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<td>Wong, Ka Man Kaman (黃嘉雯)</td>
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THE DEVELOPMENT OF MOBILE APP (i-Safe) FOR SAFETY AND RISK ASSESSMENT IN CIVIL & BUILDING CONSTRUCTION SITE

By

Ka Man Kaman WONG

Submitted in partial fulfillment of the requirements for
the degree of Bachelor Engineering (Honours) in
Building Engineering (Construction Engineering and Management)

Department of Civil and Architectural Engineering
City University of Hong Kong

March 2013
DECLARATION

I declare that this final year project entitled The Development of Mobile App (i-Safe) for Safety and Risk Assessment in Civil & Building Construction Site, represent my own work, except where due acknowledgement is made, and that is has not been previously included in a thesis, dissertation or report submitted to this University or other institution for a degree, diploma or other qualification.

Signature____________________

Ka Man Kaman Wong
Title: The Development of Mobile App (i-Safe) for Safety and Risk Assessment in Civil & Building Construction Site

Name: Wong Ka Man

Submission Year: March 2013

Abstract

Occupational Safety and Health at work has long been an important concern in construction’s industry. As Hong Kong has adopted a self-regulatory approach on the requirement of the proprietors including contractors to develop, implement and maintain the Safety Management Systems in construction’s industry, the accident rate has been decreasing but number still remain in high level. Worse still, the fatality rate does not show the trend of decrease.

Since the safety professionals are the key decision makers dealing with project safety and risk assessment in the civil & construction industry, their perceptions of safety risk would directly affect the reliability of risk assessment. In this study, the qualitative analysis on the safety professionals’ beliefs of risk assessment and their perceptions towards risk assessment will be explored. Additionally, the current paper-based site inspection is accompanied by ineffectiveness and inefficiency. Based on the above problems, the purpose of this research is to develop safety app which is based on the occurrence of various potential risks for different scope/trade of construction project so as to minimize the accident and fatality rate in the industry. In order to achieve the aim mentioned before, a mobile app “i-Safe” would be developed, and then the survey would be conducted so as to collect feedback about i-Safe.

In this paper, the construction accident rates including injuries and fatalities, study of the site inspection and risk assessment elements in safety management system, the ineffectiveness of traditional site inspection and risk assessment and the current mobile apps in construction safety field are reviewed.

Besides, the incorporation of site inspection and risk assessment elements in safety management system onto the Mobile Apps would be developed so that it can be used by Safety Officer or other safety
professionals for building or civil construction site. The user manual of this Mobile App ‘i-Safe’ is attached to this paper for reader perusal.

It is hoped that all the work done of this paper and i-Safe could be beneficial to, or having specific insights to the worldwide construction industry and of great value to improvements for future projects.
Acknowledgements

I would like to this rare opportunity to express my sincere gratitude to my Final Year Project supervisor, Dr. Ivan Fung, Vice-Chairman of The Institute of Safety and Health Practitioners and Lecturer of Department of Civil and Architectural Engineering at City University of Hong Kong, for his valuable guidance and support throughout the whole progress of this project.

Moreover, I would like to express my special thanks to all below professionals who have provided earnest assistants and dedicated their precious time by providing information and opinions during interview so the final year project can complete successfully. Lastly, I give thanks to my partners- Luk Ka Ying, as she is responsible for the safety auditor part in i-Safe, the whole app would not be developed without her part.

Mr. Eddie Lau The Project Manager of Gammon Construction Ltd.
Mrs. Dreams Tsang The Safety Director of Construction Safety & Engineering Consultants Ltd.
Mr. S.K. Lam The Safety Manager of Gammon Construction Ltd.
Mr. Leo Wong The Senior Safety Officer of Gammon Construction Ltd.
Mr. Ben Yu The Safety Supervisor of China State Construction Engineering (HK) Ltd.
Mr. Ken Fong The Apps Programmer
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Chapter 1

Introduction

1.1 Background Information

In 13th September 2009, an elevator containing six workers fell straightly from 30th floor to 8th floor in International Commerce Centre, causing all six people dead. This industrial accident was astonishing to the whole construction sector. Unfortunately, construction tragedies do not seem to decrease and this happens in Hong Kong every day.

In 1995, the government implemented Occupational Safety and Health Ordinance and Occupational Safety and Health Council but the enforcement of this legislation does not contribute great improvement in safety records. By 1998, the total number of accident is 19,588 which are the highest among last decade (Labour Department, SAR, 2007). This figure arouses concern remarkably and highly unacceptable.

In 1999, the Legislative Council approved the Factories and Industrial Undertakings Regulation (FIUO). This regulation requires the proprietors of the company to develop, implement and maintain a Safety Management System (SMS). Although the safety records show an improvement in the recent years and it is reflected in the construction accident statistics as published by the Labour Department (2012), however, the high-risk construction industry remains still recorded the highest number of fatalities and accident rate among various industry sectors.

As shown in the Table 1 & Figure 1, the number of the industrial accidents generally decreases form 2002 to 2011. At the recent years, there were 3,112 construction industrial accidents in 2011 which is slightly higher than 2,884 in 2010, and higher than the average of the past five years (2,965) by 5%. Nevertheless, from the above figure, the occupational safety performance in Hong Kong in the past decade has been improved steadily.

The construction industrial accident rate per 1,000 workers in 2010 dropped from 52.1 to 49.7 in 2012. What’s more, The accident rate per 1,000 workers in 2011 lower than the average of the past five years (55.7) by 10.7%.
Industrial Accidents in Construction Industry (2002 - 2011)

<table>
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<tr>
<th>Year</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
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<tbody>
<tr>
<td>No. of Accidents</td>
<td>6,239</td>
<td>4,367</td>
<td>3,033</td>
<td>3,548</td>
<td>3,400</td>
<td>3,042</td>
<td>3,033</td>
<td>2,755</td>
<td>2,884</td>
<td>3,112</td>
</tr>
<tr>
<td>No. of Fatalities</td>
<td>24</td>
<td>25</td>
<td>17</td>
<td>25</td>
<td>16</td>
<td>19</td>
<td>20</td>
<td>19</td>
<td>9</td>
<td>23</td>
</tr>
<tr>
<td>Employment Size</td>
<td>73,223</td>
<td>64,112</td>
<td>63,520</td>
<td>59,266</td>
<td>52,865</td>
<td>50,185</td>
<td>49,422</td>
<td>50,501</td>
<td>55,341</td>
<td>62,635</td>
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<tr>
<td>Acc. rate/1,000 Workers</td>
<td>85.2</td>
<td>68.1</td>
<td>60.3</td>
<td>59.9</td>
<td>64.3</td>
<td>60.6</td>
<td>61.4</td>
<td>54.6</td>
<td>52.1</td>
<td>49.7</td>
</tr>
<tr>
<td>Fatality rate/1,000 Workers</td>
<td>0.328</td>
<td>0.390</td>
<td>0.268</td>
<td>0.422</td>
<td>0.303</td>
<td>0.379</td>
<td>0.405</td>
<td>0.376</td>
<td>0.163</td>
<td>0.367</td>
</tr>
</tbody>
</table>

Table 1: 10-year trend of Accident Statistics (1993 – 2002) in Hong Kong construction industry
(Source: Occupational Safety and Health Statistics, August 2012)

Figure 1: Number of Industrial accidents and Accident Rate per 1,000 workers in construction industry
(Source: Occupational Safety and Health Statistics, August 2012)
From the Figure 2, the number of industrial fatalities and fatality rate per 1,000 workers are fluctuated in the past decade. In 2011, the number of industrial fatalities was 23 which is higher than 9 in 2011, and higher than the average of the past five years (18) by 27.8%.

The industrial fatality rate per 1,000 works in 2011 was 0.367 which is higher than 0.163 in 2010, and higher that the average of the past five years by (0.338) 8.7%.

![Number of Industrial Fatalities and Fatality Rate per 1,000 workers in Construction Industry 2002 to 2011](image)

*Figure 2: Number of Industrial Fatalities and Fatality Rate per 1,000 workers in construction industry (Source: Occupational Safety and Health Statistics, August 2012)*

Although the government makes every effort on promoting safety and health awareness and enforcement of legislation of safety in the construction sector, it cannot achieve great successful.

Because of the complex nature of the construction project, there are many factors affect the site safety. There has been much research showing the relationship between safety performance and multi-layered of sub-contracting, top management involvement, safety awards campaigns, incentive schemes, safety training and post-accident investigation (Tam and Fung, 1998). However, few researches focused on the effectiveness of site inspection and risk assessment for construction industry in Hong Kong.

Accurate and prompt field information can support efficient and effective management of construction projects (Taneja et al., 2011). Nowadays, with the advancement and innovation of smart phones, tablets and other electrical products like iPod touch and mini-iPad, the mobile applications are becoming more
and more popular. The mobile applications not only can entertain the phone users but also help a lot in different aspects – Education, Health, Entertainment and Social Network…etc. Thus, the advantages of this technology can be applied onto the construction safety especially in site inspection which is the most common, direct and best ways to identify safety problems and risk assessment which is very important practice to assess the hazards and risk before accident occur.

This project is an effort to complement the traditional paper based safety inspection process with an affordable electronic based inspection to increase ease communication, ease record maintenance, and reduce inspection time. Apart from development of e-Inspection tool, this project is also complement the conventional risk assessment process with built-in information and tools in the application to increase accuracy in identifying hazards.
1.2 Problem Statement

Because of the uniqueness, rapid growth, and dynamic nature of the construction site, it is the extremely complicated industry compared with the other industries. And every day construction site deals with lots of activities which surround with different hazards.

Site Inspection is an excellent way to prevent accidents from occurring and to safeguard employees (Christopher, Herbert, Gordon, and Douglas, 2001). Inspection is an essential element of a safety management system which is required for proactive day-to-day monitoring in order to ensure the hazards and risks exposed by the workers are under control and minimized to as low as reasonably practicable. Therefore, safety inspection is the most common practice to access the health and safety in the construction.

Nevertheless, the traditional inspection may cause lots of problems and it is inefficient and ineffective. First of all, the registered S.O. has to memorize a myriad of things, for instance, company policy, in-house safety rules, relevant Ordinances and Regulations, Safety Standards, Codes of Practice, Guidance Notes and Guidelines. It is not common for him forgets to inspect some items in such a complex construction site and it is not possible for him to bring bulky paper information when inspect the site. Moreover, the multiple recording of same inspection results on spreadsheets and camera is time consuming and cause confusion. Additionally, the typos and arbitrary descriptions for safety violations usually appear in the handwriting notes and it is very time consuming to input the information into the computer.

Progressive safety improvement is subject to a systematic vision of man-machine-workplace interactions and risks assessment becomes one of the most critical tasks in safety management (Giulio et al., 1998). McGuinness (1995) mentioned that accident rate is an indicator for the effectiveness of the risk assessment. Therefore, risk assessment is an essential practice to identify the hazards exposed by the workers in such a complex and busy construction site.

However, many safety professional heavily rely on their own experience and knowledge to do the risk assessment. Usually, they just rely on what they remember hearing or observing about the risk when there is no relevant information or statistic evidence on hand, making the poor accuracy of the risk assessment. To make the risk assessment more reliable, the safety professionals who are the key decision makers to carry out risk assessment have to investigate the possible causes for the accidents through conducting detailed accident reports and reviewing past accident related statistics.
1.3 Project Objectives

Both site inspection and risk assessment are essential elements of a safety management system and are implemented by the contractors compulsory. Site inspection is required for proactive day-to-day monitoring in order to ensure the hazards and risks exposed by the workers are under control and minimized to as low as reasonably practicable, whereas risk assessment is a process to estimate the magnitude of risk and decide whether the risk is tolerable. This project objective is to create an efficient and effective tool kit to minimize the accident and fatality rate in the construction industry.

This research aims as followed:

- Objective 1: To study the safety management system, safety inspection and risk assessment in the construction industry

- Objective 2: To study the general practice of traditional site inspection and risk assessment in construction industry

- Objective 3: To study the current mobile applications in construction safety

- Objective 4: To identify the user and app requirements

- Objective 5: To develop the e-inspection and risk assessment tool as Mobile App (i-Safe) for construction safety

- Objective 6: To test the developed the safety app (i-Safe) with different fields of safety professionals by interview and questionnaire survey.
1.4 Structure of the Study

In order to have better development and let the reader to have better understanding of this paper, the paper is divided into 10 chapters. The details of each chapter would be described below:

Chapter 1- Introduction

Chapter 2- Literature Review

Chapter 3- App Development Methodology

Chapter 4- Determination of User Requirements

Chapter 5- Determination of App Requirements

Chapter 6- i-Safe Design and Development

Chapter 7- Operation of i-Safe

Chapter 8- Evaluation of i-Safe

Chapter 9- Discussion

Chapter 10- Recommendation and Further Development
1.5 Project Progress

To have better management of the progress of works, a time schedule of this project is shown in the following table:

<table>
<thead>
<tr>
<th>Activity</th>
<th>2012</th>
<th></th>
<th></th>
<th>2013</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sep</td>
<td>Oct</td>
<td>Nov</td>
<td>Dec</td>
<td>Jan</td>
<td>Feb</td>
</tr>
<tr>
<td>Background Study &amp; Literature Review</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>User Interface Design</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meeting with Programmer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Development of Application (i-Safe)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collection of Feedback</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final Year Project Preparation and Submission</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Table 2: Time schedule of Final Year Project*
Chapter 2

Literature Review

2.1 Safety Management System

Kirwan (1998) said SMS is the system is considered as the set of integrated mechanisms in the organization, comprising policies, strategies, and procedures designed to control the risks that may affect employees’ health and safety.

According to the Labour Department (2002), Safety Management System is “a system which provides safety management in an industrial undertaking”. Refer to the Code of Practice on Safety Management published by the Occupational Safety and Health Branch, Labour Department, “safety management” means the management functions connected with the carrying on of an industrial undertaking that relate to the safety of personnel in the undertaking, including planning, developing, organizing and implementing of a safety policy and the measuring, auditing or reviewing of the performance of those functions.

2.1.1 Objectives of Safety Management System

Jeremy (1994) pointed the aim of SMS. It is focused on the prevention of accidents, ill-health and other forms of incident which result in loss to an organization. Hoit (2001) gave a more detailed explanation on its practical objectives, they are:

1. To gain support from all concerned for the health and safety effort
2. To motivate, educate and train the construction site workers
3. To achieving hazard and risk control by designing and purchasing policies
4. To ensure that the hazard control principles form part of supervisory training
5. To devise and introduce controls based on risk assessments

2.1.2 Key elements of Safety Management System

In the past, the Hong Kong government’s attitude towards construction safety was basing on enforcement of safety ordinances. The Labour Department is the watchdog, sending factory inspectors to carry out random checks. (Tam and Fung, 1998). The government bodies like Labour Department, Housing
Authority, Buildings Department and the Occupational Safety and Health Council have introduced some relevant ordinance, regulations, codes of practices and guidelines for the construction industry to follow, but they mainly focus on the law enforcing approach. A strategic transition has occurred. In July 1995, the Hong Kong government started to implement a new safety strategy encouraging employers and employees to manage safety on a self-regulatory manner. Against this background, the government has introduced a safety management system consisting 14 elements and this system is now enshrined in the Factories and Industrial Undertakings (Safety Management) Regulation passed on November 1999. The 14 key elements of SMS are shown as follow:

<table>
<thead>
<tr>
<th>Part 1</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Key elements</strong></td>
<td><strong>Description</strong></td>
</tr>
<tr>
<td>1. Safety Policy</td>
<td>Stating the commitment of the proprietor or contractor to safety and health at work</td>
</tr>
<tr>
<td>2. Safety Organization</td>
<td>Assuring implementation of the commitment to safety and health at work</td>
</tr>
<tr>
<td>3. Safety Training</td>
<td>Equipping personnel with knowledge to work safely and without risk to health</td>
</tr>
<tr>
<td>4. In-house Safety Rules</td>
<td>Providing instruction for achieving safety management objectives</td>
</tr>
<tr>
<td>5. Inspection Programme</td>
<td>Identifying hazardous conditions and for the rectification of any such conditions at regular intervals or as appropriate</td>
</tr>
<tr>
<td>6. Hazardous Control Programme</td>
<td>Identifying hazardous exposure or the risk of such exposure to the workers and providing suitable personnel protective equipment as a last resort where engineering control methods are not feasible</td>
</tr>
<tr>
<td>7. Accident/Incident Investigation</td>
<td>Finding out the cause of any accident or incident and developing prompt arrangements to prevent recurrence</td>
</tr>
<tr>
<td>8. Emergency Preparedness</td>
<td>Developing, communication and executing plans prescribing the effective management of emergency situations</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Part 2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Key Elements</strong></td>
<td><strong>Descriptions</strong></td>
</tr>
<tr>
<td>9. Evaluation, Selection and Control of Sub-contractors</td>
<td>Ensuring that sub-contractors are fully aware of their safety obligations and are in fact meeting them</td>
</tr>
<tr>
<td>10. Safety Committees</td>
<td>Identifying, recommending and keeping under review measures to improve the safety and health at work</td>
</tr>
</tbody>
</table>
Table 3: The 14 elements in SMS on Ch. 59(A) Factories and Industrial Undertaking (Safety Management) Regulation (Source: Bilingual Laws Information System, 2006)

2.1.3 Summary

Although construction industry is monitored under SMS on FIUO of Hong Kong statutory requirement, the high-risk construction industry still recorded the highest number of fatalities and accident rate among various industry sectors. Given to the complex nature of construction project compared with other industries, many contractors find SMS was quite difficult to perform. Langford (2000) stated that “there must be an effective tool to implement the SMS”. Also, Rowlinson (2003) pointed out that “such safety management tools should be implemented on site easily in order to analyze poor performance and promote better performance.” The Development of Mobile App (i-Safe) for Safety and Risk Assessment in Civil & Building Construction Site is one of these tools.
2.2 Review of Safety Inspection

Safety inspection is to conduct site inspection to identify hazardous conditions and for the rectification of any such conditions at regular intervals or as appropriate. It is the most effective means of identifying hazardous conditions in construction site. Andrew (2003) said that “Site Safety Inspections provide the Client with details on the physical state of a site or working environment with the view to identify and rectify any unsafe Conditions.” The person who carried out the safety inspection should have appropriate safety training and experience so that they are competent to identify the relevant hazards and evaluate the associated risks. Checklists, relevant to the site, are normally used to ensure a systematic approach to an inspection and reference legislative requirements.

2.2.1 Objectives of Safety Inspection

Pursuant to the CDP on Safety Management, the goals of safety inspection are to identify potential problems that are not anticipated during the design or planning stage; to identify equipment deficiencies, and abuse or misuse of equipment; to identify improper worker actions, malpractices; to identify changes in processes or materials which may have adverse effect on the safety and health of workers; to identify inadequacies in remedial actions; to provide management with information to assess the organization’s own safety and health performance; and to demonstrate management commitment. From the another point of view, the main outcome of safety inspection is that hazards identified in the workplace are controlled, corrected and eliminated by the effective management using appropriate control measures.

Martin and Walter (2001) mentioned that there are two reasons for conducting safety and health inspections, the first one is to detect potential hazards so that they can be corrected before an accident occur and the second one is to utilize the information collected as a basis for improving.

2.2.2 Requirements of Safety Inspection

The properly safety inspection should include a well-designed inspection form to help plan and initiate remedial action by requiring those doing the inspection to rank any deficiencies in order of importance; summary lists of remedial action with names and deadlines to track the progress on implementing improvements; periodic analysis of inspection forms to identify common features or trends which might reveal underlying weaknesses in the system and information to aid judgments about changes required in the frequency or nature of the inspection programme.
### 2.2.3 Scope of Safety Inspection

As the construction site is very sophisticated, the safety inspector has to inspect lots of things in daily, weekly and monthly. According to Johnson (2012), the scope of the safety inspection should include the following:

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials Handling and Storage</td>
<td>Equipment, job planning, layout, heights, floor loads, projection of materials, materials handling and storage methods, training for material handling equipment</td>
</tr>
<tr>
<td>Building and Grounds Conditions</td>
<td>Floors, walls, ceilings, exits, stairs, walkways, ramps, platforms, drive-ways and aisles</td>
</tr>
<tr>
<td>Housekeeping</td>
<td>Waste disposal, tools, object, materials, leakage, and spillage, cleaning methods, schedules, work areas, remote areas, and storage areas</td>
</tr>
<tr>
<td>Electricity</td>
<td>Equipment, switches, breakers, fuses, switches-boxes, junctions, special fixtures, circuits, insulation, extensions, tools, motors, and grounding</td>
</tr>
<tr>
<td>Lighting</td>
<td>Type, intensity, controls, conditions, diffusion, location, and glare and shadow control</td>
</tr>
<tr>
<td>Heating and Ventilation</td>
<td>Type, effectiveness, temperature, humidity, controls, and natural and artificial ventilation and exhaust</td>
</tr>
<tr>
<td>Machinery</td>
<td>Points of operation, flywheels, gears, shafts, sprockets, key ways, belts, couplings, sprockets, chains, frames, controls, lighting for tools and equipment, brakes, exhausting, feeding, oiling, adjusting, maintenance, lockout/tagout, grounding, work space, location, and purchasing standards</td>
</tr>
<tr>
<td>Personnel</td>
<td>Experience training, including hazard identification training; methods of checking machines before use; type of clothing; personal protective equipment; use of guards; tool storage; work practices; and methods of cleaning, oiling, or adjusting machinery</td>
</tr>
<tr>
<td>Hand and Power Tools</td>
<td>Purchasing standards, inspection, storage, repair, types, maintenance, grounding, use, and handling</td>
</tr>
<tr>
<td>Chemicals</td>
<td>Storage, handling, transportation, spills, disposals, amounts used, labeling, toxicity or other harmful effects, warning signs, supervision, training, protective clothing and equipment and hazard communication requirements</td>
</tr>
<tr>
<td>Fire Prevention</td>
<td>Extinguishers, alarms, sprinklers, smoking rules, exits, personnel assigned, separation of flammable materials and dangerous operations, explosive-proof fixtures in hazardous locations, and waste disposal</td>
</tr>
<tr>
<td>Maintenance (including tracking and abatement of preventive and regular maintenance)</td>
<td>Regularity, effectiveness, training of personnel, materials, and equipment used, records maintained, method of locking out machinery, and general methods</td>
</tr>
<tr>
<td>Personal Project Equipment</td>
<td>Type, size, maintenance, repair, storage, assignment of responsibility purchasing methods, standard observed, training in care and use, rules of use, and method of assignment</td>
</tr>
<tr>
<td>Transportation</td>
<td>Moto vehicle safety, safety belts vehicle maintenance, and safe driver programs</td>
</tr>
</tbody>
</table>

*Table 4: Scope of inspection (Sources: Johnson, 2012)*

Jonson also stated that the contractors should issue a standardized safety checklist for the use of safety officers and safety supervisors for the site safety inspection purpose so that they can carry out their
inspection more efficiently. Appendix A shows the checklists provided by several leading main construction companies in Hong Kong. Ferrett (2011) mentioned that the safety inspection checklist should facilitate:

- The planning and initiation of remedial action, by requiring those doing the inspection to rank deficiencies in priority order (those actions which are most important rather than those which can easily be done quickly)
- Identifying those responsible for taking remedial actions, with sensible timescales to track progress on implementation
- Periodic monitoring to identify common themes which reveal underlying problems in the system
- Management information on the frequency of nature of the monitoring arrangements

Tang (2003) suggested that scores or grading should be allocated to items in the safety checklists. For example, a three level grading system may be adopted to indicate the degree of priority, and whether or not immediate remedial action is needed (Table 5).

<table>
<thead>
<tr>
<th>Grade</th>
<th>Adequate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade B</td>
<td>Improvement is needed</td>
</tr>
<tr>
<td>Grade C</td>
<td>Immediate Action</td>
</tr>
</tbody>
</table>

*Table 5: Grading system in safety checklists (Sources: Tang, 2003)*

2.2.4 General Practice of Traditional Safety Inspection

Every day, the construction site has to deal with lots of activities which expose to different. Apart from the complex construction site, most of the company has many manuals, in-house rules and checklists. It is very demanding for SO to remember all the things to do.

Andrew (1998) reported that the comprehensive and efficient of safety inspection procedures can be achieved by reviewing applicable regulations so as to familiarize yourself with the hazards that are associated with the operation or equipment that you intend to inspect; altering to all hazards, and not over relying the checklists which is only a reminder. Hazards unique to a specific situation should not be overlooked; taking notes and sure to note the exact description and/or location of every hazard when observed. Include the ideals for corrective action. Do not wait until after inspection to record hazardous conditions or unsafe actions; details might be forgotten.
According to Cheung et al. (2004), safety and health issues are of very dynamic nature in construction industry. Anytime and anywhere new hazard can be identified and accident may occur. For that purpose sometimes safety officers require comprehensive safety information and rapid method to record hazard. It will be advantageous for a safety officer if a tool is designed to enable accessing safety information and instruction and to record the hazard promptly. More over Cheung et al. (2004) emphasized on the requirement of a detector of potential risks and hazards which can able to highlight with a warning sign to the activities that required immediate corrective action.

Nowadays, the current site inspection is mainly composed of three parts: recording the non-conformance behaviors or activities, correcting the hazards identified in the non-conformance behaviors or activities, and reporting the non-conformance behaviors or activities. All of parts would be recorded by taking notes and photos or input the written notes and photos to the computer as report (safety report). Nevertheless, Mohamed (2002) said that the quality of safety report in the construction industry is poor and far from perfect compared with the other countries. With respect to the hand written notes, drawbacks such as typos, arbitrary descriptions for a safety issue and inconsistent naming for the same items are also common (Lin et al., 2011). Entering paper based information into IT systems is also inherently full of inconsistencies and errors because of the sheer number of stages involved in getting the information into a format which is ultimately admissible in a Court of Law, and also to the correct construction party. It also involves many personnel who do not understand how the information was created or how it is to be manipulated. (Sommerville and Craig, 2006) Table 6 shows the drawbacks of using paper to record information.

Furthermore, the current paper based methods of transfer are slowly becoming obsolete because they cannot deliver Just In Time (JIT) information to the construction site at critical stages within the overall process (De la Garza and Howitt 1998). Checklists and standard document templates are very often used to collect and record construction site information and although these current systems are useful for recording data, paper based information is rarely compatible with electronic systems which results in laborious, time consuming procedures, where data and information has to be re-keyed and re-processed into an IT system especially computer. Therefore, the conservation onsite safety inspection is time-consuming and thus causes ineffectiveness.
Table 6: Pitfalls of paper based documentation (Source: Sommerville and Craig, 2005)

<table>
<thead>
<tr>
<th>Pitfalls of using paper based process</th>
<th>Process Pitfall</th>
<th>Perceived Pitfall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor consistency of documentation</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Poorly structured data</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Unstructured paper process</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Increased handling of documents</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor document quality</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Poor administration</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Poor End image/data quality</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Data output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No data import into database</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Lack of storage device</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No cost savings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loss of paper copies</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Slow spend and transfer of information</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slow response times</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Inconsistency with delivery of data</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor processing of documentation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increased site visits</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Distribution costs high</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No time and identify stamps</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor validation of data</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor security of process</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor safety, reliability of product</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Poor communication</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor interpretation of data</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Poor decision making</td>
<td></td>
<td></td>
</tr>
<tr>
<td>More Physical resources</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>

2.2.5 Format of Safety Inspection Report

According the guideline of the safety management system, a proprietor or contractor of a relevant industrial undertaking should keep full records of each inspection with details of both positive and negative findings. Such reports should be analyzed to identify repeated substandard situations and their underlying causes.

Johnson (2012) raised that the safety inspection report should include the some basic criteria as shown in the followings:

- Have a form that tells who, what, when, why, and where.
- Make the form or report easy to follow and use. Managers and those taking action on the report should be able to see at a glance the status of their organization
- Include recommendations to give some guidance to those taking correcting action

Appendix B shows the safety inspection report provided by two leading main construction companies in Hong Kong.
2.3 Review of Risk Assessment

Risk assessment means the characterization of potential adverse health effects of human exposures to environmental hazards (National Research Council, 1983). Risk management comprises four interdependent elements: (1) hazard identification; (2) risk analysis; (3) risk control selection; and (4) risk control implementation and maintenance (Chua and Goh, 2005).

According to the COP of Safety Management, there are five major stages in risk assessment and risk control, they are identification of hazards, determination of risk, development of safety procedures and risk control measures, implementation and maintenance of safety procedures and risk control measures and review of safety procedures and risk control measures. The persons who carry out risk assessment should have substantial training and practical experience competent to perform the duty.

2.3.1 Objectives of Risk Assessment

McGuinness (1995) advocated that “there are three reasons for carrying out risk assessment for managing safety and they are mainly the moral, legal and economic aspects”. For the moral aspect, the organizations would not wish to observe people injured or killed in their workplace. For legal aspect, the requirement to carry out risk assessment has been introduced with the recent enactment of the Factories and Industrial Undertakings (Safety Management) Regulation. For the economic aspects, mismanagement of health and safety at work would result in enormous financial implications. On the other hand, Labour Department (2002) pointed out that the objective of risk assessment and risk control is to provide a means whereby job hazards or potential hazards are identified, evaluated and managed in a way that eliminates them or reduces them to a tolerable level. Therefore, safety procedures and risk control measures can be provided to eliminate the hazards and control the risk as much as possible.

2.3.2 Requirements of Risk Assessment

There are five major requirements in the risk assessment. First, record the known hazards, then identify the new hazards, evaluate the risks associated with the hazards, analyze the effects or the potential effects resulting from these risk and finally develop and implement means to eliminate the risks or to reduce them to a tolerable level. Besides, the risk assessment and risk control should form part the safety
inspection programme, be a major component in the risk control programme and be an essential part of the health protection programme.

2.3.3 Hazard Identification

Occupational Health and Safety Department (2007) stated that Hazard identification is the process of identifying all situations or events that could give rise to the potential for injury, illness or damage to plant or property. The hazards can be identified by the following means:

- Hazard inspections/surveys.
- Incident/Accident/Hazard reports & records.
- Occupational Health and Safety (OH&S) audits.
- Job Safety Analysis (JSAs) / System Impairment Notices.
- Legislative requirements.
- Designers/Manufacturers/Suppliers recommendations.
- Reports by employees / Line Managers.

The human element should also be included in hazard identification, so cultural, organizational, group level and individual hazards should be identified (Crossland et al. 1993). For example, hazards arising from dynamic processes, the interface between trades, or individual worker’s attributes and attitudes should be considered.

In the hazard identification process, the following aspects should be accorded top priority in the hazard identification process (Labour Department, 2002):

- High frequency of accidents or near misses: jobs or works with a high frequency of accidents or near misses pose a significant threat to safety and health of employees at work should be given top priority.
- History of serious accidents causing fatalities: jobs or works that have already produced fatalities, disabling injuries or illnesses, regardless of the frequency, should have a high priority in the hazard identification process.
- Possibility of serious harm: jobs or works that may cause serious injury or harm should be analyzed by the hazard identification process, even if they have never produced an injury.
- Introduction of new jobs: whenever a new job is introduced, a hazard identification process should be conducted before any employee is assigned to it.
• Recent changes in procedures, standards or legislation: jobs that have undergone a change in procedure, equipment or materials, and work affected by new regulations or standards require hazard analysis

Tait and Cox (1998) identify three approaches to access hazards. They are intuitive, inductive and deductive.

Intuitive method includes use of brainstorming. It is important that participants be carefully selected and that ideas be allowed to flow freely in an open atmosphere. Team members could include site management and supervisors, technical specialists, OSH advisors, subcontractors and representatives of equipment or material suppliers. The ideals should be recorded and further investigated.

Inductive approaches to hazard identification identify what could go wrong. They include fault tree analysis and job safety analysis.

Deductive methods for analyzing hazards include the use of accident databases. These can be either be company databases or industry databases. The nature of hazards can be deduced from understanding and circumstances of the previous incidents.

Although there are many kinds of technique to access the risk of hazards, nevertheless, the accuracy of the assessment mainly depends on the perceptions of the decision makers on the accident causes and recognitions of the potential risks. Their cognitions, perceptions, knowledge and understanding of hazards and risks, competence and awareness of the decision makers should also be taken into account (Cox and Tait, 1998).

### 2.3.4 Risk Analysis

Determining the risk rate of construction hazards depends on the probability and severity of accident occurrence (Carter, 2006). Probability or frequency is defined as the likelihood of a hazard’s potential being realized and initiating an incident or series of incidents that could result in harm or damage. Severity of consequences is defined as the extent of harm or damage that could result from a hazard-related incident (Manuele, 2006). There are two types of risk analysis – Qualitative and Quantitative analysis. The first produces an objective probability estimate based upon known risk information applied to the circumstances being considered, the second type is subjective, based upon personal judgement backed by generalized data on risk – qualitative assessment (Allan and John, 2008). Ayyub (2003) also
mentioned that Risk can be assessed and presented using matrices by estimating probabilities and consequences in a qualitative manner or with quantitative values.

2.3.4.1 Qualitative analysis

Qualitative analysis is the simplest and least costly method of risk assessment. It can be user where the level of risk does not warrant the cost involved in applying a more detailed analysis. It can also be used as an initial screening method, to identify risks that require more thorough analysis, or where numerical data are so inaccurate as to render quantitative analysis of risk meaningless. Risk matrices are commonly used in the method of qualitative analysis. Risks are rated according to the likelihood or probability of their occurrence and their likely consequences in a risk matrix. It is a table that includes several categories of “probability”, “frequency”, or “likelihood” for its rows (or columns) and several categories of “severity”, “consequences”, or “impact” for its columns (or rows) as shown in Figure 3 (Anthony Cox, 2008). A risk matrix might be used as a 3×3 cell matrix, 5×5 cell matrix, and even 7×7 cell matrix for risk assessment of a larger structure (Jeong et al., 2010). The magnitude of risk in the table can be used to guide the selection of suitable risk control measures and to establish priorities for the implementation of these controls.

![Risk matrix in qualitative risk analysis](Source: Anthony Cox, 2008)

2.3.4.2 Quantitative analysis

Quantitative analysis is the most resource-intensive approach. Lingard and Rowlinson (2005) states that the quantification should include following data:

- Past records
- Relevant experience
- Industry practice
- Relevant published data, including reliability databases
- Test marketing and research
- Experiments and prototypes
- Economic, engineering or other models, and
- Specialist and expert judgements

The Consequences can be expressed in terms of monetary, technical or human criteria while likelihood is usually expressed as a probability or combination of probability and exposure.

Kolluru et al. (1996) pointed out that since quantitative risk assessment requires a significant commitment of a company’s resources, a multi-tiered approach can be adopted (Figure 4). This three level approach helps safety professionals target the areas that should receive the most detailed analysis.

<table>
<thead>
<tr>
<th>Level</th>
<th>Risk Strategy</th>
<th>Action outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>Screening</td>
<td>Worst-case consequences; assessment for major hazardous materials inventories</td>
</tr>
<tr>
<td>Level 2</td>
<td>Survey</td>
<td>Semi-quantitative evaluation of major process hazards, safety management systems, fire-protection/emergency response capabilities</td>
</tr>
<tr>
<td>Level 3</td>
<td>Assessment</td>
<td>Full quantification of operational risks</td>
</tr>
</tbody>
</table>

Table 7: Three level approach in quantitative risk analysis (Sources: Anthony Cox, 2008)

2.3.5 General Practice of Traditional Risk Assessment

Since the safety professionals are the key decision makers dealing with project safety and risk assessment in the construction industry, their perceptions of safety risk would directly affect the reliability of risk assessment. Thus, the executor’s experience and competency often determine the risk assessment performance. A less-skilled safety professionals may have difficulties in identifying and controlling on-site safety risks and even a highly-experienced safety professionals can miss some of relevant risk information.
2.3.5.1 Perceptions of Safety Risk

From the following table, the perceived risk rating in Hong Kong is little bit higher than UK. Many safety professionals in Hong Kong think that not used of safety harnesses (199.3) is extremely high risk item which is its perceived risk rating is much higher than other items. The throwing down of scaffold materials is relatively a high risk item in both countries. The less perceived risk rating in Hong Kong is unsecured ladder (122.8) while in UK is no warning signs on incomplete scaffolds (118.42).

<table>
<thead>
<tr>
<th>Hong Kong</th>
<th>Perceived risk rating</th>
<th>UK</th>
<th>Perceived risk rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety harnesses not used</td>
<td>246.9</td>
<td>Throwing down scaffold materials</td>
<td>150.89</td>
</tr>
<tr>
<td>Throwing down scaffold materials</td>
<td>199.3</td>
<td>Walking on tiles or asbestos sheets during roofing</td>
<td>144.34</td>
</tr>
<tr>
<td>Safety wire not used</td>
<td>193.0</td>
<td>Crawling boards not used on roofs</td>
<td>143.95</td>
</tr>
<tr>
<td>Uncovered/unguarded openings</td>
<td>187.3</td>
<td>Operatives over-reaching from ladders</td>
<td>142.84</td>
</tr>
<tr>
<td>Working without hard hats</td>
<td>172.9</td>
<td>Timber with nails left lying around</td>
<td>136.87</td>
</tr>
<tr>
<td>No guard rails at perimeter</td>
<td>168.1</td>
<td>Operatives driving too fast</td>
<td>136.87</td>
</tr>
<tr>
<td>Working platforms not fully boarded</td>
<td>163.1</td>
<td>Operatives failing to remove nails from timber</td>
<td>132.77</td>
</tr>
<tr>
<td>No toe board used at perimeter</td>
<td>156.7</td>
<td>Roof work without leading</td>
<td>125.96</td>
</tr>
<tr>
<td>Objects thrown from height</td>
<td>139.0</td>
<td>Operatives throwing debris from height</td>
<td>123.89</td>
</tr>
<tr>
<td>No warning on incomplete scaffolds</td>
<td>136.7</td>
<td>Operatives using ladders that are not secured</td>
<td>120.71</td>
</tr>
<tr>
<td>No guard rails around open trenches</td>
<td>133.4</td>
<td>Operatives working on scaffold lifts not fully boarded</td>
<td>119.54</td>
</tr>
<tr>
<td>Unsecured ladders</td>
<td>122.8</td>
<td>No warning signs on incomplete scaffolds</td>
<td>118.42</td>
</tr>
</tbody>
</table>

Table 8: 12 highest perceived risk items in Hong Kong and United Kingdom (Source: Lingard, 1992)

2.3.6 Importance of Historical Data

As mentioned above, the majority of the safety professionals determine the risk level based upon their knowledge and experience. In order to reduce the subject judgment on risk of safety professional, more objective information should be provided for them to make more objective decisions. It should be noted that even the most extreme one-off projects may have some connections with past projects and current technologies. The statistics about past site accident in the construction industry can be one of the objective evidences. A Lingard (1993) reported that the accident information such as how, why, when and
to whom accidents are happening is extremely important for the development of well-formulated prevention strategies. In the absence of reliable and detailed information, erroneous conclusions concerning accident occurrence can probably be drawn. Andersson and Lagegerlof (1983) also stated that the greatest importance of accident information is to ‘provide knowledge about risks’, to identify risks, evaluate them and find causes. Vaughan (1997) revealed that risk evaluation implies some rankings in terms of importance which suggests measuring some aspects of the factors. Short (1984) argued that “risk acceptability greatly depends on the trust in the institutions presenting the expert rating, and based on the previous failures and success of those institutions.” Slovic et al. (1980a) suggested certain methods to improve the understanding, assessment and communication of risk.

2.3.7 Format of Risk Assessment Report

According to the guideline of safety management system, risk assessment has to be conducted by a competent person with practical knowledge of the work activities as well as objectivity. Classification of work activities, identification of hazards, determination of risk and preparation of risk elimination or control measures for risk are essential in risk assessment process.

Johnson (2011) mentioned that the risk assessment report should include the following details:

- Where it happening (environment)
- Who or that it is happening to (exposure)
- What participates the hazard (trigger)
- The outcome that would occur should it happen (consequence), and
- Any other contributing factors
- Control measures

Appendix C shows the risk assessment report provided by two leading main construction companies in Hong Kong.
2.4 Review of Existing IOS/Android Mobile Apps on Safety in Construction Industry

With the advancement of information technology, the safety management in construction industry is gradually shifting from traditional paper-based process to the electronic based process. In the OSHC (Hong Kong), there are different software such as Construction Industry Safety Climate Index Software, Safety Inspection Software for Property Management and Work Safe Behavior Training Kit...etc. provided for the contractor to use. Better still, in UK, majority of contractors are using the Construction E-Tool published by OSHC (United States) to identify the hazard(s) during site inspection. It is not wonder that there are already had some mobile or tablets application on construction safety developed by the other countries and I will explain the details of them one by one. However, these apps are not popular in Hong Kong because their contents, checklists and information are not specific to the safety of builder’s works in Hong Kong. So far, there are none of apps developed only for S.O. to use in Hong Kong.

2.4.1 IOS App “i-Auditor” Version 1.0

“i-Auditor” is severing as a auditing tools. It allows the user to perform the safety audit in the construction site. In the “i-Auditor”, it provides several templates for the user to perform safety audit, for instance, “Accommodation Inspection Checklist”, “Construction Hazard Identification and Risk Assessment” and “General Workplace Inspection”. Apart from the built-in templates, it can browse through other kinds of templates that have been shared by users. Each template has own specific checklists and in the checklists, user can check the items in the construction site one by one. If there are violations observed, the user can take photos of it and click the ‘At Risk’ in the checklists. Besides, it can export the audit report into the PDF format and email the report.

However, the items in the checklists are not detailed enough. Take “Working at Height” item in check-list as an example, there are only three questions in this item in i-Auditor but in the standard check-lists issued by the Housing Authority, there are at least 10 questions in this item.

Besides, it is not user friendly in the large construction site. It is because each checklist in one template is only used for checking one location in the construction site. For example, if there are same types of violation observed in location A and location B respectively, the user can only can record one location.
Figure 4: Interface of cover page of iAuditor (Source: ISO App Version 1.0, 2012)

Figure 5: Interface of templates in iAuditor (Source: ISO App Version 1.0, 2012)
Figure 6: Interface of checklists in iAuditor (Source: ISO App Version 1.0, 2012)

2.4.2 Android App “Safety Inspector” Version 1.0

Similar to the “i-Auditor”, it provides different types of templates for the user to perform safety inspections and allows user to inspect items based on the checklists in “Safety Inspector”. But in “Safety Inspector”, other than taking the photos, the user can record the voice in each item in the check-list if necessary. Also, it outweighs than the “i-Auditor”, it is because it contains the drawing tools for added detail to images or site illustrations. However, it cannot generate the audit report into PDF format and cannot email this report to the other person.
Figure 7: Interface of cover page in Safety Inspector (Source: Android App Version 1.0, 2012)

Figure 8: Interface of checklist and drawing tools in Safety Inspector (Source: Android App Version 1.0, 2012)
2.4.3 IOS App “e-Risk” Version 1.0

“e-Risk” is a risk assessment tool, allowing user to identify the hazards in the workplace. User can conduct the risk assessment by starting a new assessment in the “e-Risk”. e-Risk provides several hazards for the user to select such as Falling Object, Hot Surface, Moving Machinery, Sharp edge…etc. After choosing hazard(s), the user has to fill in the necessary information in the risk assessment. After completion of the risk assessment, the report can be exported into PDF format and sent to the other people via email.

Nevertheless, in the “e-Risk”, the options of hazards are too less and the fill-in details of the risk assessment are also to brief and not detailed enough. The required PPE, training course and residue risk level should be provided in the risk assessment report according to the COP on safety management. Also, it does not provide any expert advice or information which can assist the user to conduct the risk assessment more accurately.

![Image of e-Risk App](image)

*Figure 9: Interface of cover page of e-Risk (Source: IOS App Version 1.0, 2013)*
Figure 10: Interface of content page of e-Risk (1) (Source: iOS App Version 1.0, 2013)

Figure 11: Interface of content page of e-Risk (2) (Source: iOS App Version 1.0, 2013)
Chapter 3

App Development Methodology

This chapter would describe the whole development process of the i-Safe. It is about the life cycle development of the app, which is divided into different stages. Each stage includes its process and work done.

![App Development Process]

*Figure 12: The app development process*

3.1 Elementary App Planning

It is the fundamental stage of the methodology which is of great importance to the whole app development since the concept, functions and information of i-Safe was all based on this stage. First off, the safety management system, the site inspection and risk assessment would be reviewed. Additionally, the problems in the construction safety inspection and risk assessment would be defined and identified. Finally, a Mobile App is purposed for solving the risk assessment and current site inspection problems of safety professionals especially safety officers and also reduce their workload by increasing the convenience. The second phase of study would be conducted deeply to see how feasible the Safety App i-Safe would be which involves the review of current safety apps and their drawbacks. This would be discussed in the Chapter 2- Literature Review.
3.2 Define User and App Requirements

In this stage, as i-Safe will be used by safety professionals which can acts as E-inspection and risk assessment tools in the construction site, the concept, design, and development of i-Safe must match up the user requirements. Therefore, the user requirements are translated into the characteristics of i-Safe during design. Chapter 4- Determination of User Requirements would describes the user needs in depth.

What’s more, platform for hoisting the i-Safe, hardware and database software selection would be considered. Chapter 5- Determination of App Requirements would explain the above aspects in detail.

3.3 Design of App:

In this stage, the layout and surface of i-Safe would be designed so as to conform the identified user requirement. The hand-drawing notes, power-point software and design web Fluidui (http://www.fluidui.com) help to design the interface of i-Safe. The background of the design and the procedures of the design and development of i-Safe would be discussed and demonstrated in Chapter 6 - i-Safe Design and Development.

3.4 Testing and Operation:

After the development process, testing of i-Safe would be carried out to seek whether there are any problems exist. In the testing process, the user input and button in i-Safe should function normally without any errors. For example, tapping the date button can display the rolling bar but not the keyboard. The testing process is carried out by the IOS simulators which would be described in Chapter 6 - 6.6 Development Tools.

i-Safe would be operated and distributed to the different aspects of safety professionals after the completion of testing procedures. The user manual would be attached for guiding end-users in Chapter 7- Operation of i-Safe.
3.5 Feedback and Evaluation

Face-to-Face interview would also be carried out to collect the comments on i-Safe from safety professionals. During the interview, evaluation questionnaire would be delivered to the user to find out the strengths and weaknesses of i-Safe, and this would be described in Chapter 8 – Evaluation of i-Safe.

3.6 Recommendation and Future Development

After evaluation, the weakness and drawbacks in i-Safe would be identified and thus the improvement to i-Safe would be made. Moreover, due to the limitations of time, hardware and software capabilities, the functionality of i-Safe are restricted. By the advancement of the technology today, the functions of the i-Safe can be further developed and extended in the foreseeable future. These would be described in Chapter 9- Recommendation and Future Development.
Chapter 4

Determination of User Requirements

As i-Safe will be used by the safety professionals to conduct safety inspection and risk assessment, so the development of i-Safety must conform to the user requirements. In this chapter, the following user needs will be discussed.

1. Accessibility
The app should be accessed by the safety professional anywhere. The safety tools and information in the app should not be restricted from the physical location of the users. Therefore, the user can do the safety works not only in home or office, but can be everywhere.

2. Availability
The availability of safety tools and information in the app is available 24 hours a day, 364 days a year. Timeless of finding information and writing report changes from slow to immediate. The users can access the safety at any time in anywhere.

3. Simplicity
The app should provide as simple an interface as possible. For example, using progressive disclosure, unique and easy-understand icon. Also, the app should not provide too many options in one page so as not to cause confusion to the user.

4. Directness
The app should provide direct and intuitive ways to accomplish tasks. Besides, the tasks should be performed directly and intuitively.

5. Comprehensibility
The app should be easily to learn and understand. The flow of actions, responses, visual presentations, and the information should be in sensible order that is easy to recollect and place in context. Also the app should be intuitive and understandable flowing in a comprehensible and meaningful order. The steps to complete a task should be obvious to the user.
6. **Clarity**
   The interface should be visually, conceptually and linguistically clear including visual element, functions, words and text.

7. **Flexibility**
   The app should provide flexibility working platform for the user so that by the screening process, they can work or search information based on their requirements.

8. **Efficiency**
   The user attentions should be captured by relevant elements of the screen when needed. The app should provide click-to-choose functions with drop down menus are preferred because they enhance the efficiency for entering records and it should avoid frequent transitions between devices such as the keyboard or choosing options box.

9. **Simple Implementation**
   The integration of new people into the process was simple. For example, if a new safety officer joins to the construction site. There is no need for briefing, training in the site office. What they need is only a iPad. The app should be easily to use by any safety professionals.

10. **User Friendly Interface**
    Beyond the familiarity with IOS operations, extensive IT knowledge is not required and, unlike the software in computer, the users do not have to install any plug-in software to run the application. The app should provide tap-view control as it offers an intuitive, easy-to-use interface for all safety professionals.

11. **Selecting Choice(s) rather than Typing Words**
    The app should avoid typing words frequently, thus, typo mistakes would not easily occur. Multiple options should be provided in the app so as to save time in typing and accelerate the process of site inspection and risk assessment.
12. Generation of Report

The conventional paper-based records are usually based on brief handwritings, quick notes and photo(s) only, resulting in poor quality of the safety records. Furthermore, as mentioned in the Literature Review, the safety records often to be re-entering or scanned into a computer or reconstructed into a format which would be prone to input errors and time-consuming. Accordingly, the capability of inputting standardized data mechanism with robust data storage and generation of report is required.

13. Transfer Functions

In order to facilitate the site inspection process, the user can transfer the related reports or photo(s) to the other people anytime, so the transfer functions should be provided in the apps. The immediate transfer of information should not restraints from site office, but can transfer the information everywhere.

14. Ownership

In order to approve the reports generated in the app, the signature functions should be provided for the safety professional to sign their name. The acceptability and ownership of the safety records in the app then can be enhanced.

15. Capturing Photos

The app must provide the ability of capturing photos which can replace the basic functions in the camera so as to collect non-conformance evidence during site inspection.

16. Measuring Tools

The app should support major measuring tools such as ruler, leveler or sound measurer for the safety professionals to determine the safety conditions in the construction site.

17. Notifications

The notifications function should be provided in the app which can alert the user to some importance notes or time like the next risk assessment times and the notes of reviewing historical data.
Chapter 5

Determination of App Requirements

In this chapter, application requirements of developing i-Safe would be discussed. The app requirements can be divided into three groups – Selection of Platform, Hardware Consideration and Database Software Consideration. I will describe them one by one and why I choose them for running i-Safe.

5.1 Selection of Platform

A series iPad model are chosen for the develop platform. There are three main reasons for using i-Pad to develop i-Safe. They are Popularity of iPad, Screen size of iPad and Apps in iPad.

![iPad Image](image.png)

*Figure 13: Image of iPad (Source: Apple, www.apple.com/hk/en/*)
5.1.1 Popularity of iPad

Over the two and half years ago, Apple has sold 100 minion iPads products. In the Figure 15, the sales number of iPads is increasing from quarter three of 2010 to 2013. In 2012, iPad sales reach a peak which total 15 minions are sold approximately. Also, other experts expect that iPad will become more and more popular among the world.

Besides, compared with other tablets, iPad still dominates the tablets sales. According to the Figure 16, Apple still is a leader in a tablet market, which is more than its four closest competitors combined although its market share slides at quarter 3 in last year because of the introduction of more tablets. Although its tablet market share is declining somewhat, 91 percent of the Web traffic generated by tablets in the last year is came from iPads (Apple Reveals Impressive Sales and Usage Statistics, 2012). Therefore, iPad in tablet market is still far and ahead from other brands in next few years.

![iPad Unit Sales](image)

*Figure 14: iPad Unit Sales from 2011 to 2013 (Source: Apple Inc. financial statements, 2013)*
Figure 15: Worldwide tablet vendors market share (Source: Apple Reveals Impressive Sales and Usage Statistics, 2012)

5.1.2 Screen size of iPad

Except the Macbook computer, iPad has the largest screen size among the Apple products. The 1024 x 768 pixels gives a large amount of space to the designer to present the apps content and interface. What’s more, the 10inch screen provides enough spacing for the user to handle the setting. User can handle more than one setting process within a one single page. Therefore, user can see the pictures, type the words and tape the icons more easily and accurately.

5.1.3 Apps in iPad

Since the iPhone apps can be launched in the iPad, but after becoming spoiled by beautiful, high-resolution iPad apps, users will find magnified iPhone apps on the large screen very crude and unattractive. iPhone apps were designed for iPhone. The iPad should be treated as an entirely new platform, with its own set of design requirements. Daivd Chartier of Agile Web Solutions (2005) said that Since there’s that 2x button for running existing iPhone apps in a full screen mode on the iPad. But I think that once iPad customer see what’s capable with the iPad’s increased screen space and
hardware and software advantages over iPhone and iPod touch, you will find that the “2x” mode quickly become the Mac OS Classic on the iPad.

5.2 Hardware Consideration of iPad

This part would describe how the built-in features of iPad would support the running progress of i-Safe, which is divided into 5 aspects – Portability, Functionality, Performance and Network.

5.2.1 Portability

To be a useful and mobile tool, i-Safe should be carried out by SO everywhere and every time. The probable feature of iPad can achieve this purpose. In addition, the lighter (652g) and thinner (0.37 inch) of iPad make SO using i-Safe more convenient. Instead of taking camera, pens and paper or other documents, SO only pick out their iPad to inspect the site or conduct the risk assessment. It just like a desktop to help SO to perform the auditing systems in i-Safe.

5.2.2 Functionality

1. Camera Functions

iSafe is expected to take the non-conformance photos as evidence and record so photo taking ability must exits inside i-Safe, the built-in camera in the front and back of i-Pad can let SO to capture the images while using i-Safe. The full screen zoom magnification allows SO to zoom in and out which enhance the convenience of SO.

2. Mail Attachment Support

The mail function in iPad can apply into the i-Safe. After SO generate the site inspection or risk assessment report, he can send the report to his colleagues to inform them the violations are occurred in the site and request them to rectify it immediately. The mail support system in iPad can let i-Safe become an interactive tool.
3. Location Support

Similarly, the GPS location in iPad can apply in i-Safe, SO is not only work for one construction project, some senior SM may work for several construction site depend on the company policy. As a result, the GPS function in i-Safe which is supported by iPad can locate the user and site.

5.2.3 Performance

1. Display

iPad has 2048x1536 resolution display which is even comparable with HD television. iSafe can launch in a large and beautiful display which can increase the attractiveness of iSafe.

2. Speed

The new A6X chip inside the iPad makes it faster and more responsive than before. i-Safe can launch instantly and run smoothly.

3. Storage

The storage of iPad can be up to 128 GB, which can allow users to store more images, words, and documents when using i-Safe.

5.2.4 Network

The 3G iPad has the ability to always be connected via a cellular provider (such as smartone in Hong Kong). This wide-area access is supplemented with built-in WiFi and Bluetooth in all iPad models. WiFi can provide desktop-like browsing speeds within a range of a wireless hot spot. On the other hand, Bluetooth can be used to connect a variety of peripheral devices to user’s iPads, including a keyboard. Better still, the new 4G LTE wireless network can allow user download information, browse the web and update the data with amazing speed in iSafe.
5.3 Database Software Consideration

Database is a backbone of the most applications and it is very importance in the development of i-Safe. It is defined as a generalized integrated collection of data, which is structure so that the data may be retrieved in any required order to fulfill the differing needs of many users (Phiri, 1999). There are different kinds of database software now, and in this project MySQL is used for storing data in the development of i-Safe. MySQL is a free license tool and a high-performance database system built around a client–server architecture. The advantages of MySQL are explained in the following paragraphs.

1. Reliability

MySQL is designed to offer maximum reliability and uptime. MySQL supports transactions, which ensure data consistency and reduce the risk of data loss, and replication and clustering, these two techniques can considerably reduce the downtime in the event of a server failure. Finally, MySQL’s large user base assists in rapidly location and resolving bugs and in testing the software in a variety environment, making this software is virtually bug-free.

2. Scalability

MySQL can handle extremely large and complex database without too much of performance drop. Tables of several gigabytes containing hundreds of the thousands of records are not uncommon. A 2005 test by MySQL Test Labs demonstrated that MySQL shows near-linear scalability in a multi-CPU environment, with performance increasing in proportion to number of CPUs added to the system.

3. Ease of Use

MySQL is well supported by a detailed manual, a large number of free online tutorials, a knowledgeable developer community, and a fair number of books. It is relatively easy to tune and optimize compared with other kinds of database.

4. Wide Application Support

MySQL exposes application programming interfaces (APIs) to many programming languages, thereby making it possible to write database-driven applications in different languages such as C, C++, Java...etc.
Chapter 6

i-Safe Design and Development

6.1 Prototype approach

Before actual development of app, it is important to create prototypes to design the interface of the app and test its’ acceptability and functionality. At the early stage of the design, paper prototypes are used to layout the main pages and control of app. After the checking by my supervisor, a powerpoint prototypes are used to demonstrate the flow of the app. And the final stage of the design, Interface Design Web is used to design the icon, pictures, colour, style and pattern of the apps.

6.1.1 Paper Prototypes

As mentioned above, handwriting on paper is used to create prototypes at the preliminary stage of the design. It is the easy, direct and simple method to design the main view and control of the app. In the paper prototypes, I only sketch the main flow of the app and decide what should be included in the app so as to meet the user requirements and the ultimate objectives of this research.

![Diagram of app design flow]

Figure 16: App design and flow presented in draft (1)
### Figure 17: App design and flow presented in draft (2)

<table>
<thead>
<tr>
<th>2.3</th>
<th>5.1. Length Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.4</td>
<td>5.2. Round</td>
</tr>
<tr>
<td>2.5</td>
<td>5.3. Leveling</td>
</tr>
<tr>
<td>2.6</td>
<td>5.4. Maximum</td>
</tr>
<tr>
<td>2.7</td>
<td>5.5. Minimum</td>
</tr>
<tr>
<td>2.8</td>
<td>5.6. Calculated Risk</td>
</tr>
</tbody>
</table>

### Figure 18: App design and flow presented in draft (3)

- Section 2.4
  - References
  - Literature review
  - Recommended app
  - Notes
6.1.2 Powerpoint Presentation to the Programmer and Safety Professionals

After receiving the valuable feedback from my supervisor and other safety professionals, the second stage of the design commence. Base on their fresh perspectives on my app’s flow, functionality and user experience, I use powerpoint to present the design, context and functions of i-Safe to the programmer, my supervisor and other safety professionals. In the powerpoint, the map flow of the app can easily present by using the hyperlink function. Also, the buttons, lists, tables and imaged can be created in the powerpoint which helps me a lot at the fundamental design stage because it is inefficient and time consuming to draw everything in the paper. The testing of powerpoint prototypes is more realistic and easily to conduct as the testers can tap an area of slide by using ‘Slide Show’ in power-point. The disadvantages of using power-point prototypes are the inbuilt templates and layouts buttons, lists, tables cannot be used for the development of the app because the resolution of them are too low and cannot suit in the such high resolution retina of iPad. They only can be used for the design purposes. Nevertheless, the whole structure of i-Safe can be shown by using powerpoint and the testers can provide more constructive feedback by testing powerpoint prototypes.

![Figure 19: App interface design in Powerpoint (1)]
The Development of Mobile App (i-Safe) for Safety and Risk Assessment in Civil & Building Construction Site

**Figure 20: App interface design in Powerpoint (2)**

**Figure 21: App interface design in Powerpoint (3)**
6.1.3 Design Platform: Fluidui

The Fluidui is a very useful interface design web for smartphones and tablets. It is for the design of the application layout with some premade buttons, lists table, datetime stamp button, etc. with an outlook like iPad. It is very simple and user-friendly for the novice at apps developer. It provides the variety of templates and layouts which are common to use for design of apps nowadays. Other than using the built-in graphics, you can upload any images to Fluidui Web you want in order to increase the flexibility of Fluidui. It is superior to the Powerpoint, it is because all the in-built elements are used for development of the app and the resolution of them are match up with the resolution of iPad. Also, it is more easily to present the flow of the app to the app’s writer because it can show the whole logical sequences of the app while powerpoint cannot. Besides, the elements provided in Fluidui are more familiar with the display elements in the iPad which would not cause strange to the user.

The both disadvantage of using Fluidui and Powerpoint is that they cannot be act like mobile app. For example, when tapping the ‘text’ button, both of the them only jump into another view showing the keyboard image to indicate user should type the works in the button, but cannot really input the words inside the button. Furthermore, the design in the Fluidui cannot be tested and verified. However, the difficulties above can be solved by the IOS Simulator which would be discussed later.

![Figure 22: App interface design in Fluidui (1)](image)

46
Figure 23: App Interface Design in Fluidai (2)
Figure 24: App flow in Fluidui
6.2 System Architecture

The whole system architecture is shown in the following diagram. After installation of i-Safe, the user can conduct either site inspection or risk assessment. If the iPad is connected to the Internet by Wifi or Cellular, i-Safe has ability to send email or search internet source. If the user wants to input the data into the computer, trailer connection is used to transfer the records in the iPad to the computer. The user can either print out the report or keep it as records. Backend sever is used which does not directly connect to the outside world. And MySQL database is used for storage of the data in the app.

Figure 25: System Architecture
6.3 Main Page

i-Safe is provided to the two main safety professionals- Safety Officer and Safety Auditor. At the main page, both of the users can assess the safety information and use the functions embedded in i-Safe at the main page before selecting the role. In my final year project, I am responsible to design the part of SO. Before the conduction of safety inspection, SO can access safety regulations, codes of practices and in-house safety rules of the company before conduction of site inspection. Furthermore, SO can use the measuring tools at the main page to judge whether the site conditions complying with the safety regulations. Also, the reminding function is provided for the user to notify the milestone date like the next assessment time or the completion date.

6.3.1 Work Flow Diagram

Work Flow Diagram is the simple form of flowchart showing how the application is work with the user decisions. It typically consists of a set of symbols representing actions or individuals connected by arrows indicating the flow from one to another. Different symbols represent different aspects of the workflow. The whole concept of i-Safe on iPad can be demonstrated by using the work flow diagram.

In this work flow diagram, there mainly are two symbols used for representation.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rectangle:</td>
<td>It is represent the process of the application, called as “Activity”</td>
</tr>
<tr>
<td>Diamond:</td>
<td>It is representing the decision making for the user. Usually it occurs between the activities.</td>
</tr>
</tbody>
</table>

*Table 9: Representation of work flow diagram*
6.3.2 Working Process of Main Page

From the below figure, the user would enter into the homepage of i-Safe after installation of i-Safe on iPad. There are five options provided for the user to choose - Start a New Project, Past Records, Today’s Notification, References and Tools. In this charter, only the working process of Start a New Project would be discussed. When user has chosen to create the new project, he has to decide the role. If user has chosen the SO role, he needs to fill in the site information first. After writing the details, user can perform four activities- Site inspection and Risk Assessment. The working process of site inspection and risk assessment would be explained later.

![Flowchart of Main Page](image)

*Figure 26: Work flow diagram of Main Page*
6.3.3 Use Case Diagram

Use Case Diagram is a graphical representation of a user’s interaction with the system and depicting the specifications of use case (Wikipedia). Similar to the Work Flow Diagram, it is composed by a set of symbols representing user and interactions connected by lines. There are three elements in the Use Case Diagram—Actor, Use Case and Association.

Actor represents the user. It is indicated by the ‘Matchstick Man’ in the diagram.

![Actor Diagram](image)

Use Case represents a part of the functionality of the i-Safe so that the user can access to this functionality. It is indicated by the circle in the diagram.

![Use Case Diagram](image)

Association represents that the user (Portrayed as an actor) can use the functionality (Portrayed as an Use Case) in i-Safe. It is indicated by a line in the diagram.

![Association Diagram](image)

Include relationship is a relationship between two use cases and it represents the use case to which the arrow points is included in the use case on the other side of the arrow. It can be viewed as a type of call to a subprogram.

![Include Diagram](image)

6.3.4 Functions of Main Page

In the Main Page, there are five major functions in the main page. It includes (1) Creating Project, (2) Reviewing Records, (3) Using Tools, (4) Studying References, (5) Notification. The Filling Information, Performing Site Inspection and Risk Assessment functions are included in the (1) Creating Project. In this
chapter, only (1) Creating Project will be discussed. While (2) Reviewing Records, (3) Using Tools, (4) Studying References, (5) Notification are under construction and will be provided for the user in the future time.

Figure 27: Use case diagram of Main Page

6.3.5 Filling Information in Creating Project

After installation of i-Safe, user can access the app to view the main page. The user can create a new project in this app. There are three sub-functions user can use in creating project. They are Filling Information, Site Inspection and Risk Assessment. The functions of Site Inspection and Risk Assessment would be discussed later.

When designing the layout of the Filling Information in Creating Project, several attributes of basic characteristics of project information are included. For example, contract number, contract name, site addresses or name of contractor. These kinds of information are significant in any safety records.
For the site location, user can either type the location of construction site or use the Global Positioning System (GPS) if necessary.

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Text / Choice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Document Name</td>
<td>The name of the document</td>
</tr>
<tr>
<td>Contract No.</td>
<td>The contract no. of the construction project</td>
</tr>
<tr>
<td>Contract Name</td>
<td>The contract name of the construction project</td>
</tr>
<tr>
<td>Contractor</td>
<td>The name of the main contractor who is responsible to this construction project</td>
</tr>
<tr>
<td>Date</td>
<td>The date of the creation of document</td>
</tr>
<tr>
<td>Prepared By</td>
<td>The name of the user</td>
</tr>
<tr>
<td>Site Location</td>
<td>The address of the construction site</td>
</tr>
</tbody>
</table>

Table 10: Fields of the Filling Information in Creating Project

![i-Safe](image-url)

*Figure 28: Interface design of Main Page*
6.3.6 Reviewing Records

i-Safe allows the user to do the site inspection and risk assessment of different construction projects. They can review the records of different projects. First of all, they need to select the construction projects they want to review. After the selection of project, they can review any reports they like.

Figure 30: Interface design of the Reviewing Records in Main Page (1)
6.3.7 Using Tools

Tools page are provided for the user to check whether the site condition comply with the regulation. For example, according to the Construction Site Safety Regulation, working platform on a scaffolding should be provided when the workers work on the scaffolding. This function can help Safety Officer to check whether the adequate working platform has been provided. i-Safe can support four tools: Length measurement, sound meter, magnifier and flash light.

Figure 31: Interface design of the Reviewing Records in Main Page (2)

Figure 32: Interface design of the Using Tools in Main Page

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6.3.8 Studying References

As mentioned above, safety officer has to memorize lots of regulations and in-house safety rules. The references page provides variety of regulations, codes of practices and guidelines for the user to study. According to the Construction Site Safety Handbook published by the Works Bureau, the following ordinances, codes of practices and guidelines would be provided in i-Safe.

<table>
<thead>
<tr>
<th>Ordinances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factories and Industrial Undertakings Ordinance</td>
</tr>
<tr>
<td>Occupational Safety and Health Ordinance</td>
</tr>
<tr>
<td>Builders' Lifts and Tower Working Platforms (Safety) Ordinance</td>
</tr>
<tr>
<td>Shipping and Port Control Ordinance</td>
</tr>
<tr>
<td>Dangerous Goods Ordinance</td>
</tr>
<tr>
<td>Electricity Ordinance</td>
</tr>
<tr>
<td>Fire Services Ordinance</td>
</tr>
<tr>
<td>Waste Disposal Ordinance</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Code of Practices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code of Practice for Safety and Health at Work with Asbestos</td>
</tr>
<tr>
<td>Code of Practice for Scaffolding Safety</td>
</tr>
<tr>
<td>Code of Practice for Safety and Health at Work for Industrial Diving</td>
</tr>
<tr>
<td>Code of Practice for the Protection of Hearing in Industrial Undertakings</td>
</tr>
<tr>
<td>Code of Practice for the Control of Lead at Work</td>
</tr>
<tr>
<td>Code of Practice for Protection of Quarry and Construction Workers from Silicosis</td>
</tr>
<tr>
<td>Code of Practice for Protection of Tunnel Workers from Silicosis</td>
</tr>
<tr>
<td>Code of Practice for the Electricity (Wiring) Regulations</td>
</tr>
<tr>
<td>Code of Practice on the Design and Construction of Builders' Lifts</td>
</tr>
<tr>
<td>Code of Practice on the Design and Construction of Tower Working Platforms</td>
</tr>
<tr>
<td>Code of Practice for Safety at Work (Lift and Escalator)</td>
</tr>
<tr>
<td>Code of Practice for Safe Use of Mobile Cranes and Tower Cranes</td>
</tr>
<tr>
<td>Code of Practice for Safe Use and operation of Suspended Working platforms</td>
</tr>
<tr>
<td>Code of Practice for Safety at Work Construction Over Water - Prevention of Fall</td>
</tr>
<tr>
<td>Code of Practice on Working Near Electricity Supply Lines</td>
</tr>
<tr>
<td>Code of Practice for the Lighting, Signaling and Guarding of Road Works</td>
</tr>
<tr>
<td>Code of Practice - Avoiding danger from gas pipes</td>
</tr>
<tr>
<td>Draft Code of Practice for Demolition of Buildings, 1998</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Guidance Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guidance Notes for Safety at Work (Falsework)</td>
</tr>
<tr>
<td>Guidance Notes for the Electrical Products (Safety) Regulation</td>
</tr>
<tr>
<td>A Guide To Safety Management</td>
</tr>
<tr>
<td>Guidance Notes on the Safe Use of Earth-Moving Machinery</td>
</tr>
<tr>
<td>Guidance Notes on Manual Handling Operations</td>
</tr>
<tr>
<td>Guidance Notes on the Selection, Use and Maintenance of Safety Helmets</td>
</tr>
<tr>
<td>A Guide to Safety &amp; Health at Work for Gas Welding and Flame Cutting</td>
</tr>
</tbody>
</table>

*Table 11: List of Ordinances, code of practices and guidance notes provided in i-Safe (Sources: Construction Site Safety Handbook, 2000)*
6.3.9 Notification

The altering function in i-Safe would notify user of upcoming or missed activities or date. Once the reports in i-Safe has been reviewed or modified by the user, i-Safe would alter the user the modification has been made. Beside, i-Safe would alert user some important dates in the reports such as the next date of risk assessment or the time of completion of correction in site inspection.
6.4 Site Inspection

The part of site inspection is designed to improve the traditional paper-based process and facilitate the site inspection process. User can do the safety inspection report by completing only 3 steps in i-Safe. Data can then be digitally recorded the first time without the use of paper forms and then directly transferred to the other people through wireless communication, thus eliminating double entry.

6.4.1 Working Process of Site Inspection

When user decides to the carry out site inspection, he can start with adding a new document. After that, he has to take photos, and then fill in the details of non-conformance behaviors done by workers. Finally, he has to fill in the basic information of this site inspection. The report would be completed after the above three steps are finished. User can decide to edit the created document to correct or update the content if necessary or export it into PDF file, or email this report to colleagues, or delete the report if it is useless.

Figure 35: Workflow diagram of Site Inspection section
6.4.2 Functions of Site Inspection

There are four main functions provided in the site inspection section. It includes (1) Taking Photo(s), (2) Filling Information, (3) Report Reviewing, (4) Exporting Report, (5) Sending Report.

![Diagram of Site Inspection section]

**Figure 36: Use Case diagram of Site Inspection section**

6.4.3 Taking Photo(s) with Editing Tools

Nowadays, taking photo(s) by camera or mobile phone is the most effective way for proofing the non-conformance behavior of the workers or unsafe condition. Therefore, camera embedded in iPad is to let user to take photo(s) in i-Safe. Given to the limited database of server, the maximum number of photos taken in each report for ‘Non-conformance’ and ‘Correction’ aspect is five. In these two parts, the user can input the image(s) by using camera or choosing from photo album. If the user decides to take photo(s) from camera, the in-built camera in iPad will be provided, on the other hand, the user can decide to choose photo(s) from the photo album which is already saved in the iPad. The taken photo(s) then will display in i-Safe. ‘Non-conformance’ is for the user to take the violation photo(s) while ‘Correction’ is
for the user to take the rectified photo(s) after the workers have corrected the unsafe activities or conditions. The camera in i-Safe adopted the zoom-in and zoom-out functions of ipad with high resolution.

After taking or choosing photo(s), editing tools would be activated and it allows user to edit the photo(s) like adding words or drawing annotations in order to indicate the non-conformance(s) in the photo(s) more clearly.

Figure 37: Interface design of Taking Photo(s) (1)

Figure 38: Interface design of Taking Photo(s) (2)
6.4.4 Filling Information

When designing the layout of the Filling Information in sitey inspection, several attributes of characteristics of safety report are included. The all-round and comprehensive information is critical to the contribution of complete and good quality safety reports. Thus, I have studied requirements of site inspection report in several books and the inspection report from two large construction firms- Gammon Construction Ltd. and China State Construction Engineering (Hong Kong) Ltd (Appendix B) to investigate the important information in the safety reports. The following table shows the fields that the users have to input into the site inspection.

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Text / Choice</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 2</strong></td>
<td></td>
</tr>
</tbody>
</table>
| Types of Non-Conformance(s) | 1. Fire Arrangement  
2. Work in Confined Space  
3. Working at Height  
4. Housekeeping  
5. Protection Against Falling Objects  
6. Work Over Water  
7. Overhead and Underground Services  
8. Flammable Liquids and Gases  
9. Road Works  
10. Occupational Safety and Health in Office  
11. Demolition  
12. Excavations  
13. Lifting Operations  
14. Mechanical Materials Handling  
15. Temporary Works  
16. Structural Steel Erection  
17. Welding/Cutting Operations and Equipment  
18. Site Traffic  
19. Site Transport  
20. Blasting  
21. Pilling  
22. Grit Blasting  
23. Diving |
24. Tunnelling/Pressurised Atmosphere  
25. Hand Dug Cassions  
26. Ground Investigation  
27. Sewage or Drainage Works  
28. Prestressing  
29. Compressed Air Tools  
30. Electrical Supply System  
31. Portable Tools  
32. Mechanical Plant and Equipment  
33. Woodworking Machines  
34. Abrasive Wheels  
35. Building Maintenance  
36. Substances Hazardous to Health  
37. Asbestos  
38. Others  

<table>
<thead>
<tr>
<th>Description(s)</th>
<th>The details of non-conformance(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrective Action(s)</td>
<td>The details of corrective action(s)</td>
</tr>
</tbody>
</table>

**Step 3**

<table>
<thead>
<tr>
<th>Exposed Workers</th>
<th>The name of the workers</th>
</tr>
</thead>
</table>
| Trade Type(s) | 1. Bricklayer  
2. Carpenter  
3. Concretor  
4. Plumber  
5. Electrician  
6. Fitter  
7. Joiner  
8. Labourer  
9. Painter  
10. Plant Equipment Operator  
11. Plaster  
12. Pneumatic Driller  
13. Rigger  
14. Bamboo Scaffolder  
15. Site Supervisory Staff  
16. Steel Fixer  
17. Structural Steel Erector |
The 37 options in the ‘Types of Non-Conformance(s)’ are based on the information provided by the Housing Authority Safety Audit System. 37 non-conformances which were commonly involved in Hong Kong construction sites.

The 20 options in ‘Trade Type’ is based on the information provided by the Employment and Earnings Statistics Section in Census and Statistic Department of HKSAR (2003a), 20 trades of works which were mainly involved on Hong Kong construction sites are identified.

The “Safety Officer Signature” is provided for the user to sign his names in order to approve that the report is conducted or approved by him.

<table>
<thead>
<tr>
<th>1. Fire Arrangement</th>
<th>2. Work in Confined Spaces</th>
<th>3. Working at Height</th>
<th>4. Housekeeping</th>
<th>5. Protection Against Falling Objects</th>
</tr>
</thead>
<tbody>
<tr>
<td>36. Substances Hazardous to Health</td>
<td>37. Asbestos</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 13: Summary of non-conformances in Housing Authority Safety Audit System
<table>
<thead>
<tr>
<th>Trades of works</th>
<th>Job descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bricklayer</td>
<td>To lay bricks and other building blocks, except stones and marble, for construction and repair of walls, partitions, arches, openings and other structures.</td>
</tr>
<tr>
<td>Carpenter</td>
<td>To erect and strike timber formwork for building works and construction work related to civil engineering.</td>
</tr>
<tr>
<td>Concreter</td>
<td>To mix, place and compact concrete using vibrating machines; to carry out capping, levelling and smoothing of concrete.</td>
</tr>
<tr>
<td>Plumber</td>
<td>To assemble, install, repair and maintain pipes, fittings, sanitary fixtures, cold, hot and flush water systems, and soil waste and rain water drainage systems in buildings.</td>
</tr>
<tr>
<td>Electrician</td>
<td>To install, test, commission, maintain, and repair electrical installations and wiring; to fit, assemble, install, test, commission, maintain and repair electrical systems and equipment.</td>
</tr>
<tr>
<td>Fitter</td>
<td>To fit, assemble, erect, install, maintain and repair mechanical plants and equipment.</td>
</tr>
<tr>
<td>Joiner</td>
<td>To carry out all internal and external woodwork (except formwork and fender) using both hand tools and woodworking machinery.</td>
</tr>
<tr>
<td>Labourer</td>
<td>To perform simple duties as directed by the tradesman, general cleaning or minor excavation work.</td>
</tr>
<tr>
<td>Painter</td>
<td>To perform painting for surfaces, fittings and fixtures of buildings and other structures for painting.</td>
</tr>
<tr>
<td>Plant and equipment operator</td>
<td>To operate construction plant and equipment for material-handling purposes including crawler mounted mobile crane, wheeled telescopic mobile crane, tower crane, truck-mounted crane, and gantry crane etc...</td>
</tr>
<tr>
<td>Plasterer</td>
<td>To apply coats of plaster to, and to render walls and ceilings to produce finished surfaces, to screed floors, staircases and roofs.</td>
</tr>
<tr>
<td>Pneumatic driller</td>
<td>To operate pneumatic or hydraulic drills to make holes and openings or break up concrete, rocks or other hard materials.</td>
</tr>
<tr>
<td>Rigger</td>
<td>To set up lifting apparatus and equipment for lifting and lowering of materials.</td>
</tr>
<tr>
<td>Bamboo scaffolder</td>
<td>To erect and dismantle bamboo scaffolding required in construction, repair or decoration work, and other forms of structures.</td>
</tr>
<tr>
<td>Site supervisory staff / fanner</td>
<td>To supervise, direct and co-ordinate the activities of workers engaged in construction works.</td>
</tr>
<tr>
<td>Steel fixer</td>
<td>To cut, bend and fix reinforcement steel bars.</td>
</tr>
<tr>
<td>Structural steel erector</td>
<td>To drill, cut and shape steel sections, to assemble structural members and erect steel structures by riveting or bolting; to operate power shears, flame cutting equipment and other tools.</td>
</tr>
<tr>
<td>Survey leveller</td>
<td>To read and interpret drawings, to set up job lines and levels and prepare templates.</td>
</tr>
<tr>
<td>Truck driver</td>
<td>To drive heavy goods vehicles to transport construction materials, building debris or excavated materials within, into or out of construction sites.</td>
</tr>
<tr>
<td>Welder</td>
<td>To carry out welding or cutting work by electric arc, oxy-acetylene flame or other welding processes.</td>
</tr>
</tbody>
</table>

Table 14: 20 trades of works commonly exist on Hong Kong construction sites
Figure 39: Interface design of Filling Information in Site Inspection (1)

Figure 40: Interface design of Filling Information in Site Inspection (2)
6.4.5 Reviewing Report

After completion of the Step 1 to Step 3, report is formed and it can be reviewed or edited by the user anytime. The size and creation date is shown once the report is finished. The user will jump back to the Step 1 page to start reviewing the report. Thus, the chosen photo(s) and filled information can be rectified by the user.
6.4.6 Exporting Report

Beside of reviewing report, the user can export the report into the PDF format if necessary so that it can be transferred to the computer or other people. The exporting format only can support PDF format now because of limit of time and technical problems, the other format including .DOCX will be developed in the future. The PDF format generated from i-Safe is shown in Appendix (D).

![Image of Exporting Report](image)

*Figure 43: Interface design of Exporting Report in Site Inspection*

6.4.7 Sending Report

After exporting into the PDF format, the user can email the relative reports to his colleagues to notify them. If the user decides to email the report, the in-built mail function in iPad will be provided. In the content of email, the document name and date will be shown by default system in i-Safe, the user can edit the content of email if necessary.
Figure 44: Interface design of Sending Report in Site Inspection
6.5 Risk Assessment

The part of risk assessment is designed to increase the reliability of making risk assessment. User can do the risk assessment report by completing only 2 steps in i-Safe. The reliability of risk assessment can be increased by studying safety information through internet and past accident records. The risk occurrence calculator tool is provided for the user to calculate the risk occurrence of different work trades which can be act as reference.

6.5.1 Working Process of Risk Assessment

When user decides to carry out the risk assessment, similarly, he starts with adding a new document. i-Safe would ask the user whether he really wants to carry out the further action. If he accepts the notification of seeing historical data, he can either search information on the internet or view the past statistics. On the other hand, if the user rejects the notification of seeing historical data, he would continue to conduct the risk assessment by filling in the information of the concerned activity. At the same time, he can decide to use the risk calculator to calculate the risk level of that activity which is act as reference. In the risk calculator, i-Safe will calculate the risk level of different work trades in Hong Kong. Then, he has to fill in the details of the concerned activity. Likewise, the risk calculator is provided for the user to use if necessary when he is filling the details of the concerned activity. Report would be formed when the above 2 steps are completed. User can decide to edit the created document to correct or update the content, or export it into PDF file, or email this report to colleagues, or delete the report if it is useless.
6.5.2 Functions of Risk Assessment

There are four main functions provided in the safety inspection section. It includes (1) Searching Updated Internet Source, (2) Statistics Finding, (3) Notification, (4) Filling Information, (5) Reviewing Report, (6) Exporting Report, (7) Sending Report. (5) Reviewing Report, (6) Exporting Report & (7) Sending Report are similar to that in site inspection section so they would not be discussed this time. The PDF format of risk assessment report generated from i-Safe is shown in Appendix (D).
6.5.3 Searching Updated Internet Sources

There are three major safety website provided for the user to browse and study before the conduction of risk assessment. They are [www.labour.gov.hk](http://www.labour.gov.hk) (Labour Department), [www.oshc.org.hk](http://www.oshc.org.hk) (Occupational Health and Safety Council) and [hkisa.org.hk](http://hkisa.org.hk) (Hong Kong Industrial Safety Association). They provide the most updated information of safety information such as the news of industrial accidents, seminar and conference related to the construction safety and legislation of the construction safety...etc. The web browser window would be activated after selection of website, hence, user can browse these webs so that they can gain more reliable information before determination of the risk level in risk assessment.
Figure 47: Interface design of Searching Updated Internet Sources in risk assessment

Figure 48: Interface design of Web Browser Window in Risk Assessment
6.5.4 Statistics Finding

The understanding of risk levels for different trades of works will be vital for the safety professionals in general practice in order to make risk assessment more realistic and thus past statistics of occupational injuries in construction industry from 2000 to 2011 is provided in i-Safe for the user to study the different kinds of injury each year. The statistics shown in i-Safe is retrieved from the Occupational Safety and Health Statistics every year published by Labour Department. Because of limit of time and storage in database, only 2010 to 2011 statistics is provided.

![Image of Risk Assessment Interface]

*Figure 49: Interface design of Statistics Finding in Risk Assessment*
6.5.6 Notification

This is the reminder function to remind the user to see and study more safety information first before conduction of risk assessment.
6.5.7 Filling Information

When designing the layout of the Filling Information in risk assessment, several attributes of characteristics of risk assessment report are included. Likewise, I have studied the criteria of risk assessment reports from several books and the risk assessment report from two large construction firms—Gammon Construction Ltd. and China State Construction Engineering (Hong Kong) Ltd (Appendix C) to investigate the important information in the risk assessment report. The following tables show the fields that the users have to input into the risk assessment.

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Text / Choice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contract No.</td>
<td>The contract no. of the construction project</td>
</tr>
<tr>
<td>Contractor</td>
<td>The name of the main contractor who is responsible to this construction project</td>
</tr>
<tr>
<td>Contract Name</td>
<td>The contract name of the construction project</td>
</tr>
<tr>
<td>Date</td>
<td>The date of carrying risk assessment</td>
</tr>
<tr>
<td>Activity</td>
<td>The name of activity in risk assessment</td>
</tr>
<tr>
<td>Situation</td>
<td>The situation of the activity</td>
</tr>
<tr>
<td>Hazard(s)</td>
<td>1. Striking against or struck by moving object</td>
</tr>
<tr>
<td></td>
<td>2. Injured whilst lifting or carrying</td>
</tr>
<tr>
<td></td>
<td>3. Slip, trip, or fall on same level</td>
</tr>
<tr>
<td></td>
<td>4. Fall of person from height</td>
</tr>
<tr>
<td></td>
<td>5. Trapped in or between objects</td>
</tr>
<tr>
<td></td>
<td>6. Stepping on object</td>
</tr>
<tr>
<td></td>
<td>7. Contact with moving machinery or object being machined</td>
</tr>
<tr>
<td></td>
<td>8. Exposure to or contact with harmful substance</td>
</tr>
<tr>
<td></td>
<td>9. Contract with electricity or electric discharge</td>
</tr>
<tr>
<td></td>
<td>10. Trapped by collapsing or overturning object</td>
</tr>
<tr>
<td></td>
<td>11. Struck by moving vehicle</td>
</tr>
<tr>
<td></td>
<td>12. Struck by falling object</td>
</tr>
<tr>
<td></td>
<td>13. Striking against fixed or stationary object</td>
</tr>
<tr>
<td>14. Contact with hot surface or substance</td>
<td></td>
</tr>
<tr>
<td>15. Injured by hand tool</td>
<td></td>
</tr>
<tr>
<td>16. Exposure to explosion</td>
<td></td>
</tr>
<tr>
<td>17. Injured by fall of ground</td>
<td></td>
</tr>
<tr>
<td>18. Exposure to fire</td>
<td></td>
</tr>
<tr>
<td>19. Others</td>
<td></td>
</tr>
</tbody>
</table>

**Further Details of Hazard(s)**

**Exposed Person/Party**
- All
- Working Party
- Lone Workers
- Public
- Others

**Existing Controls**

**The protective measures against the selected hazard(s)**

**Required Personal Protective Equipment**

1. Safety Helmet
2. Safety Shoes
3. Eye Protector
4. Breathing Apparatus
5. Safety Line
6. Stretcher
7. Explosion Proof Communication Equipment
8. First Aid Box
9. Explosion Proof Safety Helmet Lamp
10. Full-Body Safety Harness
11. Reflective Vest
12. Leather Glove
13. Ear Protector
14. Resuscitator
15. Lifting Appliances
16. Personal Alert System
17. Gas Monitor
18. Blower
19. Others

**Required Training Course**

1. Housekeeping
2. Fall of Objects
3. Fire Safety on Site
4. Electricity
5. Lighting, Ventilation and Welfare Facilities at Workplace
6. Abrasive Wheels
7. A Guide to Personal Protective Equipment
8. Manual Handling
9. Lifting Appliance
10. Lifting Gear
11. Safety Use of Material Hoist
12. Passenger Hoist
13. Load-Shifting Machinery
14. Drilling Rig
15. Working Safety with Hand Tool
16. Woodworking Machine
17. Air Compressor and Air Container
18. Storage of Materials
19. Flammable Liquid and Gases
20. Hazardous Substance
21. Excavation
22. Construction Work close to Public
23. Slope Work
24. Use of Working Platform
25. Safe Use of Ladder
26. Scaffolding
27. Confined Space
28. Work in Public Area
29. Adjacent to Water
30. Demolition Works
31. Electric Arc Welding
32. Gas Welding and Flame Cutting
33. Drilling Works
34. Others (Specific Training Course)

| Responsible Person | • Foreman  
|                    | • Subcontractor  
|                    | • Safety Officer  
|                    | • Qualified Person  
<p>|                    | • Others |</p>
<table>
<thead>
<tr>
<th>Date (Next Time to Assess)</th>
<th>The date of next risk assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probability Rating</td>
<td>• Highly Unlikely</td>
</tr>
<tr>
<td></td>
<td>• Unlikely</td>
</tr>
<tr>
<td></td>
<td>• Possibly</td>
</tr>
<tr>
<td></td>
<td>• Likely</td>
</tr>
<tr>
<td></td>
<td>• Certain</td>
</tr>
<tr>
<td>Severity Rating</td>
<td>• Very Low</td>
</tr>
<tr>
<td></td>
<td>• Low</td>
</tr>
<tr>
<td></td>
<td>• Medium</td>
</tr>
<tr>
<td></td>
<td>• High</td>
</tr>
<tr>
<td></td>
<td>• Very High</td>
</tr>
<tr>
<td>Residue Probability Rating</td>
<td>• Highly Unlikely</td>
</tr>
<tr>
<td></td>
<td>• Unlikely</td>
</tr>
<tr>
<td></td>
<td>• Possibly</td>
</tr>
<tr>
<td></td>
<td>• Likely</td>
</tr>
<tr>
<td></td>
<td>• Certain</td>
</tr>
<tr>
<td>Residue Severity Rating</td>
<td>• Very Low</td>
</tr>
<tr>
<td></td>
<td>• Low</td>
</tr>
<tr>
<td></td>
<td>• Medium</td>
</tr>
<tr>
<td></td>
<td>• High</td>
</tr>
<tr>
<td></td>
<td>• Very High</td>
</tr>
<tr>
<td>Safety Officer Signature</td>
<td>Signature of SO</td>
</tr>
</tbody>
</table>

*Table 15: Fields of Filling Information in Risk Assessment*

The 18 options in ‘Hazard(s)’ are the commonly types of accidents occurred in the Hong Kong construction industry with reference to the information published by the Labour Department (Labour, 2011).

The “Safety Officer Signature” is also provided for the user to sign his names in order to approve that the report is conducted or approved by him.
Table 16: 18 selected types of accidents commonly occurred in the Hong Kong construction sites

<table>
<thead>
<tr>
<th>Type of Accident</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Striking against or struck by moving object</td>
<td>Contact with moving machinery or object being machined</td>
</tr>
<tr>
<td>2. Injured whilst lifting or carrying</td>
<td>Exposure to or contact with harmful substance</td>
</tr>
<tr>
<td>3. Slip, trip, or fall on same level</td>
<td>Contact with electricity or electric discharge</td>
</tr>
<tr>
<td>4. Fall of person from height</td>
<td>Trapped by collapsing or overturning object</td>
</tr>
<tr>
<td>5. Trapped in or between objects</td>
<td>Struck by moving vehicle</td>
</tr>
<tr>
<td>6. Stepping on object</td>
<td>Struck by falling object</td>
</tr>
<tr>
<td>7. Contact with moving machinery or object being machined</td>
<td></td>
</tr>
<tr>
<td>8. Exposure to or contact with harmful substance</td>
<td>Contact with hot surface or substance</td>
</tr>
<tr>
<td>9. Contact with electricity or electric discharge</td>
<td>Injured by hand tool</td>
</tr>
<tr>
<td>10. Trapped by collapsing or overturning object</td>
<td>Exposure to explosion</td>
</tr>
<tr>
<td>11. Struck by moving vehicle</td>
<td>Injured by fall of ground</td>
</tr>
<tr>
<td>12. Struck by falling object</td>
<td></td>
</tr>
<tr>
<td>13. Striking against fixed or stationary object</td>
<td></td>
</tr>
<tr>
<td>14. Contact with hot surface or substance</td>
<td></td>
</tr>
<tr>
<td>15. Injured by hand tool</td>
<td></td>
</tr>
<tr>
<td>16. Exposure to explosion</td>
<td></td>
</tr>
<tr>
<td>17. Injured by fall of ground</td>
<td></td>
</tr>
<tr>
<td>18. Exposure to fire</td>
<td></td>
</tr>
</tbody>
</table>

Figure 52: Interface design of Filling Information in Risk Assessment (1)
Figure 53: Interface design of Filling Information in Risk Assessment (2)
6.6 Development Tools

There are three components to develop the iPad application successfully. They are X-code IDE, Interface Builder and IOS Simulator which is called X-code toolset and they are developed by the Apple for software development. The first version of X-code was released in 2003. These three tools are the only way to design, code and test the proposed iPad application. My project is focus on the first two blocks in the figure and the next two blocks would be done by programmer.

![Diagram of app development process]

*Figure 54: Progress of development of app*
6.6.1 X-code IDE

It is an Integrated Development Environment in Mac Operating System X. It contains code generation tool and supports compliers for different programming language like C, C++, Objective-C, Objective-C++, Java, etc. It also includes debugging function to identify any bugs during development of application without compilation.

Figure 55: Interface of X-code IDE
6.6.2 Interface Builder

It is application design software in a part of X-code toolset which is different from the prototypes mentioned above. The Interface Builder are provided for the apps developer (Programmer) and any designed things in the interface builder are supported by X-code, that means the designed layout and interface in the Interface Builder can programmatically interact the code in X-code. On the contrary, the prototypes are only for design purpose, my job is to design the templates of the app and send the design interface to the apps writer. The apps writer would copy my templates into Interface Builder by using the drawing tools and layout in IB. In this software, App’s writer can customize the interface and change its colour, front, animations and shadows. App’s writer can drag what they want into the view window of Interface Builder.

Figure 56: Interface of Interface Builder
6.6.3 IOS Simulator

IOS simulator is a very useful tool that can test the application without using the actual iPhone/iPod touch and iPad. So, after writing and designing the application, the IOS simulator would runs the application in same way as an actual IOS device. It is used to debug and test the application before installing in real iPad, as a result, user, designer, programmer can change and correct the layout and context if necessary when running the application in the IOS simulator. The tester can simulate touch gestures by using the mouse.

![Figure 57: Interface of IOS Simulator](image-url)
Chapter Seven

Operation of i-Safe

In this chapter, I am going to introduce the application of i-Safe. The content of the application guide is shown below and I would describe one by one in depth. A short video showing operation of i-Safe is also available online at http://www.youtube.com/watch?v=l7BpdbBAOv8.

Contents

7.1 Starting i-Safe

7.2 Creating a New Project

7.3 Site Inspection
   7.3.1 Step 1
   7.3.2 Step 2
   7.3.3 Step 3

7.4 Risk Assessment
   7.4.1 Step 1
   7.4.2 Step 2
   7.4.3 Browsing Internet Sources
   7.4.4 Studying Past Statistics

7.5 Deleting Report
7.1 Starting i-Safe

(1) Before starting i-Safe, you have to make sure that your iPad is up to the iOS 6.0 or higher version.

![Image of iPad settings]

Figure 58: Interface of setting page of iPad

(2) You have to rotate your iPad into landscape orientation, otherwise, screen of i-Safe cannot be displayed properly.

(3) Launch i-Safe in the interface of iPad.

![Image of i-Safe interface]

Figure 59: Interface of cover page of i-Safe
7.2 Create a New Project

(1) Tap the button “Start a New Project”

![Figure 60: Interface of main page of i-Safe](image)

(2) Tap the button “Safety Officer”

![Figure 61: Interface of role page of i-Safe](image)
(3) Input the name of document like “Final Year Project” into the “Document Name”

Figure 62: Interface of User Input of “Document Name” in site information page

(4) Input the contract number of the project like “2013427” into the “Contract No.”

Figure 63: Interface of user input of “Contract No.” in site information page
(5) Input the name of the contract like “City University of Hong Kong” into the “Contract Name”

![Image of user input of “Contract Name” in site information page]

Figure 64: Interface of user input of “Contract Name” in site information page

(6) Input the name of contractor like “Wong Ka Man” into the “Contractor”

![Image of user input of “Contractor” in site information page]

Figure 65: Interface of user input of “Contractor” in site information page
(7) Input the date by rolling the date bar

![Figure 66: Interface of user input of “Date” in site information page](image)

(8) Input the name of user like “Wong Ka Man” into the “Prepared By”

![Figure 67: Interface of user input of “Prepared By” in site information page](image)
(9) Input the location of site like “Kwai Tsing District Hong Kong” by typing or tapping the “...” icon.

![Figure 68: Interface of user input of “Location” in site information page](image)

(10) Tap the button “Next” to move on the next page.

![Figure 69: Interface of completion of site information page](image)
7.3 Site inspection

(1) Tap the button “Site Inspection” to conduct on-site inspection

![Figure 70: Interface of safety officer page](image)

(2) Tap the button “Add” to create the new inspection report

![Figure 71: Interface of content page of site inspection](image)
7.3.1 Step 1

(1) Tap the "+" icon to add the new image(s)

![Image of interface step 1 of site inspection]

*Figure 72: Interface of step 1 of site inspection*

Taking photo(s) from “Camera”

(2) Three button will be appeared and then choose “Camera”

![Image of interface taking photo(s) from Camera]

*Figure 73: Interface of taking photo(s) from "Camera" of step 1 of site inspection*
(3) Take the non-conformance photo by tapping “” button

![Figure 74: Interface of taking photo(s) of step 1 of site inspection](image)

Choosing photo(s) from “Album”

(2) Three button will be appeared and then choose “Album”

![Figure 75: Interface of choosing photo(s) from “Album” of step 1 of site inspection](image)
(3) Choose the image(s) in the camera roll

![Image of iSafe app interface](image1)

*Figure 76: Interface of choosing photo(s) from “Camera Roll” of site inspection (1)*

(4) Tap any images you want to add

![Image of iSafe app interface with selected images](image2)

*Figure 77: Interface of choosing photo(s) from “Camera Roll” of site inspection (2)*
(5) Edit image(s) if necessary

(6) Tap the button “Apply” when edition is completed

![Figure 78: Interface of editing photo(s) of step 1 of site inspection (1)](image)

(7) Tap the button “Done” to add the image(s) in the Step 1

![Figure 79: Interface of editing photo(s) of step 1 of site inspection (2)](image)
(8) Tap the button “Done” to move on the next step

![Image of the iSafe app interface showing non-conformances and corrections.

Figure 80: Interface of completion of step 1 of site inspection]

7.3.2 Step 2

(1) Input the non-conformance like “Working at Height” into “Type of Non-conformance(s)” by choosing the options in the rolling bar.

![Image of the iSafe app interface showing the user input of “Type of Non-conformance(s)”.

Figure 81: Interface of user input of “Type of Non-conformance(s)” in step 2 of site inspection]
(2) Input the details of the non-conformance like “Site inspection report 1, Worker does not safety line” into the “Descriptions”

![Image](image1.png)

*Figure 82: Interface of user input of “Description(s)” in step 2 of site inspection*

(3) Input the corrective measures like “Worker should wear safety line before working at scaffolding” into the “Corrective Action(s)”

![Image](image2.png)

*Figure 83: Interface of user input of “Corrective Action(s)” in step 2 of site inspection*
(4) Tap the button “Done” to move on the next step

![Image of iSafe interface]

*Figure 84: Interface of completion of step 2 of site inspection*

7.3.3 Step 3

(1) Input the name of the affected worker like “Tom” into the “Exposed Worker(s)”

![Image of iSafe interface]

*Figure 85: Interface of user input of “Exposed Worker(s)” in step 3 of site inspection*
(2) Input the work trade of the affected workers like “Bamboo Scaffolder” into the “Trade Type(s)” by choosing option in the rolling bar

Figure 86: Interface of user input of “Trade Type(s)” in step 3 of site inspection

(3) Input the subcontractor of the affected worker works for like “Chun Fat” into the “Subcontractor(s)”

Figure 87: Interface of user input of “Subcontractor(s)” in step 3 of site inspection
(4) Input the site inspection date into the “Inspection Date” by rolling the date bar

Figure 88: Interface of user input of “Inspection Date” in step 3 of site inspection

(5) Input the location of non-conformance like “2/F at Block 1” into the “Location”

Figure 89: Interface of user input of “Location” in step 3 of site inspection
(6) Input the completion date of the corrective action into the “Expected Completion Date” by rolling the date bar.

![Figure 90: Interface of user input of “Expected Completion Date” in step 3 of site inspection](image)

(7) Tap “[ ]” under the “Safety Officer Signature” to sign your name.

![Figure 91: Interface of user input of “Safety Officer Signature” in step 3 of site inspection (1)](image)
(8) Tap the button “Done” after signing your name

Figure 92: Interface of user input of “Safety Officer Signature” in step 3 of site inspection (2)

(9) Tap the button “Done” to produce “Site Inspection Report 1”

Figure 93: Interface of competition of step 3 of site inspection
(10) The site inspection report is formed

Figure 94: Interface of formation of site inspection report
7.4 Risk Assessment

(1) Tap the button “Risk Assessment” to conduct the risk assessment report

![Figure 95: Interface of safety officer page](image)

(2) Tap the button “Add” to create the new inspection report

![Figure 96: Interface of content page of risk assessment](image)
(3) You can tap the button “Yes” to go remain the content page or button “No” to go to the next page

![Figure 97: Interface of notification in risk assessment](image)

### 7.4.1 Step 1

1. Tap the button “No” to go to the next page

![Figure 98: Interface of notification in risk assessment](image)
(2) Input the number of contract, name of contractor and contract again into the “Contract No.”, “Contractor” and Contract Name” respectively

Figure 99: Interface of user input of “Contract No.”, “Contractor” and Contract Name” in step 1 of risk assessment

(3) Input date of conduction of risk assessment into the “Date” by rolling the date bar

Figure 100: Interface of user input of “Date” in step 1 of risk assessment
(4) Input the targeted assessment activity like “Steel Fixing” into the “Activity”

![Image](image1.png)

*Figure 101: Interface of user input of “Activity” in step 1 of risk assessment*

(5) Tap the “Done” button to move on to the next step

![Image](image2.png)

*Figure 102: Interface of completion of step 1 of site inspection of risk assessment*
7.4.2 Step 2

(1) Input the circumstances of the assessed activity like “Steel Fixing Works” into the “Situation”

(2) Input the hazard(s) exposed by the person/party like “Fall of person from height” into the “Hazard(s)” by choosing the options in the rolling bar

Figure 103: Interface of user input of “Situation” in step 2 of risk assessment

Figure 104: Interface of user input of “Hazard(s)” in step 2 of risk assessment
(3) Input the details of hazard(s) if necessary, in this case, no further description of hazard is required.

(4) Input the affect person or party like “Lone Workers” into the “Exposed Person/Party” by choosing the options in the rolling bar.

Figure 105: Interface of user input of “Exposed Person/Party” in step 2 of risk assessment

(5) Input the control measures like “Working Platform is provided when work location more than 2 meters from the ground” into the “Existing Controls”.

Figure 106: Interface of user input of “Existing Controls” in step 2 of risk assessment
(6) Input the required personal protective equipment like “Safety Helmet”, “Safety Shoes” “Safety Line” and “Leather Glove” when carry out this activity into the “Required Personal Protective Equipment” by choosing the options in the rolling bar

![Image of iSafe app interface](image1.png)

*Figure 107: Interface of user input of “Required Personal Protective Equipment” in step 2 of risk assessment*

(7) Input the required training course like “Working Safety with Hand Tool” and “Use of Working Platform” when carry out this activity into the “Required Training Course” by choosing the options in the rolling bar

![Image of iSafe app interface](image2.png)

*Figure 108: Interface of user input of “Required Training Course” in step 2 of risk assessment*
(8) Input the responsible person when carry out the assessed activity like “Foreman” and “Subcontractor” into the “Responsible Person”

![Image](image_url)

*Figure 109: Interface of user input of “Responsible Person” in step 2 of risk assessment*

(9) Input date of conduction of next risk assessment into the “Date (Next time to access)” by rolling the date bar

![Image](image_url)

*Figure 110: Interface of user input of “Date (Next time to access)” in step 2 of risk assessment*
(10) Input the probability, severity, residue probability and residue severity rating like “Unlikely”, “Medium”, Highly Unlikely” and Low into the “Probability Rating”, “Severity Rating”, “Residue Probability Rating” and “Residue Severity Rating” respectively by choosing option in the rolling bar.

<table>
<thead>
<tr>
<th>Rating</th>
<th>Probability</th>
<th>Severity</th>
<th>Residue Probability</th>
<th>Residue Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Certain</td>
<td>Very Low</td>
<td>Certain</td>
<td>Very Low</td>
</tr>
<tr>
<td>4</td>
<td>Likely</td>
<td>Low</td>
<td>Likely</td>
<td>Low</td>
</tr>
<tr>
<td>3</td>
<td>Possibly</td>
<td>Medium</td>
<td>Possibly</td>
<td>Medium</td>
</tr>
<tr>
<td>2</td>
<td>Unlikely</td>
<td>High</td>
<td>Unlikely</td>
<td>High</td>
</tr>
<tr>
<td>1</td>
<td>Highly Unlikely</td>
<td>Very High</td>
<td>Highly Unlikely</td>
<td>Very High</td>
</tr>
</tbody>
</table>

*Table 17: Rating of Probability, Severity, Residue Probability and Residue Severity*

![Image of iSafe App](image)

*Figure 111: Interface of user input of “Severity Rating”, “Residue Probability Rating” and “Residue Severity Rating” in Step 2 of risk assessment*

(11) Risk Level and Residue Risk Level will be displayed

<table>
<thead>
<tr>
<th>Risk Level (Probability x Severity) Residue Risk Level (Residue Probability x Residue Severity)</th>
<th>Colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>1x1, 1x2, 2x1, 2x2, 3x1</td>
<td>Green</td>
</tr>
<tr>
<td>1x3, 1x4, 2x3, 3x2, 3x3, 4x1, 4x2, 4x3, 5x1, 5x2, 5x3</td>
<td>Yellow</td>
</tr>
<tr>
<td>1x5, 2x4, 3x4</td>
<td>Orange</td>
</tr>
<tr>
<td>2x5, 3x5, 4x4, 4x5, 5x4, 5x5</td>
<td>Red</td>
</tr>
</tbody>
</table>

*Table 18: Calculation of risk level and their corresponding colour*
(12) Tap “________________” under the “Safety Officer Signature” to sign your name.

(13) Tap the button “Done” to produce risk assessment risk report of “Steel Fixing”.

(10) The risk assessment report is formed.

Figure 112: Interface of completion of step 2 of risk assessment

Figure 113: Interface of formation of risk assessment report
7.4.3 Browsing Internet Sources

(1) Tap the “🌐” icon to study the updated Internet Source

![Figure 114: Interface of content page of risk assessment](image1)

(2) Tap the website you want to visit like “Labour Department”

![Figure 115: Interface of website page of risk assessment](image2)
7.4.4 Studying Past Statistics

(1) Tap "chart" icon to study the past construction accident rates

Figure 116: Interface of website page of “Labour Department”

Figure 117: Interface of content Page of risk assessment
(2) Tap any years of the statistics like 2011 you want to study

![Figure 118: Interface of statistics page](image)

(3) The statistic of occupational injuries in construction industry at 2011 is displayed

![Figure 119: Interface of 2011 Statistic of occupational injuries in construction industry](image)
7.3 Deleting Report

(1) Tap the button “Delete” in the content page of either “Site Inspection” or “Risk Assessment”

![Figure 120: Interface of content page of site inspection (1)](image)

(2) Tap the icon to select the reports you want to delete

![Figure 121: Interface of content page of site inspection (2)](image)
(3) Tap the `Delete` icon to further confirm to delete the reports.

*Figure 122: Interface of content page of site inspection (3)*

*Figure 123: Interface of content page of site inspection (4)*
Chapter 8

Evaluation of i-Safe

In order to find out the feedback of i-Safe, I had conducted a interview with different aspects of safety professionals. During interview, i-Safe in iPad is provided for them to try and use and structured questionnaire was developed to collect feedback of i-Safe from the evaluators. The questionnaire has 5 sections, including the personal particulars, appraisal of i-Safe, and overview and further extension of i-Safe. The first section is used to ensure that the evaluators have certain experience in safety discipline to answer the questions. The second section is used to ensure that the evaluators have certain experience in using mobile application to answer the questions. Then the third part is used to evaluate the performance of the site inspection section. Also, the fourth part is used to evaluate the performance of the risk assessment section. Finally, the fifth part is used to find out the acceptability of i-Safe.

8.1 Evaluation Questionnaire Design

Part I: Personal Information

In order to ensure the reliability of the app evaluation, this section is used to gather information about the evaluators and make sure that they have certain experience in safety discipline.

Part II: Familiarity of i-Safe

It is used to ensure that they are familiar with the control of smart phones or tablets so as to make more reliable evaluation of app interface.

Part III: Appraisal of the Site Inspection Section in i-Safe, Part IV: Appraisal of the Risk Assessment Section in i-Safe

Section III and IV are further divided into two parts, Appraisal of interface and Appraisal of performance. They are used to evaluate the usability of the site inspection and risk assessment sections in i-Safe. The appraisal of interface refers to the evaluation of app design and layout. The appraisal of performance refers to the evaluation of adequacy and appropriateness of the site inspection and risk assessment content. A five scale point is used, which is included Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree (5 is the highest and 1 is the lowest). It allows the evaluator to select the most appropriate choice in describing their options. Additionally, it allows the evaluator to give further comment if necessary.
Part V: Overview of i-Safe

This section allows the evaluator to access the overall performance of i-Safe so as to find out the degree of acceptability and satisfactory of i-Safe.

8.2 Profile of evaluators

Five evaluators from different aspects of safety professionals were invited to evaluate usability and functionality of i-Safe. Their participation in this evaluation was on voluntary basis and the profile of the evaluators is shown in table below:

<table>
<thead>
<tr>
<th>Professionals</th>
<th>Company</th>
<th>Position</th>
<th>Experience in the business</th>
<th>No. of smart phones or tablets</th>
<th>Frequency of using apps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ivan Fung</td>
<td>City University of Hong Kong</td>
<td>Lecturer</td>
<td>10</td>
<td>2</td>
<td>Usually</td>
</tr>
<tr>
<td>S.K Lam</td>
<td>Gammon Construction Limited</td>
<td>Safety Manager</td>
<td>15</td>
<td>2</td>
<td>Often</td>
</tr>
<tr>
<td>Leo Wong</td>
<td>Gammon Construction Limited</td>
<td>Senior Safety Officer</td>
<td>7</td>
<td>3</td>
<td>Always</td>
</tr>
<tr>
<td>Dreams Tang</td>
<td>Construction Safety &amp; Engineering Consultants Limited</td>
<td>Safety Auditor</td>
<td>15</td>
<td>1</td>
<td>Usually</td>
</tr>
<tr>
<td>Ben Yu</td>
<td>China State Construction Ltd.</td>
<td>Safety Supervisor</td>
<td>6</td>
<td>2</td>
<td>Always</td>
</tr>
</tbody>
</table>

Table 19: Profile of evaluators

8.3 Evaluation of i-Safe

The purpose of inviting the above safety professionals is to evaluate the applicability of the i-Safe to site inspection and risk assessment, five different aspects of safety professionals were asked to complete the questionnaire and the result from those evaluators are summarized as below.
8.3.1 Site Inspection

I. Appraisal of interface

<table>
<thead>
<tr>
<th>Factors</th>
<th>Rating</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>User Friendly</td>
<td>4 1</td>
<td>4.80</td>
</tr>
<tr>
<td>Clear Instruction</td>
<td>4 1</td>
<td>4.80</td>
</tr>
<tr>
<td>Smooth Framework</td>
<td>5</td>
<td>5.00</td>
</tr>
<tr>
<td>Average:</td>
<td></td>
<td>4.87</td>
</tr>
</tbody>
</table>

(5 is strongly agree and 1 is strongly disagree)

Table 20: Result of i-Safe (site inspection) interface appraisal

I. Appraisal of performance

<table>
<thead>
<tr>
<th>Factors</th>
<th>Rating</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appropriate content</td>
<td>1 3 1</td>
<td>4</td>
</tr>
<tr>
<td>Understandable and suitable questions</td>
<td>2 2 1</td>
<td>4.2</td>
</tr>
<tr>
<td>Correct the problems of hand-written notes such as typos and arbitrary descriptions for safety issues</td>
<td>4 1</td>
<td>4.8</td>
</tr>
<tr>
<td>Correct the problems of hand-written notes such as inconsistent naming for same items safety issues</td>
<td>4 1</td>
<td>4.8</td>
</tr>
<tr>
<td>Time spent to complete site inspection is fast</td>
<td>3 2</td>
<td>4.6</td>
</tr>
<tr>
<td>Able to produce accurate site inspection reports</td>
<td>4 1</td>
<td>3.8</td>
</tr>
<tr>
<td>Average:</td>
<td></td>
<td>4.36</td>
</tr>
</tbody>
</table>

(5 is strongly agree and 1 is strongly disagree)

Table 21: Result of i-Safe (site inspection) performance appraisal

In the part I, the mean of appraisal of interface is 4.87 which implies that the assessors are satisfied with the interface of site inspection section in i-Safe. They found it is easy to use.

In the part II, the mean of appraisal of performance is 4.36, which reflect that the assessors are satisfied with the performance of site inspection section in i-Safe. They found it is correct the problems of handwritten notes and the time of carry out site inspection using i-Safe is fast.
### 8.3.2 Risk Assessment

#### I. Appraisal of interface

<table>
<thead>
<tr>
<th>Factors</th>
<th>Rating</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5 4 3 2 1</td>
<td></td>
</tr>
<tr>
<td>User Friendly</td>
<td>4 1</td>
<td>4.80</td>
</tr>
<tr>
<td>Clear Instruction</td>
<td>4 1</td>
<td>4.80</td>
</tr>
<tr>
<td>Smooth Framework</td>
<td>5</td>
<td>5.00</td>
</tr>
</tbody>
</table>

Average: 4.87

(5 is strongly agree and 1 is strongly disagree)

*Table 22: Result of i-Safe (risk assessment) interface appraisal*

#### I. Appraisal of performance

<table>
<thead>
<tr>
<th>Factors</th>
<th>Rating</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5 4 3 2 1</td>
<td></td>
</tr>
<tr>
<td>Appropriate content</td>
<td>4 1</td>
<td>3.8</td>
</tr>
<tr>
<td>Understandable and suitable questions</td>
<td>1 3 1</td>
<td>4</td>
</tr>
<tr>
<td>The 'Updated Internet Sources' provides enough risk information and expert instructions</td>
<td>4 1</td>
<td>4.8</td>
</tr>
<tr>
<td>The 'Past Statistics' can help me to determine the risk level of particular work trade more reliable</td>
<td>3 2</td>
<td>4.6</td>
</tr>
<tr>
<td>The notification function can remind me not to do the risk assessment carelessly</td>
<td>4 1</td>
<td>4.8</td>
</tr>
<tr>
<td>Able to produce accurate risk assessment reports</td>
<td>4 1</td>
<td>3.8</td>
</tr>
</tbody>
</table>

Average: 4.3

(5 is strongly agree and 1 is strongly disagree)

*Table 23: Result of i-Safe (risk assessment) performance appraisal*

Similarly, the mean of appraisal of interface is 4.87 in Part I. The assessors are satisfied with the interface of the risk assessment section in i-Safe, they think it has clear step to instruct them how to do and user friendly.
In the part II, the mean of appraisal of performance is 4.3 which is slightly lower than that of the site inspection, it is because the accuracy of the risk assessment report depends on the so many factors and it is difficult to include all of the factors in the i-Safe in such a limited time.

8.3.3 Overview of i-Safe

![Satisfactory of overall performance of i-Safe](image1)

*Figure 124: Satisfactory of overall performance of i-Safe*

![Recommendation to colleagues](image2)

*Figure 125: Recommendation to colleagues*

The results are positive, all the assessors think i-Safe is a useful tool for them to carry out site inspection and risk assessment and they would recommend to their colleagues.
Chapter 9

Discussion

9.1 Problems Encountered

Although there are hundreds thousands of apps available on the app store, “Development of a Safety Mobile App” is a challenge task. When people heard about apps, they always think that it is an easy work because they touch with myriads of apps in their phones a day. As, I have never created the mobile apps before, everything is strange and fresh for me. From the preparation to completion of my final year project, I face different kinds of problems including knowledge, technical and communication problems.

9.1.1 Time limitation

The final year project was started form September 2012 to April 2011. It is a tight schedule to develop a well-structured, good functionality and organizational application in half year. In the apps market, the high-volume, mission-critical application has to develop at least one year by a technical team. For me, this half year is a very short time to complete all the prepared ideas. For programmer, half year is also a very short time to write some new coding language he never wrote before. As a result, some of the functions in the app are still on the progress and they would be discussed in the Chapter 9 – Recommendation and Further Development.

9.1.2 Resources limitation

Mobile application on construction safety is new and innovative topic in the construction industry, and there are extremely less similar topics or related researches on the internet and library. Thus, it is a great
challenge for me to do this final year project because the approach to my final year project is completely different in the current construction safety paper, journals and researches.

To solve this problem, I studied the other paper and books which are related to the apps development in other discipline. Moreover, I also studied the researches which are related to the web development in the construction industry.

9.1.3 Technical Knowledge Limitation

Since I am not a computer science student, my technical knowledge is limited and basic. During the design of i-Safe, I don’t know there are some constraints in the development of apps because of my ignorant of technical knowledge. For example, tables within column cannot be formed in the apps and other than ‘back’ button, the apps must be gone in forward way. And this also causes the communication problems between me and the programmer. I am responsible for creating the aesthetics of the application while the programmer is responsible for the writing the application. Frequently, I was not always aware of the technical constraints the programmer faced, so parts of the design are technically impossible to complete within the timeframe. Because of this, many times are wasted on the redesign of the Interface and discussion of possibility of the design.

To solve this problem, I studied the knowledge of the development of IOS application in order to realize the constraints of the design and have a better communication with programmer.
9.2 Benefits of i-Safe in construction industry

9.2.1 Time Efficiency

i-Safe is an effective electronic-based tool kit to conduct site inspection and risk assessment. It can help safety professionals eliminate the double entry of recorded data, which in turn minimize the input errors caused by typos and inconsistency of safety issues. Moreover, other benefits such as automatic generation of reports and faster distributions of electronic data can result in reduction of time compared with conventional scanned and manual distributed methods. Hence, the time for preparing safety records is greatly reduced and can contribute to the good quality of safety records.

9.2.2 Mobility

The probability of i-Safe allows user to take their work with them whatever they go. User only takes the handheld iPad device to walk on-site instead of taking bulky and obstructive report forms or checklists. Moreover, users can conduct or modify their works in i-Safe anywhere instead of postponing the works until they reach their office or home.

9.2.3 Easy Management for Documentation

By storing the data in the database, the process of handle, batch, store and retrieve bulk of paper work can be shortened and the management of safety records becomes easy, fast and effective. In the long run, labour force of doing the above processes can be saved, making the management of document more efficiency.
9.2.4 Reduction of Paper and Printing Usage (More Environmental Friendly)

Since the data are electronically stored in the database, the paper-based document will no longer be existed, there is physically great reduction in paperwork and storage required. Thus, all information can be conserved while the limited and expensive office space can be better utilized. In the long term, company can even save money for renting office with less space for storing the hardcopy of documents. Better still, the reduction of paper can also achieve the environmental goals in the construction site.

9.2.5 Information Retrieval

User are able to quickly get the specific information needed at a given moment without having to wade through files, incoming mail, faxes and other documents ped all over the office. The site inspection and risk assessment report can be edited or reviewed by the user anytime, every where. In addition, by using features of app, the photos and reports are retrieved more quickly than traditional paper-based system, which can also be traceable.

9.2.6 Quality of the Safety Records

As mentioned above, the typing errors and the data inconsistency raised by arbitrary description of safety issues can be reduced, then improve the quality of the safety records. By completing the several steps in i-Safe, the format, style and content in the reports are clear, smooth and simple. Furthermore, by studying the relevant regulations and codes of practices, past statistics and internet sources in i-Safe before execution of site inspection and risk assessment, the standards and quality of the reports are greatly increased.
9.2.7 Interactive Communication Internally

The mail functions in i-Safe are designed to encourage more workers engagement with their email communications. The sender can send either site inspection or risk assessment report to his colleagues for confirmation or perusal via email in i-Safe while the receiver can provides some comments or solutions for the receiver. As a result, i-Safe allows different safety aspects of user to exchange their information.

9.2.8 Cost-benefit

The cost involved in implementing i-Safe is only purchase of i-Safe while the other costs like maintenance, upgrading are not employment of technical support personnel are not required. Besides, at a practical level, the documents are distributed more cheaply than traditional paper-based system. It will save the cost of printing hard copy, distribution and storage. Hence, the expenses of implementing i-Safe are cheaper compared with other computer softwares, and it is no doubt beneficial to the company.
9.3 Shortcomings of i-Safe

i-Safe has been tested by several safety professionals. They raised some weaknesses of i-Safe. There are two main drawbacks of i-Safe which are concluded from the 5 evaluators, they are security issue and resistance for people.

9.3.1 Security issue

Security is one of the most challenging topics faced by all application. As there are no security system in i-Safe, people who are not the safety professionals but has installed this application can use the functions in i-Safe. Beside, other people can edit the content of report in i-Safe using the user’s iPad easily. As a result, login functions must be provided in i-Safe and this would be discussed in Chapter 9 – Recommendation and Further Development.

9.3.2 Resistance for people

Gerstein (1997) said that “application of IT that alter the firm’s core technology, and which are therefore closely related to its culture, may be fiercely resisted”, especially in the extremely traditional construction industry. The workers in this industry are relatively older than that in other industries, hence, the acceptability of the information technologies are low and they would insists to use conventional practices rather than trying new and innovative practices.
Chapter Ten

Recommendation and Further Development

10.1 Under Construction

Given of the limitation of time, some of the pages in i-Safe are still developing. In order to let the reader to have better understanding of the content of i-Safe, I would list out the developing functions or pages.

1. Email Function
2. Export Function
3. 2000 to 2009 statistics of Occupation Injures in Construction Industry
4. Reviewing Record Page
5. Notification Page
6. Reference Page
7. Tool Page
10.2 Refinement

Although there are already some built-in functions and information in i-Safe but they are not robust and smart enough. This part is to describe the enhancement of the exiting functions and information in i-Safe. The new functions and information would be described in the next part and these proposed functions and information would be developed in the foreseeable.

1. Stronger Database

As this project is very new, the database is not built strongly and the stored data is limited. The more constructible and giant database would be built in order to hold more created reports, functions and information.

2. More Useful Web-site

There are only three embedded website in the risk assessment section. The more useful website including the other countries related to the construction safety can be developed in the i-Safe to provide more information, instructions, and advice to the safety professionals. After interviewing with several safety professionals in different job position, they recommend the following websites should be provided in i-Safe

3. More Past Statistic Records

The preset statistics in i-Safe is the occupational industries including industrial accidents in the construction industry. The other types of statistic like the industrial accidents and occupational diseases in the construction industry can be developed into i-Safe. If necessary, the other industries like manufacturing and Food and Beverage Services accident records with comparison of construction industry can be provided for the user so that they can have a fully comprehensive of safety performance in the construction industry. Moreover, the presentation of statistic records can be in the form of pie or bar chart other than table so as to let the user to have better understanding of the statistic.

4. More Photos Taken

In i-Safe, maximum number of the photo(s) taken in the non-conformance and correction part are 5 respectively. With the stronger database, more photo(s) can be taken by the user to produce a more detailed safety reports.
5. More format of the reports

As mentioned in the previous chapter, the format of the reports can be saved in .docx other than pdf file. As a result, the user can edit the reports in the computer once received the reports by email or trailer connection.
10.3 Recommendation and Further Extensions

1. Android Version

In this final year project, after the consideration of serious factors, iPad is chosen for the development platform. But with the increasing competitors in the tablets industry, android version of i-Safe should be developed so that more people can download and use i-Safe.

2. Chinese Version

As the construction industry in Hong Kong is very conservation, most of site documents in the construction site are Chinese. Moreover, many safety professionals especially safety supervisors prefer to see the Chinese words rather than English. Nowadays, there are none of the Chinese version of apps related to the construction safety available on the apps market. As a result, in order to attract and satisfy more users, Chinese version of i-Safe should be developed.

3. Login Page

To meet the security issue, login page is provided for different kinds of user. The user has to login to i-Safe when it is launched in iPad every times. Therefore, the privacy of user can be protected.

4. Check-lists

Different types of checklist would be developed in i-Safe like daily inspection checklist, weekly inspection checklists.

A comprehensive and all-round checklist would be developed in i-Safe. Tang (2003) suggested that the items in checklist should include the following items:

<table>
<thead>
<tr>
<th>Site Layout</th>
<th>Site hoarding and covered walkway</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site layout</td>
<td>Site fence and main entrance</td>
</tr>
<tr>
<td></td>
<td>Internal transit and drive way</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Excavation work</th>
<th>Shoring and support</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ladder and other access</td>
</tr>
<tr>
<td></td>
<td>Safety barrier</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Working platform</th>
<th>Base plate and ground support</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vertical, lateral and diagonal supports</td>
</tr>
<tr>
<td></td>
<td>Safety railing and toe boards</td>
</tr>
<tr>
<td>Item</td>
<td>Safety control measures</td>
</tr>
<tr>
<td>---------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| Ladder                    | Location of steel ladder – away from high voltage over-head cable  
Positioning of the top portion of ladder - to prevent side way movement  
Sufficient supply of fresh air/ removal of toxic gases |
| Structural steel installation | Provision of working platform  
Fixing points for safety belt  
Safety net  
Competent and qualified operatives  
Reverse signaling and banks-man |
| Demolition                | Reference to structural drawings and as-built drawings  
Provision of working platform  
Removal of debris to prevent overloading |
| Work in confined space    | Sufficient supply of fresh air/ removal of toxic gases                                                                                                  |
| Transportation            | Inspection and maintenance of transportation vehicles  
Weekly inspection and inspection report  
Including loading and handling distance |
| Tower crane/ mobile crane | Inspection and testing certificate  
Unobstructed access and egress  
Storage for inflammable goods |

*Table 24: Items should be included in checklists (Sources: Tang, 2003)*

5. **Enlarging Target User**

Safety should not be solely responsible by the safety staff, but should be everyone in the construction site. Because of this, the users of i-Safe should not be restricted to the safety professionals only, management team, engineers and workers can use i-Safe to access safety in the future and corresponding functions would be provided for different types of user.
Reference

2. Occupational Safety and Health Statistics 2011, Occupational Safety and Health Branch, Labour Department
13. Rowlinson, S. (2003), Hong Kong Construction – Safety Management and the Law, Tomasin, Hong Kong


44. Apple Inc. financial statements, 2013
45. Apple Reveals Impressive Sales and Usage Statistics, 2012
46. Daivid Chartier of Agile Web Solutions, 2005
47. MySQL Database Usage & Administration, 2010, Vikram Vaswani
Appendix A

1. Safety Inspection checklists from Gammon Construction Ltd.

2. Safety Inspection checklists from China State Construction Engineering (HK) Ltd.
# Safety Supervisor Daily Inspection Checklist

**Date of Inspection:**

**Time of Inspection:**

<table>
<thead>
<tr>
<th>A. Workplace Safety</th>
<th>Satisfactory</th>
<th>Needs Improvement</th>
<th>Not Applicable</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Safe means of access to and egress from provided for all workplaces.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Materials &amp; equipment are properly stacked &amp; stored.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Sufficient no. of rubbish bins has been provided. Scrap, waste and debris are being removed at regular intervals.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Loose / stored materials are unobstructing access and passageways.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Floor openings are covered or fenced off.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Guardrails, netting and toe boards are provided to protect workers and objects falling from elevated level.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Flammable liquids and gases are stored properly.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. No presence of dangerous protrusions, e.g. projecting nails on timbers, re-bar etc.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Dust control measures have been taken.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Signage was insufficient.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B. Personal Protective Equipment (PPE)</th>
<th>Satisfactory</th>
<th>Needs Improvement</th>
<th>Not Applicable</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Workers are wearing the appropriate PPE.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Personal protective equipment is in good condition.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>C. Excavation</th>
<th>Satisfactory</th>
<th>Needs Improvement</th>
<th>Not Applicable</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Provide adequate shoring to excavation.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Open cut to a safe angle.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Excavation has been inspected by competent person and issued Form 4.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Safe means of access/egress provided for excavation.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. No material or heavy equipment placed to the edge of</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### D. Scaffolding & Working Platforms

1. Top and intermediate guardrails has been installed.
   - 已安裝頂部護欄及中欄。
2. Toe boards has been installed.
   - 已安裝踢腳板。
3. Scaffold and working platforms has been properly planked.
   - 橋架及工作台的地板已鋪密。
4. Statutory Form 5 has been issued by Competent Person and effective.
   - 已由合資格人士簽發有效的表格五。
5. Safe access provided for scaffold / working platform.
   - 已提供安全的通道上落橋架或工作台。

### E. Temporary Works

The formal procedures (QMS-06) to control the design, erection, loading and unloading of formwork, falsework, scaffolding or excavation support system have been communicated to the relevant Engineers and workers – with all Temporary Work certificates such as ICE Certs, RPE Certs, TWC permits etc in place.

### F. Confined spaces

1. Permit-to-work system has been implemented for identified confined spaces.
   - 界定的密閉空間已實施工作許可證系統。
2. All required safety equipment such as breathing apparatus / safety harness / resuscitator / alarm system are in place for confined space works.
3. Watchful person and workers with valid certificate.

### G. Lifting appliances and lifting gears

1. Operators with valid and appropriate licenses.
2. Trained banksman and rigger are presented for lifting operations.
3. Valid certificates for lifting appliance and lifting gear are in place.
4. Colour Coding for LG is correct and up to date.
### H. Electricity

1. Weather-proof electric socket and armour cable are used outdoors.
   - 電氣插頭及電纜必須是防水及配有金屬保護套。
2. Temporary lighting and electrically powered hand-held tools and equipment rated at 110V.
   - 間時照明及電動手工具及用具均需使用110V電壓。
3. Generator, welding machines etc. are properly earthed with all exposed conductors properly covered.
   - 發電機、焊接機械等均需適當接地及所有暴露的電纜需妥善包裹。
4. Distribution boards are locked.
   - 分電箱需鎖上。
5. Distribution boards displayed with suitable warning signs, name and contact number of assigned electrical workers.
   - 分電箱貼上醒目的警告標示，寫明電工名稱及聯絡電話。
6. Cables were properly hung up.
   - 電線吊掛適當。

### I. Fire precautions

1. Adequate fire fighting equipments have been provided and are in good working condition.
   - 足夠的滅火器並保持良好的使用狀態。
2. Hot work permits system is in place and being followed.
   - 已建立熱工作許可證制度及被遵守。
3. Adequate emergency routing signage, contact numbers, instructions in case of fire are posted.
   - 資訊貼足夠的火警緊急路線，聯絡電話及指引。

### J. Plant, Machinery, Equipment

1. All dangerous moving parts of machines and equipment are enclosed or adequately guarded.
   - 所有機械的轉動危險部份已有護罩或隔離。
2. Machine has been equipped with emergency stop button.
   - 機械已安裝緊急停止按掣。
3. Only persons who have been properly trained and authorized are operating Plant & Equipment.
   - 操作機械的人仕均是已受訓及授權的。
4. Compressed air hose connections are equipped with whip check to prevent them becoming dislodged.
   - 壓縮氣體管已裝上緊急扣以防止絆倒。
5. All plants are fitted with the requisite safety devices such as flashing warning lights, rear view mirrors, warning probes etc.
   - 所有機械已裝上安全設施如閃燈、倒後鏡、警報等。
<table>
<thead>
<tr>
<th>K. Public Area 公眾地方</th>
<th>Satisfactory 滿意</th>
<th>Needs Improvement 需改善</th>
<th>Not Applicable 不適用</th>
<th>Location 位置</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Working areas outside hoarding are properly enclosed to prevent unauthorized entry. 圍欄外的工作地方已經適當圍封避免公眾人仕進入。</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>2. Materials and equipment placed at areas outside hoarding area have been properly fenced off and in a secure manner. 放置在圍欄外工作地方的物料及工具已安全地存放及圍封。</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>3. Cabin of plants at working areas outside hoarding has been locked and ignition key has been removed to prevent unauthorized operation. 放置在圍欄外工作地方的機械禦室已上鎖及拿走點火匙。</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>4. Sufficient signage has been provided. 已提供足夠的指示。</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

*Please ✓ the appropriate box.

Details of findings / follow-up actions:

____________________________________________________________________________________
____________________________________________________________________________________
____________________________________________________________________________________
____________________________________________________________________________________

Prepared By: ___________________________ Safety Supervisor: ___________________________
Name: Leung Pui Wah
Date: ___________________________

Endorsed By: ___________________________ Safety Officer: ___________________________
Name: Lai Yin Ling
Date: ___________________________
每週泥坑及沙井建造檢查表

Excavation and Manhole Construction Weekly Checklist

<table>
<thead>
<tr>
<th>項目</th>
<th>Condition</th>
<th>不適用</th>
<th>備註</th>
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<tr>
<td>Date of Inspection</td>
<td>Location</td>
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<td></td>
</tr>
<tr>
<td>項目</td>
<td>項目</td>
<td>項目</td>
<td>項目</td>
</tr>
<tr>
<td>Items</td>
<td>Condition</td>
<td>Not applicable</td>
<td>Remarks:</td>
</tr>
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<td>項目</td>
<td>項目</td>
<td>項目</td>
<td>項目</td>
</tr>
<tr>
<td>Excavation</td>
<td>Excavation in safe angle</td>
<td>Excavation edge clear of materials</td>
<td>Warning Signage in Place</td>
</tr>
<tr>
<td>1. 坑邊圍封 / 圍欄</td>
<td>Condition of barriers / fencing</td>
<td>Access and egress to excavation</td>
<td>Form 4 displayed and valid</td>
</tr>
<tr>
<td>2. 出入通道</td>
<td>Access and egress to excavation</td>
<td>Excavation in safe angle</td>
<td>Excavation edge clear of materials</td>
</tr>
<tr>
<td>3. 已張貼有效法定表格四</td>
<td>警告標貼</td>
<td>Warning Signage in Place</td>
<td>Manhole covered securely with signage</td>
</tr>
<tr>
<td>4. 泥坑斜度安全</td>
<td>Shoring for excavation in place</td>
<td>曬井標貼</td>
<td>曬井標貼</td>
</tr>
<tr>
<td>5. 泥坑邊緣沒有物料</td>
<td>曬井標貼</td>
<td>曬井標貼</td>
<td>曬井標貼</td>
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<td>6. 泥坑支樑</td>
<td>曬井標貼</td>
<td>曬井標貼</td>
<td>曬井標貼</td>
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<tr>
<td>7. 警告標貼</td>
<td>曬井標貼</td>
<td>曬井標貼</td>
<td>曬井標貼</td>
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</tbody>
</table>

*請在適當地方加上 ✓ 號 Please tick the appropriate

巡查人員名稱 : 
Name of Inspector :

巡查人員職位 : 
Position of Inspector :

巡查人員簽署 : 
Signature of Inspector :
### Air Compressor Daily Checklist

**Date of Inspection**

**Plant Permit No.**

<table>
<thead>
<tr>
<th>項目</th>
<th>狀況</th>
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<tr>
<td>1. 嚴管狀態</td>
<td>Condition of Hoses</td>
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<td>Poor</td>
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<td>2. 連接器狀態</td>
<td>Coupler</td>
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<td>3. 防甩振設備安裝</td>
<td>Anti-Whip Devices</td>
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<td>4. 狀態掛</td>
<td>Hose hang-up</td>
<td></td>
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<tr>
<td>5. 滴水托盤</td>
<td>Drip Tray</td>
<td>In Place</td>
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</tr>
<tr>
<td>6. 異壓空壓機外殼</td>
<td>Compressor Outer Casing</td>
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<td>7. 警告標誌</td>
<td>Warning signage</td>
<td>in Place</td>
<td></td>
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<tr>
<td>8. 火焰筒</td>
<td>Fire Extinguisher</td>
<td>In Place</td>
<td></td>
</tr>
<tr>
<td>9. 資料 ...</td>
<td>Form</td>
<td>2 Displayed</td>
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*請在適當的地方加上 ✓ 請標Please tick the appropriate

**Name of Inspector**

**Position of Inspector**

**Signature of Inspector**
**Fire Patrol Daily Checklist**

<table>
<thead>
<tr>
<th>Items</th>
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<tbody>
<tr>
<td></td>
<td>Good</td>
<td>Poor</td>
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**Date of Inspection:**

**Time of Inspection:**

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<th>No.</th>
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<tbody>
<tr>
<td>1.</td>
<td>Saw dust from circular saw / other task</td>
</tr>
<tr>
<td>2.</td>
<td>Chemical waste storage area</td>
</tr>
<tr>
<td>3.</td>
<td>Location of fire extinguisher</td>
</tr>
<tr>
<td>4.</td>
<td>Container office</td>
</tr>
<tr>
<td>5.</td>
<td>Slag from hot work</td>
</tr>
<tr>
<td>6.</td>
<td>FBA / Cable / Plugs</td>
</tr>
<tr>
<td>7.</td>
<td>General rubbish</td>
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<td>8.</td>
<td>Others:</td>
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*Please tick the appropriate*
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<tbody>
<tr>
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<td>2</td>
<td>Safety Vest</td>
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<td>3</td>
<td>Safety Shoes</td>
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<td>4</td>
<td>Gloves</td>
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<td>5</td>
<td>Ear Protectors</td>
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**Remarks**

<table>
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</table>

**Personal Protective Equipment Daily Checklist**

**Name**

**Date**

**Company**

**Inspector**

**Signature of Inspector**

**Key**

- A: Acceptable at time of inspection
- B: Needs to be replaced within next month
- C: Damaged or missing, immediately report
- D: Incomplete, check current PPE
- N: Not applicable

---

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安全設施每日檢查表

檢查人員姓名：_____ 座數：___ 檢查日期：

<table>
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<tr>
<th>項目</th>
<th>星期一</th>
<th>星期二</th>
<th>星期三</th>
<th>星期四</th>
<th>星期五</th>
<th>星期六</th>
<th>備註</th>
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<td>樓面</td>
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<tr>
<td>樓邊圍欄及踢腳板</td>
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<td>竹框</td>
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<tr>
<td>太陽傘及水</td>
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<tr>
<td>滅火筒及沙筒</td>
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| 升降機槽安全門 |        |        |        |        |        |        |      |
| 地洞 |        |        |        |        |        |        |      |
| 樓邊圍欄 |        |        |        |        |        |        |      |
| 樓頂圍欄 |        |        |        |        |        |        |      |
| 開士機及工人 |        |        |        |        |        |        |      |

149
<table>
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<tr>
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<td>緊急出口牌</td>
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<td>滅火器及沙筒</td>
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<td>其他</td>
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<td>工作台</td>
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安全設施每日檢查表

檢查人員姓名：__________ 座數：____ 檢查日期：__________

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<th>星期三</th>
<th>星期四</th>
<th>星期五</th>
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<td>太陽傘及水</td>
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<td>滅火筒及沙筒</td>
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**簽署**

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**Final Year Project 2012/2013**
**The Development of Mobile App (i-Safe) for Safety and Risk Assessment in Civil & Building Construction Site**
Appendix B

1. Site inspection report from Gammon Construction Ltd.

2. Site inspection report from China State Construction Engineering (HK) Ltd.
### Photo Records

<table>
<thead>
<tr>
<th>Findings</th>
<th>Action Taken</th>
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<table>
<thead>
<tr>
<th>Location:</th>
<th>Rectified Action:</th>
</tr>
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<tbody>
<tr>
<td>Deficiency:</td>
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<tr>
<td>Rectify Before:</td>
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<table>
<thead>
<tr>
<th>Findings</th>
<th>Action Taken</th>
</tr>
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<table>
<thead>
<tr>
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<th>Rectified Action:</th>
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<tbody>
<tr>
<td>Deficiency:</td>
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</tr>
<tr>
<td>Rectify Before:</td>
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Prepared By:  
(Contractor’s representative)

Endorsed By:  
(Architect’s representative)

Endorsed By:  
(Architect’s representative)

Signature: ____________________________  Signature: ____________________________  Signature: ____________________________

Name: Lam Yin Ling (Safety Officer)  Name: K.C. Mok (PBSI)  Name: TK Ng (COW)

Date: ____________________________  Date: ____________________________  Date: ____________________________

K./

ZERO HARM
地盤安全及健康檢查情況改正計劃表

<table>
<thead>
<tr>
<th>項目</th>
<th>需要更正行動</th>
<th>地點</th>
<th>負責人</th>
<th>預計完成日期</th>
<th>跟進日期及情況</th>
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<tr>
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<tr>
<td>4</td>
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審批：_________ 編制：_________  (鄭少強—地盤代表)  (陳偉德—安全主任)  (王麗瑩—助理安全主任)  (黃儀新—助理安全主任)
Appendix C:


2. Risk Assessment Report from China State Construction Engineering (HK) Ltd.
### Confined Space Risk Assessment Report – 密閉空間風險評估報告

<table>
<thead>
<tr>
<th>Activity</th>
<th>Project</th>
<th>Location</th>
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<td>從事工作</td>
<td>Confined Space</td>
<td>高山劇場附翼建築</td>
</tr>
<tr>
<td>設備地點</td>
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<td>高山劇場附翼外圍-售票處</td>
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</table>

<table>
<thead>
<tr>
<th>Likelihood (可能性)</th>
<th>Consequence (嚴重性)</th>
<th>Risk Level (風險等級)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. 非常高</td>
<td>RED</td>
<td>Extreme Risk (高風險)</td>
</tr>
<tr>
<td>4. 高</td>
<td>ORANGE</td>
<td>Significant Risk (中等風險)</td>
</tr>
<tr>
<td>3. 一般</td>
<td>YELLOW</td>
<td>Moderate Risk (中等風險)</td>
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<tr>
<td>2. 低</td>
<td>GREEN</td>
<td>Low Risk (低風險)</td>
</tr>
<tr>
<td>1. 非常低</td>
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<td></td>
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</table>

<table>
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<tr>
<th>Situation 情況</th>
<th>Hazard 危害</th>
<th>Likelihood 可能性</th>
<th>Consequence (嚴重性)</th>
<th>Risk Level (風險等級)</th>
<th>Precautions 經濟措施</th>
<th>Residual Risk 剩餘風險</th>
<th>Responsible Person 負責人</th>
</tr>
</thead>
<tbody>
<tr>
<td>當工人進入沙井 進行清掃及相關工作（使用小型旋桿機、升降機）</td>
<td>必須有人監視之有毒氣體，與有害性氣體的蒸氣或塵埃</td>
<td>2</td>
<td>5</td>
<td>10 (RED)</td>
<td>1. 警用於沙井前，先由合資格人士從外進行氣體測試。氣體測試為分不同深度進行。 2. 進入沙井前，需加設及啟動吹風機及將吹風機引至沙井。</td>
<td>5 (YELLOW)</td>
<td>警用於沙井前，先由合資格人士從外進行氣體測試。氣體測試為分不同深度進行。</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3. 當測量沙井內有有毒性氣體存在，不可進入沙井。</td>
<td></td>
<td>管工</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4. 如果測量所有通往沙井的管道，必須立即關閉塞上。</td>
<td></td>
<td>管工</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5. 在沙井頂開通氧氣孔。</td>
<td></td>
<td>管工</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>管工</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Activity</th>
<th>Project</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>從事工作</td>
<td>Confined Space</td>
<td>高山劇場附翼建築</td>
</tr>
<tr>
<td>設備地點</td>
<td></td>
<td>高山劇場附翼外圍-售票處</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Likelihood (可能性)</th>
<th>Consequence (嚴重性)</th>
<th>Risk Level (風險等級)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. 非常高</td>
<td>RED</td>
<td>Extreme Risk (高風險)</td>
</tr>
<tr>
<td>4. 高</td>
<td>ORANGE</td>
<td>Significant Risk (中等風險)</td>
</tr>
<tr>
<td>3. 一般</td>
<td>YELLOW</td>
<td>Moderate Risk (中等風險)</td>
</tr>
<tr>
<td>2. 低</td>
<td>GREEN</td>
<td>Low Risk (低風險)</td>
</tr>
<tr>
<td>1. 非常低</td>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Situation 情況</th>
<th>Hazard 危害</th>
<th>Likelihood 可能性</th>
<th>Consequence (嚴重性)</th>
<th>Risk Level (風險等級)</th>
<th>Precautions 經濟措施</th>
<th>Residual Risk 剩餘風險</th>
<th>Responsible Person 負責人</th>
</tr>
</thead>
<tbody>
<tr>
<td>當工人進入沙井 進行清掃及相關工作（使用小型旋桿機、升降機）</td>
<td>空氣中氧氣含量不足導致缺氧</td>
<td>3</td>
<td>5</td>
<td>20 (RED)</td>
<td>1. 警用於沙井前，先由合資格人士從外進行氣體測試。氣體測試為分不同深度進行。 2. 在該沙井內不可使用發電機</td>
<td>5 (YELLOW)</td>
<td>警用於沙井前，先由合資格人士從外進行氣體測試。氣體測試為分不同深度進行。</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3. 使用吹風機必須是提供清潔的空氣。</td>
<td></td>
<td>管工</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4. 在沙井頂開通氧氣孔。</td>
<td></td>
<td>管工</td>
</tr>
</tbody>
</table>

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# Confined Space Risk Assessment Report

<table>
<thead>
<tr>
<th>Situation</th>
<th>Hazard</th>
<th>Probability</th>
<th>Consequence</th>
<th>Risk Level</th>
<th>Precautions</th>
<th>Residual Risk</th>
<th>Responsible Person</th>
</tr>
</thead>
</table>
| 需人工進入井井進行抽除未完全排空及其它相關作業時 | 3 | 5 | 15 (RED) | 1. 需先確定井井所在位置並設置警示牌 | 5 (YELLOW) | 委任合資格人
| | | | | 2. 當然井井中可能存在易燃易爆性氣體或腐蝕性液體 | | 人/主管工 |
| | | | | 3. 底部井井中應保持通風良好，否則井井中應設置鼓風機 | | 管工 |
| | | | | 4. 在井井中作業時應穿戴適合的個人防護裝備 | | 管工 |
| | | | | 5. 井井作業時應設置正壓呼吸器 | | 管工 |

<table>
<thead>
<tr>
<th>Situation</th>
<th>Hazard</th>
<th>Probability</th>
<th>Consequence</th>
<th>Risk Level</th>
<th>Precautions</th>
<th>Residual Risk</th>
<th>Responsible Person</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>5 (YELLOW)</td>
<td></td>
<td></td>
<td>委任合資格人/主管工</td>
<td></td>
<td>管工</td>
<td></td>
</tr>
</tbody>
</table>

5. 在進行井井作業時，應設置正壓呼吸器。井井作業後，應先使用呼吸器吸氧，確保井井中沒有其餘有害氣體。

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## Confined Space Risk Assessment Report – 密閉空間 風險評估報告

<table>
<thead>
<tr>
<th>Situation 場景</th>
<th>Hazard 潛在危害</th>
<th>Probability 可能性</th>
<th>Consequence 後果</th>
<th>Risk Level 風險等級</th>
<th>Precautions 控制措施</th>
<th>Residual Risk 剩餘風險</th>
<th>Responsible Person 負責人</th>
</tr>
</thead>
<tbody>
<tr>
<td>當工人進入沙井進行拆卸木模板、批漆及其他相關程序</td>
<td>5. 大量水或其 他固定物質 涌入密閉空間導致工人 遇溺或被埋</td>
<td>3</td>
<td>5</td>
<td>15 (RED)</td>
<td>1. 確定通往該沙井之所有管道已關上及加上警告牌，避免 大量水份或其他物質涌入沙井之機會。 2. 如沙井內部有大量水份或其他流動性物質存在，應盡快抽走水份及流動物質。 3. 如未能截斷所有通往沙井的管道，必須由聯絡員負責監 視水位，直至工人離開沙井為止。 4. 指定緊急出口入口，及加置水泵。</td>
<td>12 (ORANGE)</td>
<td>管工</td>
</tr>
<tr>
<td>6. 因通風不足 導致熱力窒息，引致工人 憊著上升</td>
<td>2</td>
<td>4</td>
<td>8 (ORANGE)</td>
<td>1. 提供足夠通風設備，確保沙井內空氣流通。</td>
<td>4 (YELLOW)</td>
<td>管工</td>
<td></td>
</tr>
<tr>
<td>7. 因電力設備 及工具漏電 導致觸電</td>
<td>4</td>
<td>4</td>
<td>16 (RED)</td>
<td>1. 所有用於沙井的電動設備及工具必須有良好接地及完 善保養。 2. 所有在沙井內使用的照明和電工具，必須符合防水要 求。 3. 所有手提電工具必須使用 110V 電源供應。 4. 所有電纜應妥善隱起</td>
<td>9 (YELLOW)</td>
<td>管工</td>
<td></td>
</tr>
</tbody>
</table>
風險評估報告(6)
RISK ASSESSMENT REPORT (6)

孔隙工程風險評估

<table>
<thead>
<tr>
<th>個人防護裝備</th>
<th>有關標準/型號</th>
<th>個人防護裝備</th>
<th>有關標準/型號</th>
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<tbody>
<tr>
<td>安全帽</td>
<td>AS/NZ 1981:</td>
<td>安全帶</td>
<td>BSEN 381:</td>
</tr>
<tr>
<td></td>
<td>ANSI Z89.1-</td>
<td></td>
<td>56210:</td>
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<tr>
<td></td>
<td>EN397:</td>
<td></td>
<td>DIN 53211:</td>
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<td></td>
<td>CSA Z94.1:</td>
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<td>2871:</td>
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<td></td>
<td>JIS T 8131:</td>
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<td></td>
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<td></td>
<td>GB 2811:</td>
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今次評估日期：10-05-2012 (Rev.5)
下次評估日期：09-01-2012

評估員 | 職位 | 日期 |
--------|------|------|
黃秋貞 | QC   | 10-05-2012 |
江嘉明 | 醫護 | 10-05-2012 |
何錦豪 | 綜合 | 10-05-2012 |
李偉民 | 安全 | 10-05-2012 |
王國華 | 負責安全主任 | 10-05-2012 |
黃麗珍 | 負責安全主任 | 10-05-2012 |

<table>
<thead>
<tr>
<th>事故類型</th>
<th>計劃及處理步驟</th>
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<tbody>
<tr>
<td>心肺停止</td>
<td>順序1：立即通風，順序2：通脹急救，順序3：人工心肺復甦術</td>
</tr>
<tr>
<td></td>
<td>順序1：立即通風，順序2：通脹急救，順序3：人工心肺復甦術</td>
</tr>
<tr>
<td>呼吸中止</td>
<td>順序1：立即通風，順序2：通脹急救，順序3：人工心肺復甦術</td>
</tr>
<tr>
<td></td>
<td>順序1：立即通風，順序2：通脹急救，順序3：人工心肺復甦術</td>
</tr>
</tbody>
</table>

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Confined Space Risk Assessment Report – 密閉空間 風險評估報告

Others:
1. 站長工作許可證制度，許可證需列明工作地點、工作職位、氣體測試結果，方允許工作人員。工作許可證有效期限，以確保工作人員於5小時內完成所有作業。(於任何不可超過8小時)，管工需監管工作範圍，以確保已

按規定維持安全及相容，方可發放許可證。許可證需黏貼在空間入口，無人工作時需將入口上鎖及掛上警告標誌。

2. 於規定有關工作的人員，均須接受勞工局認可的訓練及持有有效證明。

3. 在密閉空間工作時，最少要有一名監工及一名監督員在入口處監督及負責與密閉空間之工作人員聯絡。如該空間被判定為極高風險，整個救援小組均要全程在入口附近待命。監工及監督員需與密閉空間內之工作人員保持聯絡。

4. 在密閉空間工作時，應利用吹風機，把敵方空氣帶往工作位置。

5. 所有監工、救援及急救用的器材，均須放置在入口旁，以備使用。

6. 當有任何人員要進行密閉空間工作時，監工、安全主任、安全督導員及救護小組絞盤等要加強巡視該地區的次數，確保該項工作安全地進行。

7. 員工工作時，應配安全帶，安全帶、安全鞋及其他有關事宜均需適度使用。

<table>
<thead>
<tr>
<th>Safety Equipment for the Work</th>
<th>工作時所需的安全設備</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety Helmet 安全帽</td>
<td>✓ Breathing Apparatus 呼吸裝置</td>
</tr>
<tr>
<td></td>
<td>Explosion Proof Communication Equipment 爆炸防止器材</td>
</tr>
<tr>
<td></td>
<td>Fall Body Safety Harness 吊繩式安全帶</td>
</tr>
<tr>
<td></td>
<td>Ear Protector 耳罩</td>
</tr>
<tr>
<td></td>
<td>Lifting Appliances 倉庫裝置</td>
</tr>
<tr>
<td></td>
<td>Gas Monitor 氣體測試儀</td>
</tr>
<tr>
<td>Safety Shoes 安全鞋</td>
<td>✓ Safety Line 救生繩</td>
</tr>
<tr>
<td></td>
<td>First Aid Box 急救箱</td>
</tr>
<tr>
<td></td>
<td>Reflective Vest 反光衣</td>
</tr>
<tr>
<td></td>
<td>Resuscitator 復蘇器</td>
</tr>
<tr>
<td></td>
<td>Personal Alert System 個人警報器</td>
</tr>
<tr>
<td>Eye Protector 眼罩</td>
<td>✓ Stretcher 緊急車</td>
</tr>
<tr>
<td></td>
<td>Explosion Proof Safety Helmet Lamp 爆炸防止頭燈</td>
</tr>
<tr>
<td></td>
<td>Leather Glove 皮手套</td>
</tr>
</tbody>
</table>

# 應有此類型安全帽，不得呼吸裝置
# Entering this Confined Space, BA is not required

Assessed by: (評估人) ____________________________
Approved by: (批准) ____________________________

Date: ____________________ Next Revised Date: ____________________ Date: ____________________

(合資格人士)
風險評估報告 (6)
RISK ASSESSMENT REPORT (6)
扎鑽工程風險評估

今次評估日期：10-05-2012 (Rev. 5)
下次評估日期：09-11-2012 要時評估

<table>
<thead>
<tr>
<th>評估員</th>
<th>職位</th>
<th>簽名</th>
<th>日期</th>
</tr>
</thead>
<tbody>
<tr>
<td>郭少強</td>
<td>QC Manager</td>
<td>QC Manager</td>
<td>10-05-2012</td>
</tr>
<tr>
<td>江秉彰</td>
<td>安全經理</td>
<td>安全經理</td>
<td>10-05-2012</td>
</tr>
<tr>
<td>邓春聲</td>
<td>護理</td>
<td>護理</td>
<td>10-05-2012</td>
</tr>
<tr>
<td>王煥強</td>
<td>副總</td>
<td>副總</td>
<td>10-05-2012</td>
</tr>
<tr>
<td>葉慶聲</td>
<td>安全主任</td>
<td>安全主任</td>
<td>10-05-2012</td>
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</table>

### 風險引發的可能性

<table>
<thead>
<tr>
<th>風險引發的可能性</th>
<th>風險的嚴重性</th>
<th>風險的影響性</th>
</tr>
</thead>
<tbody>
<tr>
<td>可能 (每五年最少發生一次)</td>
<td>可能 (每六年最少發生一次)</td>
<td>可能 (每五六年最少發生一次)</td>
</tr>
<tr>
<td>風險非常低 (VL)</td>
<td>風險非常低 (VL)</td>
<td>風險非常低 (VL)</td>
</tr>
<tr>
<td>中度的風險 (M)</td>
<td>中度的風險 (M)</td>
<td>中度的風險 (M)</td>
</tr>
<tr>
<td>高風險 (H)</td>
<td>高風險 (H)</td>
<td>高風險 (H)</td>
</tr>
<tr>
<td>風險非常高 (VH)</td>
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### 風險控制

<table>
<thead>
<tr>
<th>風險引發的可能性</th>
<th>風險的嚴重性</th>
<th>風險的影響性</th>
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</thead>
<tbody>
<tr>
<td>可能 (每五年最少發生一次)</td>
<td>可能 (每六年最少發生一次)</td>
<td>可能 (每五六年最少發生一次)</td>
</tr>
<tr>
<td>可接受水平，不需任何行動</td>
<td>可接受水平，不需任何行動</td>
<td>可接受水平，不需任何行動</td>
</tr>
<tr>
<td>規線</td>
<td>不得工作，直至風險降低</td>
<td>不得工作，直至風險降低</td>
</tr>
</tbody>
</table>

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風險評估報告 (6)
RISK ASSESSMENT REPORT (6)
扎築工程風險評估

<table>
<thead>
<tr>
<th>活動/風險</th>
<th>有關標準/型號</th>
<th>個人防護裝置</th>
<th>有關標準/型號</th>
<th>個人防護裝置</th>
</tr>
</thead>
<tbody>
<tr>
<td>安全帽</td>
<td>ANSI Z89.1, ANSI Z35, CSA Z94.1, JISB11, GB2811</td>
<td>保護性手套</td>
<td>BS50072或同等</td>
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</tr>
<tr>
<td>安全帶</td>
<td>BS EN 361 (全身式安全帶), BS 3367 (頭層教練或其他國際標準)</td>
<td>防護面罩</td>
<td>BS 5682, AS 1337, DIN 50210, 56211 (一類耳機), 2871 (頭盔及額面護面罩), BS 1542 (頭盔及額面護面罩), AS 1338 (頭盔), BS 1729 (防護頭盔)</td>
<td></td>
</tr>
<tr>
<td>口罩</td>
<td>N95 (一般用途) (general use)</td>
<td>耳塞耳罩</td>
<td>E-A-R Model 1000 Ear Muff</td>
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</tr>
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</table>

扎築工程風險評估

<table>
<thead>
<tr>
<th>險情/風險</th>
<th>預期損失</th>
<th>直接影響人員</th>
<th>由他人服務</th>
<th>預期損失</th>
<th>可能性</th>
<th>經濟性</th>
<th>事件後</th>
<th>事件後</th>
<th>事件後</th>
</tr>
</thead>
<tbody>
<tr>
<td>運送材料到地盤</td>
<td>地面工人</td>
<td>-</td>
<td>運送地面工人</td>
<td>吊繩用工具</td>
<td>不可能 (2)</td>
<td>恐要 (3)</td>
<td>-</td>
<td>恐要 (3)</td>
<td>-</td>
</tr>
<tr>
<td>備料工具失效</td>
<td>運送工人</td>
<td>-</td>
<td>運送地面工人</td>
<td>吊繩用工具</td>
<td>不可能 (2)</td>
<td>恐要 (3)</td>
<td>-</td>
<td>恐要 (3)</td>
<td>-</td>
</tr>
<tr>
<td>其它工人</td>
<td>與運送活動</td>
<td>-</td>
<td>運送地面工人</td>
<td>吊繩用工具</td>
<td>不可能 (2)</td>
<td>恐要 (3)</td>
<td>-</td>
<td>恐要 (3)</td>
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風險評估報告（6）
RISK ASSESSMENT REPORT (6)
扎鐵工程風險評估

<table>
<thead>
<tr>
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<th>有關標準/型號</th>
<th>個人防護裝置</th>
<th>有關標準/型號</th>
</tr>
</thead>
<tbody>
<tr>
<td>安全帽</td>
<td>AS/NZS1801, ANSI Z89.1, EN397, CSAZ94, JIS8131, GB25811</td>
<td>眼鏡配件</td>
<td>B3092, AS1337, DIN52920, 50211 (一般用途), Z871 (護目及護面罩), BS1042 (護面罩), BS797, AS1338 (鋼制), BS1729 (金屬加工)</td>
</tr>
<tr>
<td>安全帶</td>
<td>BSEN356(金屬式安全帶), BSEN357(連接安全繩)</td>
<td>護耳配件</td>
<td>E-A-R Model 1000 Ear Muff</td>
</tr>
<tr>
<td>口罩</td>
<td>N95 (一般用途) (general use)</td>
<td>面罩</td>
<td>N95 (一般用途) (general use)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>工程部位</th>
<th>安全管理相</th>
<th>施工單位</th>
<th>現有措施</th>
<th>可能措施</th>
<th>執行計劃</th>
<th>執行</th>
<th>優先</th>
<th>優先等級</th>
<th>優先</th>
<th>優先等級</th>
</tr>
</thead>
<tbody>
<tr>
<td>鋼筋</td>
<td>工人易受損</td>
<td>扎鐵工人</td>
<td>-</td>
<td>-</td>
<td>警告(2)</td>
<td>受傷 (2)</td>
<td>1</td>
<td>受傷 (2)</td>
<td>1</td>
<td>受傷 (2)</td>
</tr>
<tr>
<td>操作配備</td>
<td>工人易受損</td>
<td>扎鐵工人</td>
<td>-</td>
<td>-</td>
<td>警告(2)</td>
<td>受傷 (2)</td>
<td>1</td>
<td>受傷 (2)</td>
<td>1</td>
<td>受傷 (2)</td>
</tr>
<tr>
<td>燃氣</td>
<td>工人易受損</td>
<td>扎鐵工人</td>
<td>-</td>
<td>-</td>
<td>警告(2)</td>
<td>受傷 (2)</td>
<td>1</td>
<td>受傷 (2)</td>
<td>1</td>
<td>受傷 (2)</td>
</tr>
<tr>
<td>扎鐵</td>
<td>人體受損</td>
<td>扎鐵工人</td>
<td>-</td>
<td>-</td>
<td>警告(2)</td>
<td>受傷 (2)</td>
<td>1</td>
<td>受傷 (2)</td>
<td>1</td>
<td>受傷 (2)</td>
</tr>
</tbody>
</table>
## Risk Assessment Report (6)

**Risk Assessment Report (6)**

### Risk Assessment Table

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Standard/Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety帽</td>
<td>AS/NZS1801, ANSI Z89, EN397, CSA Z94.1, JIST8131, GB2811</td>
</tr>
<tr>
<td>Protective Gloves</td>
<td>Standard BS0072 or equivalent</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Standard/Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety Belt</td>
<td>BSEN361 (full-body safety belt), BS337 (stand-alone or other international standards)</td>
</tr>
<tr>
<td></td>
<td>BSEN360, EN353, EN352 (safety harness or other international standards)</td>
</tr>
<tr>
<td></td>
<td>EN354, 355, BS14397 (safety harness or other international standards)</td>
</tr>
<tr>
<td>Goggles</td>
<td>Standard BS2802, AS1337, DIN58210, 58211 (general use), Z87.1 (safety goggles)</td>
</tr>
<tr>
<td></td>
<td>BS1542 (safety glasses), BS6789, AS1338 (safety glasses), BS1720 (safety glasses)</td>
</tr>
<tr>
<td>Face Mask</td>
<td>N95 (general use)</td>
</tr>
<tr>
<td></td>
<td>E-A-R Model 1000 Ear Muff</td>
</tr>
</tbody>
</table>

### Risk Assessment Summary

<table>
<thead>
<tr>
<th>Activity</th>
<th>Directly Affecting Personnel</th>
<th>Indirectly Affecting Personnel</th>
<th>Existing Measures</th>
<th>Risk Category</th>
<th>Preventive Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Railing Construction</td>
<td>-</td>
<td>-</td>
<td><strong>Provide temporary safety railing</strong></td>
<td><strong>Low</strong></td>
<td><strong>Install temporary safety railing</strong></td>
</tr>
</tbody>
</table>

### Remarks

1. The incident occurred from a height of 2 meters or higher, which is considered a high risk category.
2. The accident could have been prevented by ensuring proper training and supervision.
3. Regular inspections and maintenance are recommended to prevent future incidents.
Appendix D:

1. Site inspection report in i-Safe

2. Risk assessment report in i-Safe
Site Inspection Report

Contract Name

Contract No.

Contractor

Site Location:

Date:

Prepare by:
<table>
<thead>
<tr>
<th>Non-conformance photo(s)</th>
<th>Correction photo(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of non-conformance(s) :</td>
<td>Exposed Workers :</td>
</tr>
<tr>
<td>----------------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>Descriptions :</td>
<td>Trade Type :</td>
</tr>
<tr>
<td>Corrective action(s) :</td>
<td>Subcontractor(s) :</td>
</tr>
<tr>
<td>Location :</td>
<td>Expected completion Date :</td>
</tr>
</tbody>
</table>

Inspection Date:

Sign by:
Risk Assessment Report

Contract Name

Contract No.

Contractor

Site Location:

Date:

Prepare by:
**Risk Assessment Report**

<table>
<thead>
<tr>
<th>Contract Number:</th>
<th>Document Name:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Contract Name:</strong></td>
<td><strong>Date of initial issue:</strong></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Activity:</strong></td>
<td><strong>Sign by:</strong></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Legend:**

**Risk Definition and Classification**

**Qualitative Measures of Probability**

<table>
<thead>
<tr>
<th>Rating</th>
<th>Descriptor</th>
<th>Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Certain</td>
<td>The event is expected to occur in most circumstances.</td>
</tr>
<tr>
<td>4</td>
<td>Likely</td>
<td>The event will probably occur in most circumstances.</td>
</tr>
<tr>
<td>3</td>
<td>Possibly</td>
<td>The event should occur at some time.</td>
</tr>
<tr>
<td>D</td>
<td>Unlikely</td>
<td>The event could occur at some time.</td>
</tr>
<tr>
<td>E</td>
<td>Highly Unlikely</td>
<td>The event may occur only exceptional circumstances.</td>
</tr>
</tbody>
</table>

**Qualitative Measures of Severity**

<table>
<thead>
<tr>
<th>Rating</th>
<th>Descriptor</th>
<th>Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Very High</td>
<td>Death, toxic release off-site with detrimental effort, huge financial loss</td>
</tr>
<tr>
<td>4</td>
<td>High</td>
<td>Extensive injury, loss of production capability, off-site release with detrimental effects, major financial loss.</td>
</tr>
<tr>
<td>3</td>
<td>Medium</td>
<td>Medical treatment required, on-site release contained with outside assistance, high financial loss.</td>
</tr>
<tr>
<td>2</td>
<td>Low</td>
<td>First aid treatment, on-site release immediately contained, medium financial loss.</td>
</tr>
<tr>
<td>1</td>
<td>Very Low</td>
<td>No injury, low financial loss.</td>
</tr>
</tbody>
</table>

**Risk matrix**

<table>
<thead>
<tr>
<th>Probability</th>
<th>Severity</th>
<th>Risk Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Very Low</td>
<td>Low</td>
</tr>
<tr>
<td>5</td>
<td></td>
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</tr>
<tr>
<td>Certain</td>
<td>Red</td>
<td>Red</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Yellow</td>
</tr>
<tr>
<td>Likely</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>Yellow</td>
</tr>
<tr>
<td>Possibly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>Green</td>
</tr>
<tr>
<td>Unlikely</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>Green</td>
</tr>
<tr>
<td>Highly Unlikely</td>
<td></td>
<td></td>
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</table>

**Risk Level**

<table>
<thead>
<tr>
<th>Level</th>
<th>Control Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>Manage by routine procedure</td>
</tr>
<tr>
<td>Orange</td>
<td>Management responsibility must be specified</td>
</tr>
<tr>
<td>Yellow</td>
<td>Senior management attention needed</td>
</tr>
<tr>
<td>Green</td>
<td>Detailed research and management planning required at senior levels</td>
</tr>
</tbody>
</table>
## Risk Assessment Report

<table>
<thead>
<tr>
<th>Contract Number:</th>
<th>Document Name:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contract Name:</td>
<td>Date of initial issue:</td>
</tr>
<tr>
<td>Activity:</td>
<td>Sign by:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Situation</th>
<th>Hazard(s)</th>
<th>Further Details of Hazard(s)</th>
<th>Probability</th>
<th>Severity</th>
<th>Risk Level</th>
<th>Exposed Person/Party</th>
<th>Existing Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Required Personal Protective Equipment</th>
<th>Required Training Course</th>
<th>Responsible Person</th>
<th>Residue Probability</th>
<th>Residue Severity</th>
<th>Residue Risk Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix E:

1. Questionnaire of i-Safe Evaluation
Questionnaire of i-Safe Evaluation

Objective: This survey is to collect the feedback of using i-Safe, your opinion and comments are extremely useful for me in final year project.

I am Year 3 student from City University of Hong Kong and I am currently carry out a survey about a mobile app for construction safety among senior safety management, safety officer, safety supervisors and related safety professionals in construction industry. I am pleased if you could spend your spare time to finish this questionnaire. Please indicate your perception of the statement. All the information are kept CONFIDENTIAL and for ACADEMIC purpose only.

Instruction: Please complete the following questions and “✓” the most appropriate choice.

Part 1: Personal Information

1. What is your post?
   Safety Manager   Safety Auditor   Safety Officer   Safety Supervisor   Other ___________

2. How old are you?
   18-25   26-35   36-45   46-55   56 or below

3. What is your educational level?
   Below Primary   Primary   Secondary   Certificate/Diploma   Degree or higher

4. How long have you been working in this industry?

Part 2: Familiarity of Mobile Apps

5. Do you have any smart phones?
   Yes    No

6. Do you have any tablets?
   Yes    No

7. How many smart phones or tablets do you have?
   One    Two    Three    More than three

8. How often do you use mobile apps in your smart phones of tablets?
   Always   Often   Sometimes   Rarely   Never
Part 3: Appraisal of Site Inspection Section in i-Safe


I. Appraisal of interface

<table>
<thead>
<tr>
<th>Factors</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>User Friendly</td>
<td>5 4 3 2 1</td>
</tr>
<tr>
<td>Clear Instruction</td>
<td>5 4 3 2 1</td>
</tr>
<tr>
<td>Smooth Framework</td>
<td>5 4 3 2 1</td>
</tr>
</tbody>
</table>

Other comments of interface:

II. Appraisal of Performance

<table>
<thead>
<tr>
<th>Factors</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appropriate content</td>
<td>5 4 3 2 1</td>
</tr>
<tr>
<td>Understandable and suitable questions</td>
<td>5 4 3 2 1</td>
</tr>
<tr>
<td>Correct the problems of handwritten notes such as typos and arbitrary</td>
<td>5 4 3 2 1</td>
</tr>
<tr>
<td>descriptions for safety issues</td>
<td></td>
</tr>
<tr>
<td>Correct the problems of handwritten notes such as inconsistent naming</td>
<td>5 4 3 2 1</td>
</tr>
<tr>
<td>for same items safety issues</td>
<td></td>
</tr>
<tr>
<td>Time to spent to complete safety inspection is fast</td>
<td>5 4 3 2 1</td>
</tr>
<tr>
<td>Able to provide accurate site inspection report</td>
<td>5 4 3 2 1</td>
</tr>
</tbody>
</table>

Other comments of performance:

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
Part 4: Appraisal of Risk Assessment Section in i-Safe


I. Appraisal of Interface

<table>
<thead>
<tr>
<th>Factors</th>
<th>Rating</th>
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</thead>
<tbody>
<tr>
<td>User Friendly</td>
<td>5</td>
</tr>
<tr>
<td>Clear Instruction</td>
<td>4</td>
</tr>
<tr>
<td>Smooth Framework</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

Other comments of interface:

II. Appraisal of Performance

<table>
<thead>
<tr>
<th>Factors</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appropriate content</td>
<td>5</td>
</tr>
<tr>
<td>Understandable and suitable questions</td>
<td>4</td>
</tr>
<tr>
<td>The &quot;Updated Internet Sources&quot; provides enough risk information and expert instructions</td>
<td>3</td>
</tr>
<tr>
<td>The &quot;Past Statistics&quot; can help me to determine the risk level of particular work trade more reliable</td>
<td>2</td>
</tr>
<tr>
<td>The notification function can remind me not to do the risk assessment roughly</td>
<td>1</td>
</tr>
<tr>
<td>Able to provide accurate risk assessment report</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

Other comments of performance:

III. Overview of i-Safe

Are you satisfied with the overall performance of i-Safe?

Yes  No

Would you recommend i-Safe to your colleagues?

Yes  No