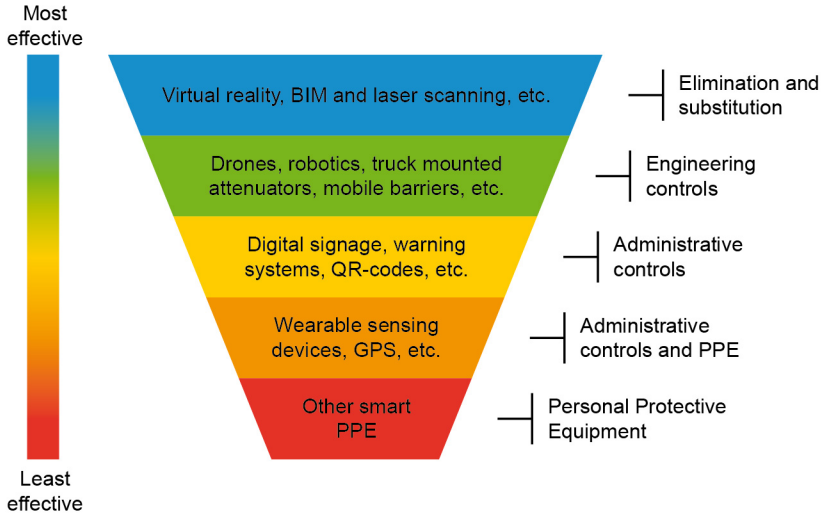
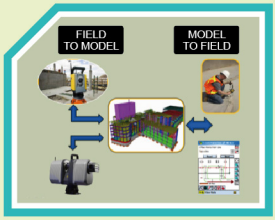


Figure 6 - Hierarchy of Technological Controls (After Karakhan, 2018)

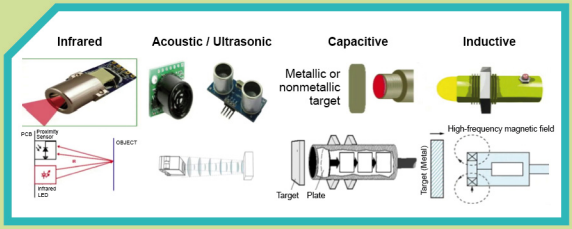
In general, virtual reality (VR), BIM and laser scanning, etc., are the technologies which can be used to eliminate and substitute hazards for person at height or near hole. Drones, robotics, etc., are engineering controls, and digital signage, warning systems, QR-codes, wearable sensing devices, etc., are administrative controls. Details of these technologies are given in Figure 7.

Type of Technologies	Description (with CITF Pre-approved Items)[9]
Virtual Reality (VR)	VR is used to train workers about the dangerous tasks of working near hole. VR training creates realistic workplace experience for interactive learning. Users can experience the consequences of the fall from height accident, which can deepen their understanding on the importance of working at height safety. VR can help the workers to understand dangerous conditions and avoid unsafe acts, thus this can eliminate risks at source. **CITF Pre-approved Items** *- Trimble XR10 with Hololens 2*[10]    VR Immersive Training for Working at Height[11]

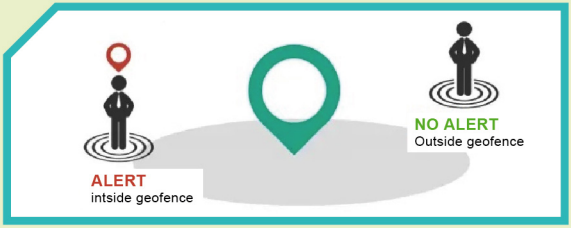
9. https://www.citf.cic.hk/?route=search-key
10. PA20-075. Beijing Tiantuo Tianbao Technology Co., Ltd.
11. https://www.housingauthority.gov.hk/mini-site/site-safety/common/resources/safety-promotion-events/site-safety-seminars/seminar-2020-2/pdf/video-2.pdf

Type of Technologies	Description (with CITF Pre-approved Items)
Building Information Modelling (BIM) and laser scanning	In a scan to BIM process, a laser scanner is used to capture an accurate 3D scan of the real world conditions on a project. The scan data is then imported into a 3D modeling environment to create either accurate as-built models or to inform the design with the real world conditions. It can be used to identify and assess potential hazards involving working at height or near hole safely from afar. It would be useful if this technology is used in the planning stage to identify any potential safety hazards, and based on these, devise suitable safety measures to reduce the hazards before works commence. **CITF Pre-approved Items** - *Trimble Tx5 3D Laser Scanner*[12] - *FARO Focus M70 3D Laser Scanner*[13] - *Topcon GLS-2000 Series Laser Scanner*[14] - *Green Valley International LiBackpack C50 Laser Scanner System*[15] - *UAV-based LiDAR System Z-Lab librid 6*[16]  

12. PA18-003 Yau Lee Construction Co. Ltd / Global Virtual Design and Construction Ltd
13. PA19-020. Sigma Mascot (HK) Limited
14. PA19-032. YSF Corporation Limited
15. PA20-016. A & P Instrument Company Limited
16. PA20-066. South Instruments Technology Limited

Type of Technologies	Description (with CITF Pre-approved Items)
Proximity sensors	Proximity sensors are devices that are used to detect objects nearby, or within a set radius, without physical contact up to a nominal range or sensor vicinity. When an object (either a person or an equipment) enters into the determined range of the sensor, the object will be detected and a signal will be sent to the sensor, warning devices or platforms. Common technologies used for the proximity sensors include infrared, radio frequencies, Bluetooth and specialized lasers. These sensors can be installed near hole or edge, attached to guardrail or post. They will emit signal or alert the person when he is getting close to the dangerous area. **<u>CITF Pre-approved Items</u>** - *WISENMESHNET® System* - *Visual Intelligence Safety Compliance Monitor (VISCMon) system*[17] 

17. PA18-032. VHSoft Technologies Co. Ltd.

Type of Technologies	Description (with CITF Pre-approved Items)
Location geofencing	Geofencing is a location-based service in which an app or other program uses radio frequency identification (RFID), Wi-Fi, GPS, or cellular data to trigger a targeted action (such as a text, email, app notification) when a mobile device or RFID tag enters or exits a virtual geographic boundary, known as a geofence. It can be used to alert workers through apps or wearables that they are about to enter a restricted or hazardous area at work, such as near a hole or an edge of a building, or to prevent unauthorized people from entering a construction site. 
Safety alert system for temporary lift shaft gate[18]	Working in temporary lift shaft is one the high-risk processes in construction site, which involves risks, such as working at height and falling of a person or material. Most of the accidents are caused by unauthorised entry. A safety alert system via NB-IoT (Narrow Band-Internet of Things) has been developed. This safety alert system provides real time alert signals to a central monitoring platform, leading to a workflow for follow-up action. It can enhance the implementaion of the permit-to-work procedures of lift shaft, improve the efficiency and effectiveness of lift shaft control, as well as avoiding malpractice and entry of trespassers.

18. https://www.citf.cic.hk/?route=pre-approved-detail&id=71

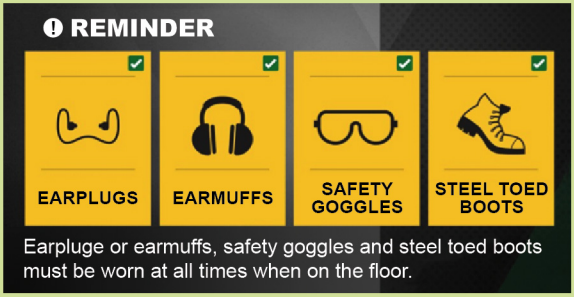
Type of Technologies	Description (with CITF Pre-approved Items)
Safety alert system for temporary lift shaft gate	**CITF Pre-approved Items** - *SmartWorks – Safety Alert System for Temporary Lift Shaft Gate*[19]  Four leaf of lift shaft gates are installed as an esstential safety measure for lift shaft  NB-IoT senor is installed on the inner side of the door   When there is unauthorised opening of the gate, it will be detected by the NB-IoT sensor and a alert signal will be sent to the control office and officer-in-charge for immediate follow-up action.

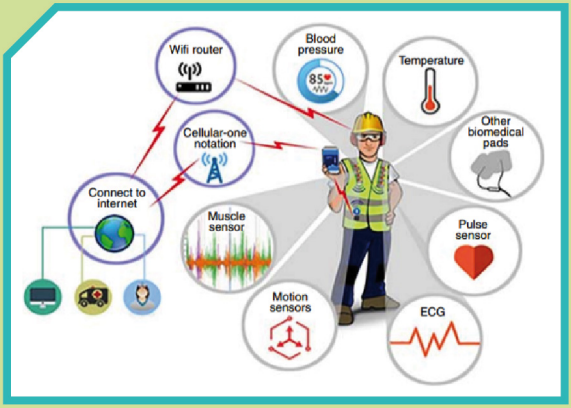
19. PA20-033. SmarTone Mobile Communications Limited

Type of Technologies	Description (with CITF Pre-approved Items)
RFID lift shaft control system	The system is used in lift shaft works. It can be used in conjuction with the permit-to-work procedure and provides a real time monitoring of worker inside the lift shaft, lift shaft-in and shaft-out record summary, etc. When an unauthorised worker gets in the lift shaft, the RFID will send a signal to trigger an alert. 
FallGuard and G-Eye	This is an IoT device provided with a chargeable battery powered mobile CCTV with AI computer vision, which is installed for active monitoring of the activies near the hole. **<u>CITF Pre-approved Items</u>** *- A.I. Surveillance System for Construction Site Safety*[20]  

20. PA22-005. iSafety Limited

Type of Technologies	Description (with CITF Pre-approved Items)
FallGuard and Digital G	An IoT sensor is attached to a hole cover. When the cover is flipped up by more than 30°, the status on the dashboard will change. The sensor has a 7-year battery life. It has no SIM card, no gateway, and is a simply plug-and-play device. It is reusable. On the dashboard, project details, locations of temporary hole covers and alert history will be provided. The alert system can be transferred via Whatsapp / SMS / Telegram.     

Type of Technologies	Description (with CITF Pre-approved Items)
Digital safety signage	It is an effective method to warn workers of potential workplace hazards and remind them of the necessary safety protection and precautions required in order to perform a task safely. The signage can be placed close to a hole or an edge area to alert workers of the hazards working in the areas. 
Mobile phone app for permit-to-work and in / out record system for lift shaft work	This mobile app provides an efficient and effective means for giving approval and checking of the permit-to-work system. It also provides the workers' information to supervisor / authorised persons for verification of the approvered workers working in the lift shaft.  

Type of Technologies	Description (with CITF Pre-approved Items)
Wearable sensing devices[21]	Wearable sensing devices can perform biometric screening on the worker's physical characteristics (e.g., body temperature, heart rate, respiration, repetitive motion, fatigue management, etc.) and send real-time data to safety supervisors on site for monitoring. The devices utilize oxygen and temperature sensors to alert workers of unsafe air quality or temperature conditions that could cause injuries. The devices can be embedded in PPE like hard hats and help prevent workers from entering hazardous areas, like areas near a hole or edges, or getting too close to an equipment. The devices can also be used to monitor lone workers, prevent collisions with machines and help to find all employees faster in an emergency. They can also help prevent or reduce health risks from too long an exposure to high temperatures during hot work. 

21. https://www.chubb.com/us-en/businesses/resources/4-technologies-to-improve-workplace-safety.html

Type of Technologies	Description (with CITF Pre-approved Items)
Wearable sensing devices	**CITF Pre-approved Items** - *Automated IoT Construction Monitoring Devices and Monitoring System*[22] - *Construction Stage Tunnel Access Control System (TACS)*[23] - *UtterBerry*[24] - *Dasloop IoT Smart Helmet with Cloud Based Management Platform*[25] - *iSmartBuild Real-time Monitoring System*[26] - *Artificial Intelligence Computer Vision Cloud viAct*[27] - *InfoSMART™ Attend – Real Time Manpower Attendance in-site Record System*[28] - *BLAXTAIR Pedestrian / Machinery Anti-collision Camera*[29] - *SmartWorks*[30] - *Ultra-wide Band Wireless Positioning Safety System*[31] - *BLE Material & Attendance Tracker*[32] - *EverHigh Precise Positioning & Safety Management System*[33] - *Karta-X_KACSA v2.0 AI Assisted Construction Safety Analytic (KACSA)*[34] - *LumiCon End-to-End IoT Solutions for Smart Construction Sites*[35] - *Heat Shielding Reflective Vest with Nano Coating Technology*[36] - *Focuslite Ear-Defender*[37]

Figure 7 - Technologies Applicable to Hole Management

22. PA19-004. LR Construction Technologies Ltd.
23. PA18-007. ATAL Technologies Limited.
24. PA19-013. Utter Berry.
25. PA19-031. Beeinventor Limited.
26. PA19-044. Novox Limited.
27. PA19-045. Customindz Limited.
28. PA19-047. Infotronic Technology Ltd.
29. PA20-020. EBSL.
30. PA20-025. SmarTone Mobile Communications Limited.
31. PA20-032. Transcendence Company Limited.
32. PA20-085. Hornbird Technology Limited.
33. PA20-116. XenseTech Limited.
34. PA20-119. Karta-X Technologies Limited.
35. PA20-126. AOMS Technologies
36. PA20-052. Houston Environmental Materials Co. Limited.
37. PA21-038. Digital G Limited.

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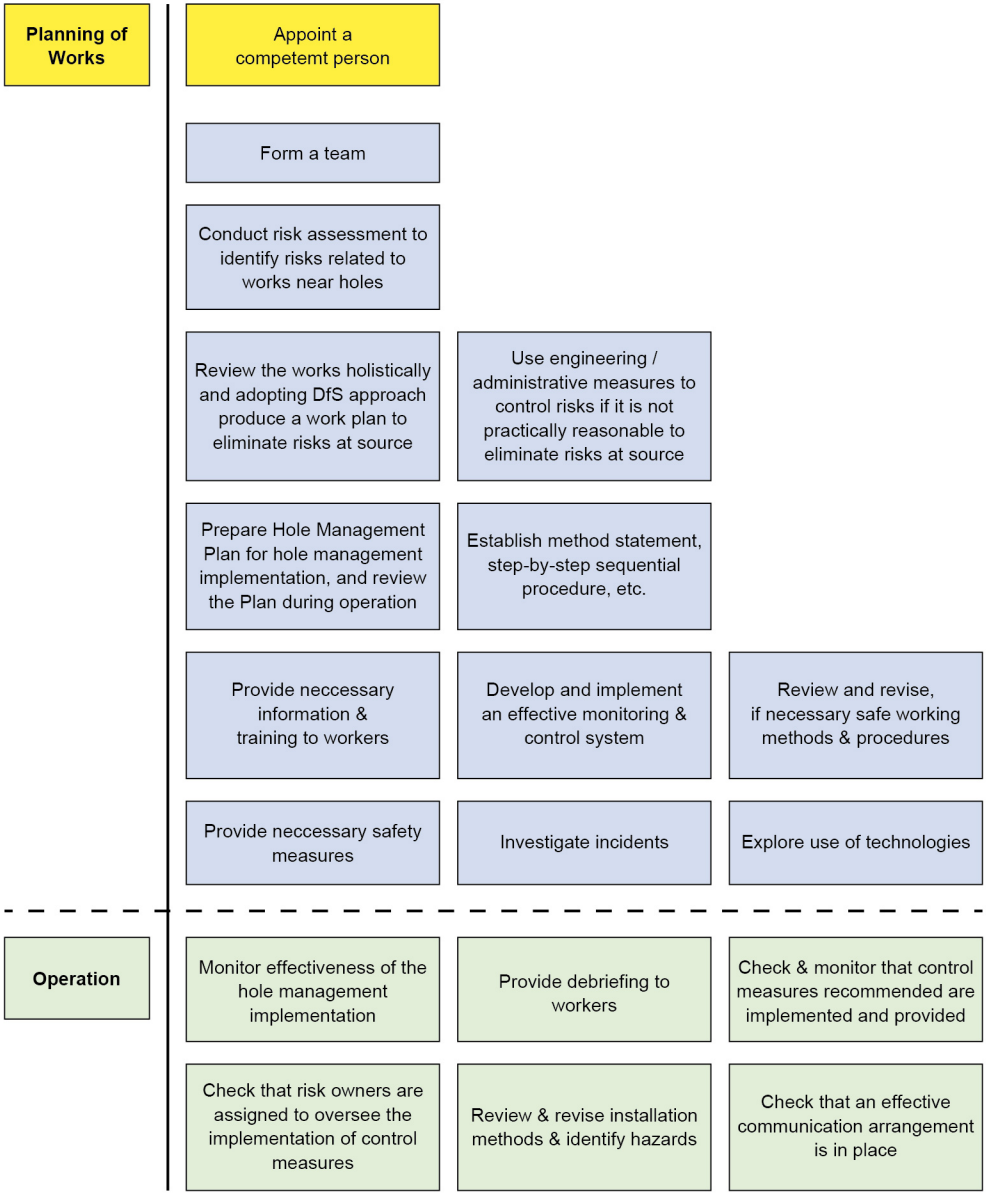
Appendix A – Workflow for Managing Risks of Fall From Hole



Appendix B – Checklist of Control Measures for Fall From Hole

Items	Good	Needs Improvements	Needs Immediate Improvements
A. General			
1. Is a team formed for the hole management?			
2. Is a risk assessment carried out?			
3. Is the DfS approach adopted to produce a work plan to eliminate the risks at source in the planning of works?			
4. Are safe working methods and procedures formulated?			
5. Are the necessary safety measures provided?			
6. Is a Hole Management Plan up to the requirements prepared?			
7. Are safety information and training provided to workers?			
8. Is an effective monitoring and control system developed and implemented?			
9. Are the workers debriefed of the process and the proper use of safety measures on site?			
10. Are the safety systems on site monitored and checked?			
11. Are risk owners assigned to oversee the hole management implementation?			
12. Are the work processes checked?			
13. Is an effective communication arrangement among different parties on site in place?			

Items	Good	Needs Improvements	Needs Immediate Improvements
B. Fall Prevention Devices			
B.1 Guardrails and toe-boards			
1. Are all floor edges, staircase edges, lift shafts or other dangerous places, at a height of not less than 2 m, equipped with suitable guard rails and toe boards?			
2. Are guard rails of adequate strength provided and fixed tightly on secure floor slabs to prevent people from falling?			
3. Are the guard rails inspected regularly by a competent person?			
B.2 Hole covers			
1. Are all holes and other dangerous places provided with covers of a suitable structure which are fixed tightly at correct places?			
2. Are covers marked with bold characters to clearly indicate their use?			
3. Are covers used to guard / cover all floor holes with apertures greater than 50 mm?			
4. Are covers clearly marked with bilingual signs stating "Hole below"?			
B.3 Scaffolds			
1. Are scaffolds inspected before first use and then at regular intervals not exceeding 14 days immediately preceding each use by a competent person?			
2. Are scaffolds inspected by a competent person following their exposure to adverse weather conditions?			
B.4 Working platforms			
1. Are the working platforms inspected before first use and then at regular intervals not exceeding 14 days immediately preceding each use by a competent person?			

Items	Good	Needs Improvements	Needs Immediate Improvements
B.5 Lift Gates			
1. Are lift gates locked at all times when access is not required?			
2. Are lift gates self-closing?			
3. Are lift gates readily openable, at any time, from inside the lift shaft without the need of a key?			
4. Is the lift shaft opening fully covered by the 4-leaf gates?			
5. Is the maximum mesh aperture less than 5 mm?			
B.6 Fragile Roof			
1. Are all fragile surfaces clearly identified in the workplace, such as asbestos cement sheets, plastic sheets, corroded metal sheets, glass, wood, wool slabs and skylights, and appropriate warning notices fixed at the access points to all such areas?			
2. Are workers informed of the location of all fragile/ brittle roofing material?			
3. Is a suitably located safe working platform provided?			
4. Are warning signs securely fixed in a prominent position clearly visible to persons accessing the working area?			
5. Is a safe access to such work areas provided?			
6. Is a safe access to workplaces, such as canopies and the tops of covered walkways been provided via (i) permanent staircases; (ii) temporary working platforms with internal stairs; (iii) walkways / passageways complete with suitable guard rails?			

Items	Good	Needs Improvements	Needs Immediate Improvements
C. Work Positioning System / Fall Restraint System			
1. Where it is not practicable to provide a safe working platform, is there any provision of suitable safety belts or similar equipment to prevent people from falling and getting injured?			
2. If safety harnesses are being used, is there any provision of proper anchor points, such as independent lifelines and suitable equipment that are able to provide continuous protection against people falling from height?			
3. Are safety harnesses kept under proper maintenance?			
4. Are safety harnesses inspected regularly by a competent person?			
5. Are all independent lifelines and anchor points examined and accepted by a registered professional engineer?			
D. Fall Arrest System			
1. Are safety harnesses inspected regularly by a competent person?			
2. Is training provided to workers on the correct use of fall arrest systems? Are proper records kept of such training?			
3. Is there a minimum clear distance of 5 m below the anchor point for anchor points fixed above workers?			
4. Are safety-harness anchorage points designed to withstand the forces of a person falling from the platform?			
5. Are workers' safety harnesses attached securely to the fall arrest systems of independent lifelines?			

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