<table>
<thead>
<tr>
<th><strong>Title</strong></th>
<th>Design and development of construction safety planning model for BIM in Hong Kong construction industry</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Author(s)</strong></td>
<td>Law, Yuen Fong (羅婉芳)</td>
</tr>
<tr>
<td><strong>Citation</strong></td>
<td>Law, Y. F. (2012). Design and development of construction safety planning model for BIM in Hong Kong construction industry (Outstanding Academic Papers by Students (OAPS)). Retrieved from City University of Hong Kong, CityU Institutional Repository.</td>
</tr>
<tr>
<td><strong>Issue Date</strong></td>
<td>2012</td>
</tr>
<tr>
<td><strong>URL</strong></td>
<td><a href="http://hdl.handle.net/2031/6851">http://hdl.handle.net/2031/6851</a></td>
</tr>
<tr>
<td><strong>Rights</strong></td>
<td>This work is protected by copyright. Reproduction or distribution of the work in any format is prohibited without written permission of the copyright owner. Access is unrestricted.</td>
</tr>
</tbody>
</table>
Design and Development of Construction Safety Planning Model for BIM in Hong Kong Construction Industry

By
Yuen Fong LAW

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

Department of Civil and Architectural Engineering
City University of Hong Kong

March 2012
ABSTRACT

Safety planning is essential if construction projects are to be completed on time, on the budget, and without experiencing accidents or injuries in construction site. Under F&IU (Safety management) regulation, self-regulatory safety management approach is enacted. However, most contractors find it difficult to develop an effective safety planning due to its flexibility and increase in project's complexity. As a result, general safety plans are commonly found. However, every construction project is unique in nature. Without identifying all possible risks and hazards right at the planning stage, construction site safety cannot be secured.

Furthermore, safety planning has always been ignored by design planners and architects. Previous research reveals that a higher priority shall be given in designing to eliminate or avoid a hazard than simply controlling the hazard or protecting the workers from the hazard. So, concern on safety should start at the design stage and throughout the whole project.

Under such background, safety planning model, i-SPM 2013 was developed in this study. i-SPM Model not only acted as a useful supplementary guideline of safety planning for construction safety professionals, but also assisted them to integrate it into the BIM in this technological world. By integrating it into BIM, it can arouse both safety professionals and design planning team's awareness on design for safety (DfS) issue at the start of the design level. Visually shown all potential risk and hazard in construction site, BIM helped the concerned safety professionals and parties to plan effective construction safety prevention measures with reference to i-SPM 2013 integrated.

i-SPM 2013 was constructed in three stages. In the first stage, 24 importance factors in safety planning were identified and classified into Policy, Personnel, Process and Incentive Aspects from Literature Review. Then, importance on the derived factors was prioritized through questionnaire survey among safety professionals. Verification on the model was carried out through interview as the final stage. Finally, i-SPM 2013 model with 23 factors was developed.

The survey’s findings reflected that most respondents recognized risk assessment as an important component in safety planning. They also showed their awareness and positive attitude on implementing BIM-safety in construction project. To successfully integrate i-SPM 2013 into BIM, strong communication between safety and construction technology experts, together with continuous evaluation on the model were required.
ACKNOWLEDGEMENTS

I would like to take this opportunity to thank my supervisor, Dr. FUNG, Ivan Wing Hong, the lecturer in Department of Civil and Architectural Engineering at City University of Hong Kong for his teaching, valuable advice and assistance throughout the preparation of the study.

I am also indebted to the safety professionals and construction practitioners who have extended their helping hands to provide valuable information in the survey and interview and to devote their precious time to answer my quires.

Finally, I would like to express my sincere gratitude to my family members and friends for their love and patience. Had it not been for their kindly support, I would not be able to complete this study.

Law Yuen Fong, Isra
March 2012
# TABLE of CONTENTS

ABSTRACT ................................................................................................................................. i
ACKNOWLEDGEMENTS ........................................................................................................ iii
TABLE of CONTENTS ............................................................................................................ iii
LIST of TABLES ......................................................................................................................... ix
LIST of FIGURES ....................................................................................................................... xii

Chapter One - Introduction ........................................................................................................ 1
1.1. Concern on construction safety industry ................................................................. 1
1.1.1 Accident Statistics ............................................................................................... 1
1.1.2 Economic Feature ............................................................................................... 2
1.1.3 Major issues of site safety ................................................................................... 3
1.2. Current state of safety planning ............................................................................. 4
1.3. Why safety planning in Building Information Modelling (BIM)? ...................... 6
1.4. Research Aim and Objectives ............................................................................... 7
1.5. Research Methodology ........................................................................................... 8
1.5.1 Literature Review ............................................................................................... 8
1.5.2 Questionnaires .................................................................................................... 8
1.5.3 Interview .............................................................................................................. 9
1.6. Organization of Research Study ............................................................................ 9

Chapter Two - Literature Review ............................................................................................ 11
2.1. Introduction ............................................................................................................. 11
2.2. Overview on Safety Management in Hong Kong .............................................. 11
2.2.1 Law related to construction safety .................................................................... 11
2.2.2 Traditional safety management ......................................................................... 13
2.2.3 Factories and industrial undertakings (Safety Management) Regulation ....... 14
2.3. Various Safety Management System Standards ................................................. 15
2.3.1 Summary on various SMSs .............................................................................. 16
2.4. Integrated approach on safety planning into BIM ............................................... 18
2.4.1 Introduction on Building Information Modeling (BIM) .................................. 18
2.4.2 Use of BIM ................................................................. 19
2.4.3 BIM VS CAD ........................................................... 19
2.4.4 Benefits and Obstacles of BIM ........................................ 20
2.4.5 Shortcoming of BIM Safety Research in Hong Kong .......... 21
2.4.6 BIM-based safety management .......................................... 22
2.4.7 Concept of safety-in-Design with the safety planning model ........ 23

Design for Safety (DfS) ...................................................... 23
Necessity of DfS in Hong Kong .............................................. 24

Chapter Three - Framework development of i-SPM 2013 ........... 26
3.1. Introduction ................................................................. 26
3.2. Problems in safety planning .............................................. 26
3.2.1 Lack of common format for construction industry ............. 26
3.2.2 Contractor’s negative attitude ........................................ 27
3.3. Essentialness of Safety Planning ......................................... 28
3.4. Objectives of safety planning model .................................... 28
3.5. Current content of safety planning ...................................... 29
3.5.1 14 core elements in Safety Planning in Hong Kong .......... 29
3.5.2 Comparison between elements in OHSAS 18001 and ILO 2001 .. 32
3.5.3 Distinction on OHSAS 18001:2007 and ILO 2001 ............... 34
3.5.4 Similarities and Differences between the elements in international guidelines and SMS in Hong Kong ......................... 34
3.6. Factors affecting the safety planning .................................... 35
3.6.1 Policy aspect .......................................................... 35
3.6.2 Personnel Aspect ....................................................... 37
3.6.3 Process Aspect ........................................................ 40
3.6.4 Incentive aspect ......................................................... 44
3.7. Framework of i-SPM 2013 ................................................. 46
3.7.1 Integrated i-SPM 2013 in BIM-safety ................................ 46
3.7.2 Framework of i-SPM 2013 ............................................. 46
Chapter Four - Research Methodology ..............................................................48
4.1. Introduction .................................................................................................48
4.2. Quantitative Research- Questionnaire Survey ..............................................48
4.3. Reason for the adopting Questionnaire Survey ............................................48
4.4. Selection of target population group ...........................................................49
4.5. Distribution Progress in Collecting Data .....................................................49
4.6. Structure of the Questionnaire .................................................................49
4.7. Format of the Questionnaire .......................................................................50
4.8. Data Analysis ...............................................................................................50
4.9. Qualitative Research- Interview ..................................................................51

Chapter Five - Data Descriptions of Survey .......................................................53
5.1. Introduction .................................................................................................53
5.2. Demography of Survey Participants ............................................................53
5.3. Result of the i-SPM 2013 for BIM Survey- Safety Planning Components .................................................................59
  5.3.1. Policy 01- Understanding of Legislations and Regulations ....................60
  5.3.2. Policy 02- Proper implementation of Safety Policy ...............................61
  5.3.3. Policy 03- Proper implementation of In-house safety rules and regulations ......................................................................................................................62
  5.3.4. Personnel 01- Top management’s leadership in safety planning process ..................................................................................................................63
  5.3.5. Personnel 02- Proper consideration on worker’s safety culture ..............64
  5.3.6. Personnel 03- Proper implementation on good working relationship and environment ........................................................................................................65
  5.3.7. Personnel 04 - Proper Establishment of Safety Committee ..................66
  5.3.8. Personnel 05- Proper Delegation of responsibility and accountability in safety organization ........................................................................................................67
  5.3.9. Personnel 06- Systematic Safety and Health training program .............68
  5.3.10. Process 01- Implementation of initial review ........................................69
  5.3.11. Process 02- Proper implementation of hazardous inspection program ....................................................................................................70
  5.3.12. Process 03- Proper implementation of health and safety assurance
Chapter Six - Data Analysis and Discussion on i-SPM 2013

6.1 Introduction

6.2 Ranking by Relative Important Ranking Method

6.3 Rank Agreement Factor (RAF), Percentage Agreement (PA) and Disagreement (PD) between group of participants

6.4 Discussion- Cross-comparisons on three contract-sum group

6.4.1 Ranking and Findings in Policy Aspect

6.4.2 Ranking and Findings in Personnel Aspect

6.4.3 Ranking and Findings in Process Aspect

6.4.4 Ranking and Findings in Incentive Aspect

6.5 Findings on comparisons with different demography information

6.6 Modified i-SPM 2013
Chapter Seven - Interview for Verification of i-SPM 2013

7.1. Introduction

7.2. Data Collection

7.3. Result Analysis

7.3.1 Necessity of reviewing i-SPM 2013 model regularly

7.3.2 Risk assessment and controlling process as the prime objective in safety planning

7.3.3 Arguments on the inclusion of disincentive program

7.3.4 Positive expectation on the integration of safety into BIM by highlighting the hazards through clash detection and visualization earlier

7.3.5 Requirement on strong communication between safety and construction technology experts to solve interface’s problems between components on model and construction process

7.3.6 Continuous evaluation on the process

Chapter Eight - Discussion- How to introduce i-SPM 2013 into BIM

8.1. Positive attitude on integrating safety into BIM

8.2. How to introduce i-SPM 2013 into BIM

8.3. BIM- i-SPM 2013 functionalities

8.3.1 Form a project-specific safety plan

8.3.2 Form a safety library function

8.3.3 Create a Risk Assessment template

8.3.4 Safety analysis on hazard activities

8.3.5 Converting a traditional safety planning into more interactive in construction site

8.3.6 Provide effective communication and information flow

Chapter Nine - Conclusion and Recommendation

9.1. Conclusion and Recommendation

9.2. Limitation and further study

9.2.1 Limited Sample Size
9.2.2 Limited Number of Safety Attitude Questions ........................................... 116
9.3. Further Study .................................................................................................. 116

Reference and Bibliographies .............................................................................. 117

APPENDIX A- F&IU (SM) R .................................................................................. 121

APPENDIX B- Various Safety Management Systems ........................................ 123
B-1 Hong Kong Safety Management System ...................................................... 123
B.2 “Successful Health and Safety Management”, HS(G)65 ............................ 126
Systems’ (OHSMS) ................................................................................................... 128
B.4 Continuous Improvement Model (NSC 1994) .............................................. 130
B.5 OHSAS 18001:1999 ......................................................................................... 131
B.6 International Labour Organization - Guidelines on Occupational Safety and
Health Management Systems (ILO-OSH 2001) ......................................................... 133

APPENDIX C - Questionnaire ............................................................................... 135

APPENDIX D - Interview Questionnaire .............................................................. 138

APPENDIX E - Samples of Safety Plan from Local Main Contractors .......... 143
LIST of TABLES

Table 1.1: Industrial Accidents in Major Industries (1999 - 2010) Source: Labour Department (2011) ................................................................. 1
Table 1.2 Industrial Accidents in Construction Industry (2001 - 2011) Source: Labour Department (2011) ................................................................. 2
Table 2.1 Summary on the comparison of various SMS ....................................................... 17
Table 2.2 Top benefits of BIM and the top obstacles to BIM adoption ......................... 20
Table 3.1 Core elements in safety management system ............................................................. 30
Table 3.2 Benchmarking Three SMS: OHSAS 18001, ILO Guidelines, and SMS in Hong Kong ................................................................. 33
Table 5.1 Classification method of the contract sum ................................................................. 57
Table 5.2 Descriptive Distribution of Policy 01- Understanding of the Factories and Industrial undertakings (Safety Management) Regulation .......... 60
Table 5.3 Descriptive Distribution of Policy 02 “Proper implementation of Safety Policy” ........................................................................................................... 61
Table 5.4 Descriptive Distribution of Policy 03 “Proper implementation of In-house safety rules and regulations” ................................................................. 62
Table 5.5 Descriptive Distribution of Personnel 01-Top management’s leadership in safety planning process ............................................................. 63
Table 5.6 Descriptive Distribution of Personnel 02-“Proper consideration on worker’s safety culture” ................................................................................................. 64
Table 5.7 Descriptive Distribution of Personnel 03 “Proper implementation on good working relationship and environment” ................................................................. 65
Table 5.8 Descriptive Distribution of Personnel 04- Proper establishment of Safety Committee ........................................................................................................... 66
Table 5.9 Descriptive Distribution of Personnel 05- Proper Delegation of responsibility and accountability in safety organization ......................... 67
Table 5.10 Descriptive Distribution of Personnel 06-Systematic Safety and Health training program ................................................................. 68
Table 5.11 Descriptive Distribution of Process 01 “Implementation of initial review” ........................................................................................................... 69
Table 5.12 Descriptive Distribution of Process 02 “Proper implementation of
HAZARDOUS INSPECTION PROGRAM”.................................................................70

TABLE 5.13 DESCRIPTIVE DISTRIBUTION OF PROCESS 03 “PROPER IMPLEMENTATION OF HEALTH AND SAFETY ASSURANCE PROGRAM”.................................................................71

TABLE 5.14 DESCRIPTIVE DISTRIBUTION OF PROCESS 04 - PROPER RISK ASSESSMENT TO HAZARDOUS AND DANGEROUS ACTIVITIES .................................................................................................72

TABLE 5.15 DESCRIPTIVE DISTRIBUTION OF PROCESS 05- PROPER IMPLEMENTATION OF EMERGENCY RESPONSE PLAN .................................................................................................73

TABLE 5.16 DESCRIPTIVE DISTRIBUTION OF PROCESS 06-PROPER IMPLEMENTATION ACCIDENTS AND INCIDENTS INVESTIGATION .................................................................74

TABLE 5.17 DESCRIPTIVE DISTRIBUTION OF PROCESS 07- PROPER PROVISIONS OF PERSONAL PROTECTIVE EQUIPMENT .................................................................................................75

TABLE 5.18 DESCRIPTIVE DISTRIBUTION OF PROCESS 08-PROPER IMPLEMENTATION ON SAFETY PROMOTION .................................................................................................76

TABLE 5.19 DESCRIPTIVE DISTRIBUTION OF PROCESS 09- PROPER SELECTION AND MANAGEMENT OF SUBCONTRACTORS .................................................................................................77

TABLE 5.20 DESCRIPTIVE DISTRIBUTION OF PROCESS 10- PROPER IMPLEMENTATION OF COMMUNICATION AND INFORMATION FLOW .................................................................................................78

TABLE 5.21 DESCRIPTIVE DISTRIBUTION OF PROCESS 11- MAINTENANCE AND TIGHT CONTROL ON THE DOCUMENTATION .................................................................................................79

TABLE 5.22 DESCRIPTIVE DISTRIBUTION OF PROCESS 12-PROPER IMPLEMENTATION OF INTERNAL AUDIT .....................................................................................................................80

TABLE 5.22 DESCRIPTIVE DISTRIBUTION OF PROCESS 13-CONDUCT REGULAR MANAGEMENT REVIEW .................................................................................................................................81

TABLE 5.24 DESCRIPTIVE DISTRIBUTION OF INCENTIVE 01- INTRODUCTION OF SAFETY INCENTIVE PROGRAM .................................................................................................................82

TABLE 5.25 DESCRIPTIVE DISTRIBUTION OF INCENTIVE 02-INTRODUCTION OF DISINCENTIVE PROGRAM .................................................................................................................................83

TABLE 5.26 AREA(S) THE RESPONDENTS /RESPONDENTS’ COMPANY HAVE BEEN USING THE BIM APPROACH ON A PROJECT .................................................................................................86

TABLE 5.27 RESPONDENTS’ THINK ABOUT IMPLEMENTING BIM IN THEIR CURRENT/FUTURE PROJECT .................................................................................................................................88

TABLE 6.1 RELATIVE IMPORTANT INDICES (RII) AND RANKING OF FACTORS IN THREE CONTRACT SUM PROJECTS .................................................................................................................91
Table 6.2 Ranking of the 24 factor in four aspects among three project contract sum groups

Table 6.3: Average Rank Agreement Factor (RAF), Percentage Agreement (PA) and Percentage Disagreement (PD) on three different contractor sum group

Table 6.4 Modified ranking of the factors in policy aspects in I-SPM 2013 from the survey

Table 6.5 Modified ranking of the factors in personnel aspects in I-SPM 2013 from the survey

Table 6.6 Modified ranking of the factors in process aspects in I-SPM 2013 from the survey

Table 6.7 Modified ranking of the factors in incentive aspects in I-SPM 2013 from the survey
LIST of FIGURES

FIGURE 1.1 GROSS VALUE OF CONSTRUCTION WORK IN NOMINAL TERM (COMPILED FROM HONG KONG ANNUAL DIGEST OF STATISTICS 2001-2011) ................................................................. 3
FIGURE 2.1 THE CHANGE IN THE AEC INDUSTRY AFTER ADOPTING A BIM APPROACH (HTTP://WWW.IPAMA-AGE.ORG/NEWS/20091204.HTML) ................................................................. 19
FIGURE 2.2 RELATIONSHIP BETWEEN COMPANY’S PERFORMANCE ON THE USE OF CAD AND BIM TECHNOLOGY (HTTP://BUILDINGINFORMATIONMANAGEMENT.WORDPRESS.COM/) ................................................................. 20
FIGURE 2.3 SAFETY MANAGEMENT AS A PART OF BIM-BASED CONSTRUCTION PROCEDURES. KIVINIELI (2011) .......................................................................................................................... 22
FIGURE 2.4 TIME/SAFETY INFLUENCE CURVE. THE ABILITY TO INFLUENCE SAFETY DIMINISHES AS SCHEDULE GOES TO END. SOURCE: TAEBAT (2011) ................................................................. 25
FIGURE 3.1 OPTIMUM COST OF A SAFETY MANAGEMENT SYSTEM (ROWLINSON, 2003) ................. 27
FIGURE 3.2 FRAMEWORK OF I-SPM 2013 .................................................................................. 47
FIGURE 4.1 RESEARCH METHODOLOGY ................................................................................ 52
FIGURE 5.1 CAREER POSITIONS OF THE RESPONDENTS ................................................................. 53
FIGURE 5.2 GENDER OF RESPONDENTS .................................................................................. 54
FIGURE 5.3 EDUCATION LEVELS OF RESPONDENTS ................................................................. 54
FIGURE 5.4 YEARS OF EXPERIENCE IN CONSTRUCTION INDUSTRY OF RESPONDENTS ......... 55
FIGURE 5.5 YEARS OF EXPERIENCE IN CONSTRUCTION SAFETY INDUSTRY OF RESPONDENTS .... 56
FIGURE 5.6 TYPES OF PROJECT OF THE RESPONDENTS ................................................................ 56
FIGURE 5.7 NUMBER OF EMPLOYEES THE RESPONDENTS INVOLVED IN THE RECENT PROJECT ... 57
FIGURE 5.8 PROJECT CONTRACT SUMS OF THE RESPONDENTS .................................................... 58
FIGURE 5.9 DESCRIPTIVE DISTRIBUTION OF POLICY 01-UNDERSTANDING OF THE FACTORIES AND INDUSTRIAL UNDERTAKINGS (SAFETY MANAGEMENT) REGULATION ................................. 60
FIGURE 5.10 DESCRIPTIVE DISTRIBUTION OF POLICY 02 “PROPER IMPLEMENTATION OF SAFETY POLICY” .................................................................................................................. 61
FIGURE 5.11 DESCRIPTIVE DISTRIBUTION OF POLICY 03 “PROPER IMPLEMENTATION OF IN-HOUSE SAFETY RULES AND REGULATIONS” ........................................................................... 62
FIGURE 5.12 DESCRIPTIVE DISTRIBUTION OF PERSONNEL 01- TOP MANAGEMENT’S LEADERSHIP IN SAFETY PLANNING PROCESS .......................................................................................... 63
FIGURE 5.13 DESCRIPTIVE DISTRIBUTION OF PERSONNEL 02- “PROPER CONSIDERATION ON WORKER’S SAFETY CULTURE” .................................................................................. 64
FIGURE 5.14 DESCRIPTIVE DISTRIBUTION OF PERSONNEL 03 “PROPER IMPLEMENTATION ON GOOD WORKING RELATIONSHIP AND ENVIRONMENT” ......................................................... 65
FIGURE 5.15 DESCRIPTIVE DISTRIBUTION OF PERSONNEL 04- PROPER ESTABLISHMENT OF SAFETY COMMITTEE .................................................................................................................. 66
FIGURE 5.16 DESCRIPTIVE DISTRIBUTION OF PERSONNEL 05- PROPER DELEGATION OF RESPONSIBILITY AND ACCOUNTABILITY IN SAFETY ORGANIZATION ...................................... 67
FIGURE 5.17 DESCRIPTIVE DISTRIBUTION OF PERSONNEL 06- SYSTEMATIC SAFETY AND HEALTH TRAINING PROGRAM ........................................................................................................... 68
FIGURE 5.18 DESCRIPTIVE DISTRIBUTION OF PROCESS 01 “IMPLEMENTATION OF INITIAL REVIEW” ...................................................................................................................... 69
FIGURE 5.19 DESCRIPTIVE DISTRIBUTION OF PROCESS 02 “PROPER IMPLEMENTATION OF HAZARDOUS INSPECTION PROGRAM” .................................................................................. 70
FIGURE 5.20 DESCRIPTIVE DISTRIBUTION OF PROCESS 03 “PROPER IMPLEMENTATION OF HEALTH AND
SAFETY ASSURANCE PROGRAM” .......................................................................................................................... 71

FIGURE 5.21 Descriptive Distribution of Process 04-Proper Risk Assessment to Hazardous and Dangerous Activities .......................................................................................................................... 72

FIGURE 5.22 Descriptive Distribution of Process 05-Proper Implementation of Emergency Response Plan .......................................................................................................................... 73

FIGURE 5.23 Descriptive Distribution of Process 06-Proper Implementation Accidents and Incidents Investigation .......................................................................................................................... 74

FIGURE 5.24 Descriptive Distributions of Process 07-Proper Provisions of Personal Protective Equipment .......................................................................................................................... 75

FIGURE 5.25 Descriptive Distribution of Process 08-Proper Implementation on Safety Promotion .......................................................................................................................... 76

FIGURE 5.26 Descriptive Distribution of Process 09-Proper Selection and Management of Subcontractors .......................................................................................................................... 77

FIGURE 5.27 Descriptive Distribution of Process 10-Proper Implementation of Communication and Information Flow .............................................................................................................. 78

FIGURE 5.28 Descriptive Distribution of Process 11-Maintenance and Tight Control on the Documentation .......................................................................................................................... 79

FIGURE 5.29 Descriptive Distribution of Process 12-Proper Implementation of Internal Audit .......................................................................................................................... 80

FIGURE 5.30 Descriptive Distribution of Process 13-Conduct Regular Management Review .......................................................................................................................... 81

FIGURE 5.31 Descriptive Distribution of Incentive 01-Introduction of Safety Incentive Program .......................................................................................................................... 82

FIGURE 5.32 Descriptive Distribution of Incentive 02-Introduction of Disincentive Program .......................................................................................................................... 83

FIG5.33 Level of knowledge and awareness of Building Information Modeling (BIM) of the Respondents .......................................................................................................................... 85

FIG. 5.34 Numbers of Construction Projects completed using BIM .......................................................................................................................... 85

FIG. 5.35 Area(s) the respondents’/respondents’ company have been using the BIM approach on a project .......................................................................................................................... 86

FIGURE 5.36 Respondents’ think about implementing BIM in their current/future project .......................................................................................................................... 87

FIGURE 5.37 Respondents’ opinion on increasing demand on the use of BIM in construction safety .......................................................................................................................... 88

FIG. 6.1 Modified i-SPM 2013 .................................................................................................................................................. 102

FIGURE 8.1 An overview on the BIM showing the additional of Safety Planning sub-model (http://sikafutu.com/delivery/Deliver.html) .......................................................................................... 109

FIGURE 8.2 Safety icon added in the toolbar .................................................................................................................................................. 109

FIGURE 8.3 Content of the safety planning shows on the side .......................................................................................................................... 110

FIGURE 8.4 Example illustrating the use of “Construction Safety related legislations and regulations” .................................................................................................................................................. 110

FIGURE B.1 Hong Kong Safety Management System (Occupational Safety and Health Branch, 1999) .................................................................................................................................................. 123

FIGURE 2.2 Successful Health and Safety Management (HSG65) .................................................................................................................................................. 127

FIGURE B.3 Elements of the BS 8800: 1996 .................................................................................................................................................. 128

FIGURE B.4 OHS management system elements of BS 8800: 1996 .................................................................................................................................................. 129

FIGURE B.5 The continuous improvement Model of SMSs (NSC, 1994) .................................................................................................................................................. 130
FIGURE B.6 KEY PROCESS OF OHS MANAGEMENT SYSTEM IN OHSAS 18001 ......................... 131
FIGURE B.7 ELEMENTS OF OHS MANAGEMENT SYSTEM IN OHSAS 18001 .................... 132
FIGURE B.8 MAIN ELEMENTS OF THE SMSs (ILO-OSH, 2001) ...................................... 133
FIGURE B.9 OSH MANAGEMENT SYSTEM OF ILO-OSH 2001 ........................................... 134
FIGURE 8.4 CONTENT OF THE SAFETY PLANNING SHOWS ON THE SIDE ....................... 141
FIGURE 8.5 EXAMPLE ILLUSTRATING THE USE OF “CONSTRUCTION SAFETY RELATED LEGISLATIONS AND REGULATIONS” ................................................................. 141
Chapter One - Introduction

1.1. Concern on construction safety industry

1.1.1 Accident Statistics

Construction industry, being one of the most hazardous industries all over the world (Tam, 2003; Lingard and Rowlinson, 2005), always has a poor reputation of a high accident rate and hazardous activities on site. This causes loss of many lives, health, skilled personnel, compensation, and disrupting the production.

Table 1 show the number of industrial accidents in three major industries, including construction Industry, food and beverage services and manufacturing Industry (Labour Department, 2011). These three major industries are usually contributing the highest accident rate in Hong Kong. From 1999 to 2010, construction industry always constitutes the highest accident rate. In 2011, the accident rate in construction is around 52.1% which is the highest and is significantly higher than that of the overall 13 industries (24.9%). This revealed that in Hong Kong, construction safety is always a key issue to concern and improvement in construction safety performance is necessarily required.

<table>
<thead>
<tr>
<th>Year</th>
<th>Construction Industry</th>
<th>Catering Industry</th>
<th>Manufacturing Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>14078</td>
<td>12549</td>
<td>5499</td>
</tr>
<tr>
<td>2000</td>
<td>11925</td>
<td>12621</td>
<td>5346</td>
</tr>
<tr>
<td>2001</td>
<td>9206</td>
<td>11914</td>
<td>4385</td>
</tr>
<tr>
<td>2002</td>
<td>6239</td>
<td>10149</td>
<td>4636</td>
</tr>
<tr>
<td>2003</td>
<td>4367</td>
<td>8527</td>
<td>3719</td>
</tr>
<tr>
<td>2004</td>
<td>3833</td>
<td>9410</td>
<td>2936</td>
</tr>
<tr>
<td>2005</td>
<td>3548</td>
<td>8902</td>
<td>2912</td>
</tr>
<tr>
<td>2006</td>
<td>3400</td>
<td>9294</td>
<td>2949</td>
</tr>
<tr>
<td>2007</td>
<td>3042</td>
<td>8876</td>
<td>2735</td>
</tr>
<tr>
<td>2008</td>
<td>3033</td>
<td>8049</td>
<td>2467</td>
</tr>
<tr>
<td>2009</td>
<td>2755</td>
<td>7470</td>
<td>1991</td>
</tr>
<tr>
<td>2010</td>
<td>2844</td>
<td>7541</td>
<td>2009</td>
</tr>
</tbody>
</table>

Acc. Rate/1000 Workers

<table>
<thead>
<tr>
<th>Year</th>
<th>Construction Industry</th>
<th>Catering Industry</th>
<th>Manufacturing Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>198.4</td>
<td>66.9</td>
<td>22.2</td>
</tr>
<tr>
<td>2000</td>
<td>149.8</td>
<td>66.2</td>
<td>23.4</td>
</tr>
<tr>
<td>2001</td>
<td>114.6</td>
<td>61.5</td>
<td>20.7</td>
</tr>
<tr>
<td>2002</td>
<td>85.2</td>
<td>54.7</td>
<td>18.8</td>
</tr>
<tr>
<td>2003</td>
<td>68.1</td>
<td>49.6</td>
<td>15.7</td>
</tr>
<tr>
<td>2004</td>
<td>60.3</td>
<td>51.5</td>
<td>17.5</td>
</tr>
<tr>
<td>2005</td>
<td>59.9</td>
<td>47.3</td>
<td>17.7</td>
</tr>
<tr>
<td>2006</td>
<td>64.3</td>
<td>47.2</td>
<td>18.4</td>
</tr>
<tr>
<td>2007</td>
<td>60.6</td>
<td>43.5</td>
<td>17.4</td>
</tr>
<tr>
<td>2008</td>
<td>61.4</td>
<td>38.7</td>
<td>16.3</td>
</tr>
<tr>
<td>2009</td>
<td>54.6</td>
<td>35.7</td>
<td>15.9</td>
</tr>
<tr>
<td>2010</td>
<td>52.1</td>
<td>34.7</td>
<td>16.8</td>
</tr>
</tbody>
</table>

Table 1.1: Industrial Accidents in Major Industries (1999 - 2010) Source: Labour Department (2011)
The accident rate and the fatality rate in construction are still in an unacceptably high level in Hong Kong which consider as a civilized society. According to Table 2, accident rate in construction reached the peak at 114.6 in 2001 and maintained a downward trend from 2001 to 2010 (Labour Department, 2011). It seems that safety performance in Hong Kong construction industry has continued to improve. However, the fluctuated fatality rate and the upwards trend on the surge of accident is observed and drew great attention.

At mid-October, 2011, 18 out of 24 fatal industrial cases happened in the construction industry, compared to 7 fatal cases in the same period of last year. As such, safety and health in the construction industry must be addressed with a high level of attention, or Hong Kong will continue to be prosperous only at the expense of life and limb.

1.1.2 Economic Feature

Construction industry does not only contribute to the majority of industrial accidents and deaths but also to the economies. The role of the industry in economic development has been validated by several studies (Strassman, 1975; Turin, 1969; Wells, 1986; Ofori, 1988). When economic growth has been significant, the growth of construction output has been even more dramatic (Wells, 1986).
The construction industry has tremendously contributed to the overall Hong Kong’s economy in term of GDP and job opportunity. The GDP see increases 12 % from 2003 to 2010. And in 2011 January to September, the gross value of construction work in nominal terms was already chasing to that the total value in 2010. (Figure 1.1)

Furthermore, with the challenges posed by the commencement of major infrastructural projects and the growth in building repair and maintenance works recently in Hong Kong, issue on construction safety would loom large if safety is not given proper attention.

![Gross value of construction work in nominal terms](image.png)

**Figure 1.1 Gross value of construction work in nominal term (compiled from Hong Kong annual Digest of Statistics 2001-2011)**

### 1.1.3 Major issues of site safety

#### Unique nature among other industry

Although health and safety management is widely practiced within all industries under the Factories and industrial undertakings (Safety Management) Regulation (F&IU(SM)R), in construction industry, site condition cannot be controlled as “pure” manufacturing industry (Godfaurd, 2011). Construction industry has the unique characteristic that products are unique form substance, form, size, and purpose (Porteous, 1999).
Multi-layers of subcontracting system

Besides, construction is a significant employer of labor due to the large proportions of its activities and its labor-intensive characteristics (Haupt, 1996). With sophisticated subcontracting system of three to four level of subcontract works, the complexity make it difficult to determine who is responsible for safety planning.

Tight construction program

An unreasonably short construction period is usually allowed for the majority of construction projects. Within a tight construction period and high rating in the production rate, not much time is allocated for planning stage. Therefore, contractors’ interest in safety will be privileged.

Safety Practitioners

Safety management systems (SMS) must be developed and administered by qualified safety practitioners. They should have updated and extensive knowledge on trade practice, safety technology and the wide spectrum legal requirements on safety and should commit to safety mission. However, safety practitioners of this quality are very rare in Hong Kong.

According to the Building and Civil engineering Industry Manpower Survey Report 2011, there were totally 869 safety officers and 505 assistant safety officers/ safety supervisors employed in construction industry. And in 2011, there were totally 1143 construction sites, hence every safety officers (with less than one assistant for each) took care 1.3 sites in average. There is still a heavy workload for safety officers.

1.2. Current state of safety planning

In fact, in all countries, safety becomes paramount especially in construction industry. Safety and health in the workplace constitute an important issue to
the government and the construction industry, and over the past few decades, there has been a rapid progression of regulations, policy mandates, incentives, and training and awareness development programmes to combat the recognized and identified causes of injuries and accidents in construction. The corporations are responding to the many drivers by developing corporate policies to attain “Zero Accidents” and “Zero Incidents”.

Traditionally, safety is managed separately from construction. It's because safety always consider as a hindering component to the production work and extra expense. However, such practice tends to disregards the safety constraints within construction process and results in consistently high accident statistic. A well integrated safety management in construction process shall be achieved, otherwise, the construction project never attain the optimum benefit of the three vital objectives- cost, time and quality.

Furthermore, many researchers also pointed out the lack of integration between construction process and safety issues (Gambatese and Hinze, 1999; Benjaoran, 2009; Sulankivi et al 2010). Effective safety planning contributes in the prevention of accidents and ill health of site personals. Planning well for safety plays an important role in reducing unnecessary cost and delays.

In order to reduce the frequency and severity of construction accidents, firms implement safety programs and procedures that include written safety plans (Hallowell, 2010). Nevertheless, many constructors found difficulty in converting F&IU(SM)R directive into actions and practical implementation.

Chong Pui Ho et. al. (2000) conducted a research on safety planning. With approximate 5% of budget spends on safety plan and procedures, many contractors questioned on the worthiness of spending such amounts on safety plans. The proposed research further identified the significant of assessing hazards and risks on the site. More productivity and prevention of accidents/injuries are achieved. So, it is always important to investigate possible safety issues before commencing the work on sites.
Raglan (2003) revealed that many construction companies these days have a generic safety plan that is fulfilling the minimum requirement on each element on SMS. They seldom prepare a tailor-made one for each particular project and rarely have sufficient follow up action to monitor the implementation of the plan. This results to the failure in function and occurrence of accident.

In fact, safety planning is essential as we cannot control what we did not plan for. Any unidentified hazards will not be planned for safety measures. Therefore, during the planning phase, safety must be regarded as important as construction activities (Kartam, 1997). Safety requirements should be the same as construction activities in work breakdown structure. A proactive safety plan and early involvement of safety in the project before hazards can be created.

As a result, one of the objectives of this study is to identify the important elements for developing a safety planning model, i-SPM 2013. It aims at assisting contractors, especially small and medium companies in designing safety plan which comply to regulation and can identifies all the potential risk and hazards activities. At the same time, increasing awareness on safety issues at the project planning stages is addressed to remind designers and construction professionals.

1.3. Why safety planning in Building Information Modelling (BIM)?

Furthermore, pervious researches focus on the causes of accident, the review of construction procedures, the introduction of safety culture and the implementation of SMS. They all contribute a remarkable improvement in safety performance, but with the increase in the project's complexity and diversity, each construction site has its specific hazards and these differ from one location to another which cannot be generalized. The improvement in safety performance may reach level out nowadays and is difficult to improve further. Rajendran and Clarke (2011) researched on the new methods and tools to prevent these injuries and illnesses. One such tool is BIM.
BIM is one of the most conspicuous attributes of a fundamental change that is swiftly transforming the construction industry (Rohena, 2011; Hergunsel, 2011; Taiebat, 2011). A safer worksite is resulted with the improvement in communications.

So, it is advisable to incorporate i-SPM 2013 into BIM as a sub-model to prove that decisions of designers and project planners have direct impact on workers’ safety and must consider it as a part of design and planning processes. As a result their interactions with safety professionals can be encouraged to make them more responsible for workers safety. They must be made aware of various means by which their design and decisions improve the site safety conditions. Therefore, i-SPM 2013 will be designed in such a way that safety could be addressed right from the design stage.

1.4. Research Aim and Objectives

This research aims to explore the factors that affect construction safety planning for developing i-SPM 2013, as a sub-model into BIM.

In this project, the following objectives are focused:

1. To examine the safety management in Hong Kong and other developed countries for developing i-SPM 2013 particular for construction industry;
2. To increase the collaboration of the designers and contractor in construction safety issue by exploring the potential use of BIM in safety dimension;
3. To identify the importance of the contributing elements in construction safety planning and the current utilization of BIM in contractors’ aspect via a questionnaire survey;
4. To verify the validity of the above safety planning model via interview with safety professionals; and
5. To establish a conceptual integration between i-SPM 2013 and BIM to raise the awareness of cooperating the safety management right at the design stage.
1.5. Research Methodology

In this study, three kinds of research methods including literature review, questionnaires and interview are conducted and works as supplement to gather a more comprehensive data and information for designing and developing i-SPM 2013 model.

1.5.1 Literature Review

In order to gain better understanding on construction safety planning, a brief review on SMS is required. Relevant information was obtained through extensive reading of books, journals, academic research papers, dissertations, press releases, government publications and related statistical reports.

In fact, studies on safety performance are abundant. Therefore books and journals could give a clear idea on the causes and factors of poor safety performance in Hong Kong. It provides a better insight to the obstacle to satisfactory SMS and the considerations in safety planning. Information about construction safety in BIM can also be found.

Besides, due to the ease of accessibility, most information such as electronic version of safety management in different countries was obtained from the internet. By studying those guidelines, components and rationale on SMS could be interpreted which can further analyze the important factors required in safety planning.

1.5.2 Questionnaires

After reviewing literatures, factors on construction safety planning are identified. A questionnaire was then carried out for the second part of data collection. It aim at finding out the degree of importance among those proposed factors and the utilization of the BIM on safety dimension in different Construction Companies. Questionnaires were sent to safety officers, safety managers and other safety related professionals in Hong Kong.
1.5.3 Interview
Conducting interview is the third part of data collection. It can obtain in-depth information and explanations to the questionnaires findings. During the interview, complex data can be collected through direct face-to-face communication, clarifications on the quarries or follow-ups on interviewees’ answers. It can also enhance the accuracy of the collected data. Safety professionals were interviewed as they are more familiar with the construction safety.

1.6. Organization of Research Study
The whole research is organized into seven main sections as follows:

Chapter 1 introduces the perspective of the research in terms of the basis and overall purpose. It briefly introduces the research background information, aim and objectives, scope and limitations of the dissertation. Furthermore, it includes an overview of the structure and organization of the study.

Chapter 2 is literature review which provides a synopsis of the development of safety management and safety planning in Hong Kong, including background, rationale and failure on its implementation. It further reviews on current construction safety study in BIM and illustrate the feasible of cooperating i-SPM 2013 into BIM.

Chapter 3 continues to present the literature about the content of the safety plan and address the key elements of i-SPM 2013. Comparisons on elements present in the SMS are made. The major issues are the setup of various factors in safety planning.

Chapter 4 describes the methodology used in this research. It describes the proposed method used for the research, addresses the suitability and achievement of the aim and objectives of the study, and discusses the selection basis of the methodological approach for the research.
Chapter 5 and Chapter 6 present the findings and analysis of the questionnaire survey in which relevant and related research questions are posed. The results are based on the analysis of feedback from respondents. Discussions on i-SPM 2013 is included in Chapter 6.

Chapter 7 presents the findings and analysis of the interview result in which opinion and suggestion on relevant and related research questions are asked.

Chapter 8 presents the discussion on the introduction of i-SPM 2013 into BIM with visual illustrations for the ease of reference and future development.

Chapter 9 completes the dissertation with a summary of the research, conclusions and recommendations for future research.
Chapter Two - Literature Review

2.1. Introduction

A number of literatures have been investigated related to safety planning and BIM technologies. In this chapter, it mainly divided into two parts I) a synopsis of the safety management and II) current safety study in BIM. At the end of this chapter, concept on integrating safety planning model into BIM will be summarized.

2.2. Overview on Safety Management in Hong Kong

2.2.1 Law related to construction safety

Law related to industrial safety was first introduced in 1992. Until the enactment of F&IU Ordinance in 1955, the safety legislation started to develop. The main 6 ordinances governing the safety and health for the construction workers employed in construction sites are as follow:

1. Chapter 59 FACTORIES AND INDUSTRIAL UNDERTAKING ORDINANCE (4 subsidiary regulations not related to construction are not listed)
   - Construction Sites (Safety) Regulations
   - Factory and Industrial Undertaking Regulations
   - Factory and Industrial Undertaking (Abrasive Wheel) Regulations
   - Factories and Industrial Undertakings (Asbestos) special Regulations
   - Factories and Industrial Undertakings (Blasting by Abrasives) special Regulations
   - Factories and Industrial Undertakings (Carcinogenic Substances) Regulations
   - Factories and Industrial Undertakings (Cartridge-Operated Fixing Tools) Regulations
   - Factories and Industrial Undertakings (Confined Spaces) Regulations
   - Factories and Industrial Undertakings (Dangerous Substances) Regulations
   - Factories and industrial Undertakings (Electricity) Regulations
   - Factories and Industrial Undertakings (Lifting Appliances and Lifting Gear)
Regulations
- Factories and industrial Undertakings (Notification of Occupational Diseases) Regulations
- Factories and Industrial Undertakings (Woodworking Machinery) Regulations
- Factories and Industrial Undertakings (Cargo Handling) Regulations
- Factories and Industrial Undertakings (Work in Compressed Air) Regulations
- Factories and Industrial Undertakings (Protection of Eyes) Regulations
- Factories and Industrial Undertakings (Spraying of Flammable Liquids) Regulations
- Factories and Industrial Undertakings (Safety Management) Regulations
- Factories and Industrial Undertakings (Safety Officers and Safety Supervisors) Regulations
- Factories and Industrial Undertakings (Suspended Working Platform) Regulations
2. Chapter 509 OCCUPATIONAL SAFETY AND HEALTH ORDIANCE
3. Chapter 470 BUILDERS’ LIFTS AND TOWER WORKING PLATFORMS (SAFETY) ORDIANCE,
4. Chapter 469 OCCUPATIONAL DEAFNESS (COMPENSATION) ORDIANCE
5. Chapter 360 PNEUMOCONIOSIS (COMPENSATION) ORDIANCE

Industrial safety laws in Hong Kong are chaotic as laws occasionally overlap from one to another. The OCCUPATIONAL SAFETY AND HEALTH ORDIANCE covers both industrial and non-industrial workplace whereas the F&IU ORDIANCE covers industrial workplace only.

There are also other laws related to construction safety with which contractors are required to comply when they carry out construction works. These laws includes but not limited to the following:

1. Chapter 123 BUILDING ORDIANCE
2. Chapter 56 BOILERS AND PRESSURE VESSELS ORDIANCE
3. Chapter 295 DANGEROUS GOODS ORDIANCE
4. Chapter 311 AIR POLLUTION ORDIANCE
5. Chapter 51 GAS SAFETY ORDIANCE
Double-barreled approach is adopted in the industrial safety law in Hong Kong. The government enforces the “hardware” regulations, which set out the safety standards for employers and employees to obey. On the other hand, the government has promoted the “software” regulations to achieve the concept of self-regulation.

2.2.2 Traditional safety management

According to Dennis (1997), the characteristics of traditional safety management program are summarized as follows:

1. Focus on injuries, illnesses, and other end-of-the-0principeline measures. A narrow view of accident is taken. Near misses, at-risk behaviors, and upstream measures are not tracked or understood.
2. Tend to be reactive, not preventive.
3. Tend to be project-oriented rather than system-oriented.
4. Consider safety as a separate function rather than a part of all functions.
5. Tend to blame the worker for accidents. Often a Theory X view is taken of workers (based on McGregor’s Theory X and Theory Y: Theory X holds that workers do not like work or responsibility and must coaxed to put effort in their job).
6. Focus on the attitudes of workers. The underlying assumption is that,
because workers are responsible for accidents, they must have bad attitudes.

7. Rely heavily on promotional campaigns to get people to feel responsible for safety and to give them the “appropriate” attitude.

8. Are based on a top-down model. Management bases, coaxes, and entices. Workers are rewarded with prized or are disciplined.

9. Place a strong emphasis on rules and close supervision of workers.

From above summary, it is not difficult to find that traditional approach to safety management have largely concentrated their efforts on safety rules and physical environmental controls to control employee behavior and interactions. This approach is resulted from reactive approaches to accidents rather than from proactive approaches to safety. Modern safety management emphasized that effective safety management of the organization, through the utilization of appropriate structure, function, roles, system and safety procedures, is of prime importance for the prevention of a poor safety performance.

2.2.3 Factories and industrial undertakings (Safety Management) Regulation

Over a long period of time, safety records in construction industry are so poor that safety has enduring become a matter of grave concern to the Hong Kong government and the public. In 1995, a consultant paper on the review of the industrial safety recommends the government to focus on the enforcement for promoting safety management. The findings of the review reaffirmed that “those who create and work with the risk should deal with the risk” i.e. the proprietors and the workers. It also concluded that self-regulation and government legislation is the key to improve existing safety management. Thus, the F&IU(SM)R evolved in 2000 and provides the basis for this research.

The F&IU(SM)R is the basic and most important regulation influencing the construction’s safety management in Hong Kong. The enterprises are required to set up a systematic, integrated, proactive and participative approach towards company-based SMS. The main aim is to ensure continuous
improvement of the safety of workers.

With reference to the regulation, there are 14 elements that proprietors and contractors are required to deal with when they implement SMS. The elements are divided into 3 main parts and the adoption of which shall refer to the aggregate number of workers working category” as stipulated on APPENDIX A.

As the risk assessment is the main tool used in the safety management processes and the preventive measures are required to be integrated into all activities at all levels, Leung (1995) concluded that SMS can facilitate the proprietor to identify hazards at work and target resources and efforts to eliminate such hazards.

Leung (1995) also states that an efficient SMS can result in decreased accident rates and workers’ compensation premiums, a related increase in productivity, better safety culture; improved employee perception of the physical and psychosocial working environment both increased hazard reporting by employees and increased worker participation in safety and health activities.

2.3. Various Safety Management System Standards

Understanding on SMS is critical in safety planning and safety plan is an executive tool for a systematic SMS. Over the past 20 years, a variety of SMS standards, guidelines, models and frameworks have been developed. Six SMSs are compared in this section (Refer to APPENDIX B). They are

1. Hong Kong Safety Management System;
2. “Successful Health and Safety Management”, HS(G)65
4. Continuous Improvement Model (NSC 1994);
5. OHSAS 18001: 2007
2.3.1 Summary on various SMSs

Based on the definition given in BS 8800:1996, SMS can be thought as an independent set of preventive measures, which is targeted at maintaining and improving safety performance of an organization. Moreover, the BSI emphasizes that those elements of occupational health and safety is all essential for an effective SMS. Likewise, the HS(G)65 provides the basic criteria for an effective SMS. Insofar as occupational health and safety (OHS) are concerned, OHSAS 18001:2007 recommends the development of a holistic safety management process for an organization.

Forming the most sophisticated safety planning model does not simply mean combining all the variables from various SMSs or OHSMSs. The term “comparison” means examining common elements of these standards to investigate the alike and different. This process can avoid unnecessary duplication or imposition of contradicting requirements.

From the overview on the key activities included in various SMSs, it revealed that the principal of the SMS are actually universal. However, according to the HS(G)65, the detail of the action shall depend on the size of the organization, the hazards presented by its activities, products or services, and the adequacy of its existing arrangements. And the most significant key point is that the SMS should definitely fit the construction nature of its countries.

Although the SMS models presented above seem to differ in certain aspects such as the terms used, different guidelines often have many similarities in substance (Mitchison and Papadakis, 1999). After summarizing the above SMSs (Table 3.1), all models have more or less the same following basic activities: policy; planning, organizing and implementation; monitoring; and review and audit.
### Policy

A safety policy is the management’s expression of the decisions to be followed in the organization (Kuusisto, 2000). Written safety policy should be set out by the top management. Besides, it should be concise, clearly written, dated and signed or endorsed, should include long-term and permanent objectives and indicate the key responsibilities and practical arrangements. An organization’s safety policy sets the scene from the top regarding the board’s beliefs, intentions, priorities and requirements of managers and the workforce (Waring, 1996; ILO, 2001, Raglan 2003).

### Planning, organizing and implementation

The developed policy can be communicated and readily accessible to employees. Planning means the determination of safety objectives and priorities and the preparation of the working programme to achieve the goals (Kuusisto, 2000).

Organizing means all hierarchical levels, from top management to every employee are involved by determining the clear tasks and responsibilities (Kuusisto, 2000). At this stage, coordination will be required.

Implementation is to ensure risks are adequately controlled (Waring, 1996). According to the HSE (1998), managers need to commitment and participation of staff; staffs need to be competent; responsibilities must be clearly allocated; and staff should be consulted and involved in solving problems (Raglan, 2003).

### Monitoring
Success in implementation requires appropriate and adequate monitoring of progress and outcomes (Waring, 1996). Monitoring includes active monitoring (before things go wrong), which establishes that procedures are in place and are working, and reactive monitoring (after things go wrong), which involves learning from mistakes (HSE, 1998).

### Review and Audit

A safety audit and a periodic review are essential stage on SMS implementation. It is the structured process of collecting independent information on the efficiency, effectiveness and reliability of SMS, and drawing up plans for corrective action (HSE, 1998). Safety review is a process of evaluating the efficiency of safety performance and decision making on the nature and timing of the actions necessary to treat insufficiency (Lindsay, 1992).

### 2.4. Integrated approach on safety planning into BIM

#### 2.4.1 Introduction on Building Information Modeling (BIM)

BIM was first incepted in the 1970s and rapidly developed in the 1980s and 1990s. It is being increasingly implemented in the construction industry to produce data-rich models of buildings and structures.

According to Wikipedia®, BIM is the process of generating and managing building data during its life cycle. It covers geometry, spatial relationships, light analysis, geographic information, quantities and properties of building components such as manufacturers’ details. It can be used to demonstrate the entire building life cycle, including the processes of construction and facility operation. Quantities and shared properties of materials can be extracted easily. Scopes of work can be isolated and defined. Systems, assemblies and sequences can be shown in a relative scale with the entire facility or group of facilities. Dynamic information of the building, such as sensor measurements and control signals from the building systems can also be incorporated within BIM to support analysis of building operation and maintenance.
2.4.2 Use of BIM

BIM is an innovative technology that has transformed the way buildings are designed, constructed and managed. According to McGraw-Hill Construction (2008), BIM is being broadly adopted across the construction industry and its use is expected to exponentially expand within forms and across the Architecture, Engineering and Construction (AEC) industry in the coming year.

In Hong Kong, as of now BIM usage is confined mostly to the design and planning stages of the project, with very little of it being used in the construction phase. However, construction phase is well known for its roots of accidents. Furthermore, BIM technology are proved with the potential to be used in safety planning procedures particularly those related to tasks on construction sites in recent studies (Gambatese 2005; Chavada, 2010).

2.4.3 BIM VS CAD

BIM is a successor to the computer-aided drafting (CAD). As in CAD drawings, there is a lack of interactivity and without automatically reflection on the change in one view to another while BIM based architectural software have allowed this function by the production of intelligent 3D/4D models.

Besides the form (geometry), BIM is also meant for modeling the functions and behavior of building systems and components (Sacks et al, 2004). With numerous information covered by BIM, BIM are, therefore, gradually replacing
the traditional CAD technology with clear advantage highlighted (Birx, 2005, Khandoze, 2005, Sacks and Barak, 2008).

Figure 2. 2 Relationship between company’s performance on the use of CAD and BIM technology (http://buildinginformationmanagement.wordpress.com/)

### 2.4.4 Benefits and Obstacles of BIM

BIM users face a very broad range of drivers and hurdles on the path to adoption. In general, they see the need to balance the benefits of improved productivity and coordination with the challenges of BIM related costs and training issues. According to a McGraw-Hill survey (2008), the top benefits of BIM and obstacles are:

<table>
<thead>
<tr>
<th>Top benefits of BIM</th>
<th>Top obstacles to BIM adoption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easier coordination of different software and project personnel</td>
<td>Adequate training</td>
</tr>
<tr>
<td>Improved productivity</td>
<td>Senior management buy-in</td>
</tr>
<tr>
<td>Improved communication</td>
<td>Cost of software</td>
</tr>
<tr>
<td>Improved quality control</td>
<td>Cost of required hardware upgrades</td>
</tr>
<tr>
<td></td>
<td>A/E risk of losing intellectual property and liability issues and sharing of information between A/E, contractors and facility owners</td>
</tr>
</tbody>
</table>

Table 2.2 Top benefits of BIM and the top obstacles to BIM adoption
2.4.5 Shortcoming of BIM Safety Research in Hong Kong

Studies done by Kiviniemi (2011) and Rohena (2011) point out that BIM technologies are actually gradually moving from the worlds of architecture and engineering to the arenas of construction companies and other participants in the construction operations that is dramatically reshaping the ways of work in construction project teams. They also figured out the benefit of the involvement of contractor in terms of the increase in productivity and improvement of the final project outcomes for all the parties involved. The findings of studies on the use of BIM have shown that communications can be improved and errors can be eliminated; thus resulting in a safer worksite.

In fact, studies on utilizing BIM in Safety aspect in construction industry has been started in various countries recently, such as USA, Finland and Norway (Kiviniemi et al., 2008; Wong et al., 2009; Succar, 2009; Khemlani, 2005; Arayici, 2008). It shows that Hong Kong is lagging behind. In Hong Kong, contractors involved in the BIM are still in a limited basic and little researches on the study of construction safety in BIM are found.

In Finland, the association of Finnish Contractors is actively promoting the implementation of the BIM in the industry. VTT, one of the important organizations in the research of BIM, carried out on-going safety BIM research project from 2009 to encourage and develop utilization of BIM technology in construction planning and management - from viewpoint of occupational safety. Example are “Building Information Model (BIM) promoting safety in the construction site process” from October 2007 to February 2009 and “BIM-based Safety Management and Communication for Building Construction” from April 2009 to June 2011 which aim to develop procedures and use of BIM technology for safety planning, management, and communications, as part of the 4D-construction planning.

Moreover, the theme of the 2012’s CIB W099 International Conference is "Modeling and Building Health and Safety" and it specially address the use of BIM to add the safety dimension for monitoring and improving safety
performances on construction projects by launching a competition. It revealed that BIM, recognized as one of the most conspicuous attributes that is swiftly transforming the construction industry, is worth investigating and can be efficaciously enhance a safer worksite from improving the communications, eliminating errors by integrating design and collaborative features of BIM.

2.4.6 BIM-based safety management

Kiviniemi (2011) introduced the concept of BIM-based safety management. In BIM-based safety management the most important matters are safety communication, safety planning and risk management (Figure 2.3). BIM-based orientation, introduction, education and supervision are the possible ways to reinforce safety communication by visualization.

BIM-based safety planning offers possibilities to execute the planning process together with several partners. This way the safety planning process attains better results and solutions which are additionally shown as 3D safety plans. BIM-based risk assessment and risk management offer the same benefits. All this requires that there is know-how to use BIM-based safety management process and practices and also that the safety management is incorporated in the whole construction process.

Figure 2.3. Safety management as a part of BIM-based construction procedures. Kiviniemi (2011)
2.4.7 Concept of safety-in-Design with the safety planning model

Lingard and Rowlinson (2005) pointed out that conventional safety practices have held designers responsible for safety as the end-users, and considered constructors responsible for the safety of construction workers. However, in recent years, and with the advent of self-regulation, it has become apparent that the contractor alone cannot deal with safety issues. In fact, many safety issues arise due to design consideration. Hence, it is important that the designer is aware of the role he or she can play in enhancing construction safety at the design phrase.

Benjaoran (2009) and Gambarese et al. (2007) also addressed that at the design phrase, designers can actually play an important role in early influencing construction safety by introducing the concept of safety-in-Design. As such, designers must realize their privilege and be capable of identifying risks and hazards in the resulted construction method that directly influenced by their design. Hence, responsibility moves not solely to designer, but to client, to insist that safety be designed into the project.

Design for Safety (DfS)

Gambatese and Hinze (1999) developed a design tool to assist designer in identifying project-specific safety hazards and to provide best practices to eliminate the hazards. These safety design suggestions accumulated to form the database of the knowledge. In addition, Hadikusumo and Rowlinson (2004) suggested that a virtual reality was used to stimulate and bring back perception of hazards and safety knowledge in both explicit and implicit forms. Such tool can assist on the design-for–safety (DfS) process.

DfS mainly addressing the consideration of safety during the upstream phrase of the construction that is the design phrase. So, it can help in promoting the collaboration between designers and constructors through the entire project delivery process.
It is a viable intervention that assists designers in addressing safety in the design. Besides, Whittington et al. (1992) and Suraji et al. (2001) showed that a significant number of hazards can be avoided upstream of the construction process during planning, scheduling, and design, numerous industry, project, and educational barriers to its implementation.

Taiebat (2011) summarized that designing for construction safety is supported by the hierarchy of controls common to safety and health professions which identifies designing to eliminate or avoid hazards as the preferable mean in reducing risk. The code and standards keeps the designers responsible for the safety of the final building, and contractors for the safety of construction worker.

\section*{Necessity of DfS in Hong Kong}

With a lagged behind safety record among all other industry and the existence of the mindset that construction work is inherently unsafe, the construction industry is prompt to consider alternative dimension for reducing the construction worker risk apart from implementing measure in the constructors’ aspect.

In fact, a higher priority shall be given in designing to eliminate or avoid a hazard than simply controlling the hazard or protecting the workers from the hazard (Manuele, 1997). This has supported by Szymerski’s time-safety influence curve (Szymerski, 1997) in illustrating the influence of safety to the greatest extent in the early phases of a project. Gambatse et al. (2005) also showed the general relationship between design efforts and the associated additional project costs in figures similar to Figure 2.4.
Furthermore, many studies as stated in the Taiebat’s studies (2011) have been done and data are collected to prove and confirm the efficiency of the link between design and worker’s safety. Both Gambatese et al. (2008); Jeffrey and Douglas (1994); Trethewy and Atkinson (2003); Hecker et al. (2005) and Weinstein et al. (2005) reached the same results that indicate the existence of a definite link between design decisions and safe construction both directly and indirectly.

It is supported by various statistical surveys carried out all over the world. The European Foundation (1991) claimed that 60% of the surveyed accidents could have been eliminated, reduced, or avoided with more thought during the design stage. While in UK, Gibb et al. (2004) announced that out of the 100 construction accidents surveyed, 47% of the cases would have reduced if there are changes in the permanent design.

The survey among contractors also ranked design as the highest out of all components identified that negatively affect safety (Gambatese 2005).
Chapter Three - Framework development of i-SPM 2013

3.1. Introduction

This chapter aims to provide a basic framework on the context of i-SPM 2013 by investigating the problems of construction safety planning, importance of safety planning and comparing the key elements in various SMSs to illustrate factors included in the model.

3.2. Problems in safety planning

An effective safety plan shall be specific depending on the scope and the complexity of the work activity and modified from time to time as work activity proceeds according to experience and information received in the implementation of the plan (LD, 1999). However, generic safety plans are always found in many contractors’ company due to the lack of format of the safety plan in construction industry and contractor’s attitudes on having an effective safety plan.

3.2.1 Lack of common format for construction industry

Baxendale (2000) points out that the principal contractor had encountered difficulty in preparing safety plan due to the lack of adoption of a common format in the construction industry. So, although responses are found to be broadly based on the HSE’s guidelines in his findings, the variation in content and quality of the plan was very extreme. Furthermore, he stated that without common format of risk assessments, the majority having a format based on generic risk assessments by safety advisors.
3.2.2 Contractor’s negative attitude

The value of written safety plans has always been a concern to some construction professionals (Chong Pui Ho et. al., 2000; Goetsch, 2010). They critique it as bureaucracy, paperwork and counterproductive (Goetsch, 2010). Furthermore, many construction contractors still believe safety is a luxury (Tam, 1996). As a result, most safety plans wind up by borrowing, copying and modifying provisions from numerous other safety plan used in similar or different projects. Rowlinson (2003) also addressed on the contractor’s reluctant to spend time, cost and resources in designing and developing a specific safety plan for each particular project.

According to Holland and Jensen, an optimum cost of SMS can be determined through careful adjustment of the prevention and control costs with the direct and indirect cost off the construction accidents as shown on the following figure 3.1. Such economic balance is intuitively appealing, however, in real practices, it is difficult to implement. If a target has been set for lost time accidents and a zero fatalities target has been established, it is unlikely that the optimum points indicated would be acceptable to the employer (Rowlinson, 2003). Therefore, in order to maximize its profit and be cost effective, contractors are most likely reduced the cost and time in developing an effective safety plan.

![Figure 3.1 Optimum cost of a safety management system (Rowlinson, 2003)](image-url)
3.3. Essentialness of Safety Planning

Raglan (2003) confirmed that a safety plan is the foundation upon which the health and safety management of the construction phase needs to be based. Furthermore, Goetsch (2010) suggested contractors are worth to devote time and resources on safety plan.

In Goetsch’s study (2010) on the implementation of safety plan, there were concrete evidences to support that a well-written safety plan can prevent accidents, injuries, illnesses, and associated expenses that can drain the productivity of a company as well as its profit. He pointed out that it is ethical obligations for contractors to provide the safest, healthiest work environment for their employees and subcontractors. He also illustrated the inverse correlation between the comprehensive safety plan and the injury rate. Company without such a plan experienced 30% more accidents than those with safety plan. Baxendale (2000) also revealed that departments focus on safety though written plans can preserve the consistency that cultivates safety and efficiency.

Furthermore, high-quality construction work management can also be achieved because Plan can force contractors to put their commitment to safety and health in writing, to establish clear policies and set goals for safety and health, and to provide an effective way for communicating (Goetsch 2010).

3.4. Objectives of safety planning model

Summarized from Green Cross (Volume 10 No 2, March 2003) and Raglan’s study (2003), in general, the objective of the safety plan should be as followed.

- It should be based on the company’s safety policy, which should explicitly indicate the company’s objectives and commitments to achieving certain safety standards.
- It should be in strict compliance with all relevant legal, contractual, and regulatory obligations with regard to health and safety.
- It should include all the main aspects of the site safety issue.
3.5. Current content of safety planning

3.5.1 14 core elements in Safety Planning in Hong Kong

Under the F&IU(SM)R, although there is no mandatory requirement on the safety plan, it should complement in SMS.

According to “A guide to Safety Management” published by Labour Department, safety plan is developed when the senior management has determined the safety and health objective, defined its safety policy and included their commitment. This is a determination stage as it requires the senior management to have a clear understanding on the system and the scope of safety and health of the organization itself in order to achieve those goals and commitments. Once the safety plan is comprehensively established and implemented step-by-step with regular auditing and follow-up improvement, the goal of continuous improvement can then be successfully achieved.
### Table 3.1 Core elements in safety management system

<table>
<thead>
<tr>
<th>Core elements in safety management system</th>
<th>Short term</th>
<th>General Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A safety policy which states the commitment of the proprietor or contractor to safety and health at work</td>
<td>Safety Policy</td>
<td>General intentions, approach and objectives of an organization together with the criteria and principles on which actions and responses are based.</td>
</tr>
<tr>
<td>A structure to assure implementation of the commitment to safety and health at work</td>
<td>Safety Organization</td>
<td>Safety organization involves a structure where people in the company work together in a coordinated manner, based on their knowledge, training and responsibilities, to achieve the safety and health objectives set by the top management.</td>
</tr>
<tr>
<td>Training to equip personnel with knowledge to work safely and without risk to health</td>
<td>Safety Training</td>
<td>Training programme includes formal off-the-job training, instruction to individuals and groups, and on-the-job coaching and counseling to equip personnel with knowledge to work safely and without risk to health.</td>
</tr>
<tr>
<td>In-house safety rules to provide instruction for achieving safety management objectives</td>
<td>In-house Safety Rules &amp; Regulation</td>
<td>In-house safety rules cover general rules, specialized work rules, specialized work permits and procedures.</td>
</tr>
<tr>
<td>A programme of inspection to identify hazardous conditions and for the rectification of any such conditions at regular intervals or as appropriate</td>
<td>Inspection programme</td>
<td>Inspection as an active monitoring programme which monitor the achievement of objectives and the extent of compliance with pre-set standards.</td>
</tr>
<tr>
<td>A programme to identify hazardous exposure or the risk of such exposure to the workers and to provide suitable personal protective equipment as a last resort where engineering control methods are not feasible</td>
<td>Programme for Inspection of Hazardous Condition</td>
<td>A pro-active programme to identify hazardous exposure or the risk of such exposure to the workers by prepare a list of work activities covering premises, plant, people and procedures, and gather information about them.</td>
</tr>
<tr>
<td>A programme to identify hazardous exposure or the risk of such exposure to the workers and to provide suitable personal protective equipment as a last resort where engineering control methods are not feasible</td>
<td>Personal Protection Programme</td>
<td>Provision of Personal protective equipment (PPE) to keep the hazard under control and meet legal requirements.</td>
</tr>
<tr>
<td>Investigation of accidents or incidents to find out the cause of any accident or incident and to develop prompt arrangements to prevent recurrence</td>
<td>Accident/Incident Investigation</td>
<td>The investigation of accidents or incidents is a reactive monitoring system which includes identifying and reporting.</td>
</tr>
<tr>
<td>Emergency preparedness to develop, communicate and execute plans prescribing the effective management of emergency situations</td>
<td>Emergency Preparedness</td>
<td>The emergency response plan, including procedures on what can and should be done, what equipment is necessary and what people are needed, should then be developed for responding to each emergency situation. The emergency response plan should be written and communicated to all employees. It should be posted throughout</td>
</tr>
</tbody>
</table>
| Evaluation, selection and control of sub-contractors to ensure that sub-contractors are fully aware of their safety obligations and are in fact meeting them | Evaluation, Selection and Control of Subcontractors | The evaluation and selection strategy should clearly aim at ensuring that sub-contractors with knowledge of good safety standards and a good record of putting them into practice would be selected for the work.

| Safety committees to identify, recommend and keep under review measures to improve the safety and health at work | Safety Committee | An enterprise should establish one or more than one safety committees to carry out the functions of identifying, recommending and keeping under review measures to improve the safety and health of the workers in the enterprise.

| Evaluation of job related hazards or potential hazards and development of safety procedures | Job Hazards Analysis | Hazard analysis is for the identification and assessment of job hazards and risks, the formulation, implementation and maintenance of risk control measures and the review. The programme should aim at recording known hazards/risks, identifying new hazards or assessment of the risks, evaluation of the hazards/risks, analysis of the effects or the potential effects resulting from these hazards/risks, and development and implementation of means to eliminate the hazard s/risks or to manage the them to an acceptably low level.

| Promotion, development and maintenance of safety and health awareness in a workplace | Safety Promotion | Safety promotion programmes should be developed and maintained by the proprietor or contractor of an enterprise in order to put into practice the promotion of safety and health. The programmes should have clearly defined objectives and should require very careful thought and consideration if the maximum benefit is to be obtained.

| A programme for accident control and elimination of hazards before exposing workers to any adverse work environment | Process Control Programme | An effective process control programme requires a systematic approach to evaluating the whole process. Using this approach, the process design and technology, operational and maintenance activities and procedures, emergency preparedness plans and procedures, training programmes, and other elements which impact on the process are all considered in the evaluation.

| A programme to protect workers from occupational health hazards | Health and Assurance Programme | The proprietor or contractor of an industrial undertaking with any worker exposed to any aforesaid substance or agent shall ensure that the worker is provided with medical surveillance in accordance with the relevant regulation.
3.5.2 Comparison between elements in OHSAS 18001 and ILO 2001

Then, elements in OHSAS 18001:2007 and ILO 2001 will be discussed. Reasons for selecting them as the comparing basis are as followed. First, they both are based on “plan-do-check-act” management model which is same as the SMS used in Hong Kong. Besides, these two SMSs are well recognized with clear and comprehensive structure which can provide an insight on the additional factors in developing safety planning model. Therefore, both management systems provide a comparative basic. Table 3.2 shows the benchmarking of the three safety management systems.

<table>
<thead>
<tr>
<th>BS OHSAS 18001: 2007</th>
<th>ILO-OSH 2001</th>
<th>SMS in Hong Kong</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1 General requirements</td>
<td>3.0 Policy (title only)</td>
<td>---------------</td>
</tr>
<tr>
<td>4.2 OH&amp;S policy</td>
<td>3.1. Occupational safety and health policy 3.2. Worker participation</td>
<td>Safety Policy</td>
</tr>
<tr>
<td>4.3 Planning (title only)</td>
<td>Planning and implementation (title only)</td>
<td>---------------</td>
</tr>
<tr>
<td>4.3.1 Hazard identification, risk assessment and determining controls</td>
<td>3.7 Initial review 3.8 System planning, development and implementation 3.10 Hazard prevention 3.10.1 Prevention and control measures 3.10.2 Management of change 3.10.5 Contracting</td>
<td>Job Hazard Analysis</td>
</tr>
<tr>
<td>4.3.2 Legal and other requirements</td>
<td>3.7.2(Initial review) 3.10.1.2(Prevention and control measures)</td>
<td>In-house Safety Rules &amp; Regulations</td>
</tr>
<tr>
<td>4.3.3 Objectives</td>
<td>3.9 Occupational safety and health objectives</td>
<td>Safety Policy Safety Committee</td>
</tr>
<tr>
<td>4.3.3 Programme(s)</td>
<td>3.8 System planning, development and implementation 3.16 Continual improvement</td>
<td>Safety Promotion Safety Committee</td>
</tr>
<tr>
<td>4.4 Implementation and operation (title only)</td>
<td></td>
<td>---------------</td>
</tr>
<tr>
<td>4.4.1 Resources, roles, responsibility, accountability and Authority</td>
<td>3.3 Responsibility and accountability 3.8 System planning, development and implementation 3.16 Continual improvement</td>
<td>Safety Organization</td>
</tr>
<tr>
<td>4.4.2 Competence, training and</td>
<td>3.4 Competence and training</td>
<td>Safety Training</td>
</tr>
<tr>
<td>Framework Development</td>
<td>Of i-SPM 2013</td>
<td>Chapter Three</td>
</tr>
</tbody>
</table>

### Table 3.2: Benchmarking Three SMSs: OHSAS 18001, ILO Guidelines, and SMS in Hong Kong

<table>
<thead>
<tr>
<th>4.4.3 Communication, participation and consultation</th>
<th>3.2 Worker participation 3.6 Communication</th>
<th>Safety Committee</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.4.4 Documentation</td>
<td>3.5 Occupational safety and health management system documentation</td>
<td>-----------------</td>
</tr>
<tr>
<td>4.4.5 Control of documents</td>
<td>3.5 Occupational safety and health management system documentation</td>
<td>-----------------</td>
</tr>
<tr>
<td>4.4.6 Operational control</td>
<td>3.10.2 Management of change 3.10.4 Procurement 3.10.5 Contracting</td>
<td>Personal Protection Programme Health Assurance Programme Evaluation, Selection &amp; Control of Subcontractors Process Control Programme</td>
</tr>
<tr>
<td>4.4.7 Emergency preparedness and response</td>
<td>3.10.3 Emergency prevention, preparedness and response</td>
<td>Emergency Preparedness</td>
</tr>
<tr>
<td>4.5 Checking (title only)</td>
<td>Evaluation (title only)</td>
<td>-----------------</td>
</tr>
<tr>
<td>4.5.1 Performance measurement and monitoring</td>
<td>3.11 Performance monitoring and measurement</td>
<td>Programme for Inspection of Hazardous Condition</td>
</tr>
<tr>
<td>4.5.2 Evaluation of compliance</td>
<td></td>
<td>-----------------</td>
</tr>
<tr>
<td>4.5.3 Incident investigation, nonconformity, corrective action and preventive action (title only)</td>
<td>3.12 Investigation of work related injuries, ill health, diseases and incidents and their impact on safety and health performance 3.16 Continual improvement</td>
<td>-----------------</td>
</tr>
<tr>
<td>4.5.3.1 Incident investigation</td>
<td></td>
<td>-----------------</td>
</tr>
<tr>
<td>4.5.3.2 Nonconformity, corrective action and preventive action</td>
<td>3.15 Preventive and corrective action</td>
<td>-----------------</td>
</tr>
<tr>
<td>4.5.4 Control of records</td>
<td>3.5 Occupational safety and health management system documentation</td>
<td>-----------------</td>
</tr>
<tr>
<td>4.5.5 Internal audit</td>
<td>3.13 Audit</td>
<td>Safety Audit</td>
</tr>
<tr>
<td>4.6 Management review</td>
<td>3.14 Management review 3.16 Continual improvement</td>
<td>Safety Committee</td>
</tr>
</tbody>
</table>
3.5.3 Distinction on OHSAS 18001:2007 and ILO 2001
Basically, there are no fundamental differences between ILO 2001 and OHSAS 18001:2007, and there is a large degree of overlapping in system elements and most are common requirements. The distinction is mainly the priority of the elements which are addressed.

3.5.4 Similarities and Differences between the elements in international guidelines and SMS in Hong Kong
However, when elements in two guidelines are compared with that used in Hong Kong, it is obvious that the two SMSs provide a more holistic framework for the proprietors or contractors to follow.
As the fundamental to any safety planning is to identify hazards, assess risk and prioritize it, and implement control to reduce unacceptable risks, all three systems specify clear requirement for hazards identification, risk assessment, and risk control; however, the three systems vary in the level details specified. The effective of any safety planning is highly dependent on the ability of the system to comprehensively identify all hazards. Therefore, a detail and sophisticated procedure that combined the above three systems on the hazards identification, risk assessment, and risk control are required.

The ILO 2001 and OHSAS 18001:2007 include explicit clauses for employees-involvement and participation as one of the elements while in HKSMS only implied in the 14 elements. In fact, it should be addressed. It is essential for all employees to have access to systems that will effectively make their voice heard. Employees spend most of their working hours at work and they have a unique knowledge of work processes, which is essential in identifying hazards at work. Moreover, employees are more likely to follow and abide with safety requirements if they participate in the processes of risk assessment and risk control.

Management commitment, Setting safety management objectives, division of responsibility and authorities, assessment and monitoring of performance, accountability, and management review are all common elements for continual
improvement. OHSAS and ILO standards explicitly states compliance with Legal requirements as one important objective of the SMS, HKSMS includes it into the in-house safety rules. These few elements shall be separated in the safety planning model to emphasis on the step to obtain a continuous improvement in safety management which is one of current problem find in the safety planning.

In order to assure that risks are controlled to an acceptable level, documentation, records and record keeping is an important requirement of the ILO guidelines and OHSAS standards. Safety planning model shall have explicit requirements for documentation for the ensure of compliance.

3.6. Factors affecting the safety planning

From previous sections, 24 factors that may contribute to the effectiveness of safety planning were identified. They were classified into Policy, Personnel, Process and Incentive aspects. This classification is based on the Teo and Ling (2006) 3P+I model on the measurement of effectiveness of SMS. The 24 factors for safety planning are now briefly reviewed.

3.6.1 Policy aspect

Understanding of Legislations and Regulations

Ng et al. (2005) have pointed out that having a weak organization culture with ill-defined safety roles and inadequately developed safety procedures, the lack of sound safety policies would result in poor safety performance of construction sites as most contractors in Hong Kong. Therefore, legislation and its enforcement have to be considered.

In Hong Kong, construction safety related legislation is mainly governed by the F&IU Ordinance (Cap. 59) and its subsidiary regulations. Others legislations and regulations are discussed in chapter 2. In the model, all construction safety related legislations or code of practices shall be implicated to ensure safety planning is complied to the law and for ease of reference.
According to Teo and Ling (2006), great impact can be seriously affected the worksite’s safety level with the implication of safety legislation and policies, in which legislation forms a framework in regulating and controlling health and safety. The senior management shall ensure the complement of the legislation into safety plan.

Safety Policy
A good safety policy is one which is comprehensive, well laid-out and incorporates specific and reasonable goals. A safety policy is used to indicate a contractor’s commitment to safety, to spell out the safety objectives and to set out the ways and means to achieve the safety objectives.

Tam (2002) also stated that clear statement on management’s concern towards prevention of accidents at the construction site shall be comprised in safety plan to avoid any doubt of the employee. Policy should outline the organization's aims and objectives for its safety program and should increase the accountability for the company in order to demonstrate the management's attitude towards safety matters and make known to all levels of management and employee alike.

Therefore, a safety policy should contain a general statement spelling out the company’s safety commitment and objectives and the management and staff’s primary responsibilities for safety. It should also contain a description of a system of responsibility and accountability for various levels of management and staff for safety to provide for a clear and logical allocation of duties and responsibilities for safety; the placing of the ultimate responsibility on the senior members of management; and the clear identification of responsibilities for training, monitoring compliance with the policy, maintaining contract with sources of advice such as safety advisor and the government, etc, and responding to employee initiatives.

In-house safety rules and regulations
In-house safety rules are essential as to provide safe working procedures or permit to work procedures in writing so as to clearly identify the hazards and/or
potential risks, and to clearly work out steps to be taken to minimize risks in specific high-risk activities.

Mearns et al. (2003) showed that safety rules and procedures have significant correlation with accident rates. According to OSHA (1999), it covers general rules, specialized work rules, specialized work permits and procedures. By providing all personnel with a common understanding of their obligations and responsibility, the objective of safety management can be achieved.

3.6.2 Personnel Aspect

Top management's leadership in safety planning process

Top management leadership and commitment are crucial to the success of effective implementing the safety plan. Anton (1988) stated that all levels of management must be involved in the activities required for planning, organizing, and controlling job-related health and safety activities.

Also, Hinze and Raboud (1988) advocated top management involvement to reduce site accidents. Surveys commissioned by the HSE revealed that 75% of all fatal accidents in the building and civil engineering industries in the United Kingdom are generally caused by ineffective management action taken. Large-scaled construction companies generally have better safety performance due to the high level of safety support and commitment shown from the top management. Other research found that the reduction in accidents would be achieved when top management takes an active interest and is dedicated to safety enhancement as well as maintaining good safety standards.

Proper consideration on worker's safety culture

Poor attitudes and bad behaviours of workers lead to difficulties in monitoring and control. However, Tam (2002) showed a positive link between safety performance and workers’ attitudes. The safety behaviour and attitudes represent organizational safety culture where the beliefs and values refer specifically to matters of health and safety.
Teo et al. (2005) proved that the safety culture in an organization is dependent upon the safety commitment of the management and workers towards its safety promotions and campaigns. Perception surveys can be conducted as a tool to detect differences in employees’ attitudes and to test the effectiveness of a safety programme.

**Proper implementation on good working relationship and environment**

Vredenburgh (2002) addressed that upward communication flow shall be maintained to have a good working relationship. Since employees close to the work, they can give practical suggestion, especially those affect them.

**Proper establishment of Safety Committee**

A safety Committee is to promote cooperation between various parties involved in the project for carrying out work smoothly and safely. It provides a platform for the contractor, subcontractors, safety professionals, engineers, foremen and other site personnel to solve safety problems together.

General speaking, a good safety committee is one which has a sufficient wide representation with well-defined terms of reference. Safety committee with representation of workers’ safety and health representatives and employers’ representatives is essential for maintaining the construction site safety (McDonald et al. 2000; Ng et al. 2005, Teo and Ling 2004).

All these studies showed a strong relationship between safety committee and the project performance, in term of safety aspect. Such a relationship is supported by Herrero et al. (2002) that committees play a central role in implementing safety management strategies and programs. Teo and Ling (2006) developed also concluded “safety committee and safety organization” is one of the factors computing the construction safety index for SMS. It reflects the importance of the establishing safety committee for safety management.
Proper delegation of responsibility and accountability in safety organization

It is important that responsibilities for safety and health should be identified and allocated properly in a clear and logical way. Each member of the enterprise to which the responsibilities are allocated should know what he is responsible for and to whom he is responsible regarding safety and health matters. The allocation of responsibilities should be recorded in document and it should be clearly stated that the final responsibility and accountability for safety and health rest with the top management. The top management must accept the responsibility for ensuring safety and health is incorporated into the running of the business. A relevant person at the top management should be designated to take up this final responsibility and accountability. Lastly, the document for allocation of responsibilities for safety and health should be signed and dated by the above person and be reviewed and revised periodically to maintain its validity and effectiveness.

Systematic Safety and Health training program

A good safety training system must be one that ensures everyone working on the site is fully aware of the type of hazards he is likely to be exposed to and the precaution to be taken to prevent accidents. There has been much research on site safety training emphasizing the importance of training needs and believe that training can be used as a drive for attitudinal change.

Provision of safety training for employees, especially workers should be seriously considered under the personnel factors. A study on the effect of first aid training on Australian construction workers concluded that training has a positive preventive effect on workers to avoid injury. It has also been found that workplace injuries would be reduced if workers received first aid training Dupont (1996).

Furthermore, active participants from the workers on safety programme can be achieved from receiving occupational safety training. It provides workers with the knowledge, capabilities and skills needed to carry out their tasks safely. Fernandez-Muniz et al. (2007) proved that it also helps them to identify the
risks in the workplace, and the procedures available to prevent, correct or minimize these risks.

As a result, organization should institute a systematic, comprehensive safety and health training programme for new employees, provide a mentor for these employees and use a buddy system to help orient newly recruited employees, and launching discussion of safety issues in training sessions, training to meet emergency situations in the safety, health and quality systems to improve the level of safety and health for all employees, (Vredenburgh, 2002). The studies of Ostrom et al. (1993), Tinmannsvik and Hovden (2003), Cohen et al. (1975), Smith et al. (1975) and Zohar (1980) have found that those companies with lower accident rates were characterized by good safety training for employees.

3.6.3 Process Aspect

Implementation of initial review

As a general safety plan is usually existed in most contractors' companies, existing safety planning including safety management system and relevant arrangement shall be evaluated and documented by an initial review.

Under ILO (2001) and BSI (2007), initial review is considered as a separate element that the contractor need to established in the safety management system for the achievement of the continuous improvement.

A project-specific safety plan shall be developed by renewing the current applicable laws and regulations, tailored guidelines of the company; identify, anticipate and assess hazards and risks to safety and health arising from the existing or proposed work environment; determine whether planned or existing controls are adequate to eliminate hazards or control risks; and analyze the data provided from workers' health surveillance.

Hazard identification and analysis

Construction site is undoubtedly regarded as the one of the most workplace full of hazardous activities. However, site safety can be greatly managed if
Potential risk activities can be identified beforehand with sufficient measure and protection on the working environment planned. Therefore, plan for hazard identification is an important feature in safety planning and design.

Cox and Cox (1996) have figured out that hazard identification is a systematic process for identifying hazards and recommending corrective action. Hazard is identified through the analysis of the organization’s work-related injury and disease records, accident investigation report, information from workplace inspection, information from the analysis of work activities, or any other reliable source that is appropriate for the construction industry.

Tam (2002) also admitted that a safe system of work should be able to eliminate identified hazards, and to complete the work with minimum amount of risk. Safety officers must ensure the proper recognition of hazards in all activities where losses could occur. Cox defined the major responsibility of management was to identify the hazards to which employees would be exposed in the workplace and to eliminate the hazards through engineering methods.

### Proper risk assessment and control

Different construction methods shall be considered and selected to meet different safety standards and expectations. Safety Officers or supervisors shall have adequate perception on the work process according to projects’ nature.

Risks are assessed for all hazards that employees may be exposed to in the construction worksite. It provides the information needed for risk handling. Risks should be analyzed, tracked, and resolved or controlled until mitigated. Teo and Ling (2006).

Risk controls are planned in a systematic way using information from risk assessments. Risk controls plan including decisions on assigning the tasks and responsibility, what resources are required, and timescale of the tasks to be completed.
Proper implementation of emergency response plan

According to Fernandez-Muniz et al. (2007), the emergency prevention, preparedness and response plan are a set of approach aim at describing the response employees and the management to face when there are emergency situations. Through the assessment of potential accident and emergency response needs, contractors can plan to meet them and develop specific procedures to cope with them. Contractors shall review this plan during the occurrence of accidents, incidents or emergency situations and make any necessary corrective measures.

Proper implementation accidents and incidents investigation

The accident investigation objected to gather factual information about the details that led to the accident. Data collection and analysis are gathered until an adequate and sufficient comprehensive explanation is obtained. Accident and incident investigation is carried out in five steps, namely, isolate the accident site, record all evidence, photograph or videotape the scene, identify witnesses, and interview witnesses.

Attention shall also be emphasized on the frequent occurred accidents on construction sites. They are mostly caused by unsafe working conditions at heights, stepping on, striking against or tripping over objects, poor lighting conditions, burial by earth collapse during excavation, collapse of scaffolding and working platforms, hazards in lifting operations, electrocution, fire hazards, lack of proper access and inadequate education and training.

Proper provision of personal protective equipment

Negative behaviours and attitudes prompt most workers not to put on their personal protective equipment whilst working on site. Therefore, during the safety planning, consideration should not only focus on the provision of the PPE, address on how to ensure the employees wear well equipped PPE should also be focused (Teo and Ling, 2006). In addition, engagement of poor tools and equipment can also cause accidents.
 Proper implementation on safety promotion
To praise the efforts made by individual site, site management, sub-contractors or individual employees to reduce accidents at work in the form of presentation of safety and health award.

The major attributes for a successful safety promotion programme should include the following:

(a) Critical safety problems should be properly identified
(b) Focus and safety slogan for the programme should be clearly determined
(c) Objectives of the safety promotion programme such as raising awareness or increasing knowledge should be clearly established
(d) Activities in support of the main theme or slogan of the programme should be organized
(e) Programme should be related to accidents or practices in the workplaces
(f) Visuals and videos should be used to attract attention and interests
(g) Incentives for participation in the programme should be provided
(h) Programme activities should be coordinated with other elements of the safety management system, but there should be no overlapping of activities

 Proper selection and management of subcontractors
Due to the nature of diversification of activities in construction industry, control over the large numbers of subcontractors on construction sites is a important process factor. With higher numbers of subcontracting, the chances of accident occurrences will be more frequent (Teo and Ling 2006).

In Hong Kong, a chain of subcontractors is commonly observed. As such, the probability of the lack of communication, coordination and control will increase (Rolwinson 2003). Furthermore, Rolwinson pointed out practice on shifting all safety responsibilities of main to subcontractors are commonly observed. Safe working environment in subcontractor may not be easily guaranteed.

 Maintenance and tight control on the documentation
With an effective communication and information transferred between
management and employees, better safety standards can be yielded and safety policies can be achieved.

Regular communication about safety issues between management, supervisors and workforce is an effective management practice to improve safety in construction site. Vredenburgh (2002) included communication and feedback as a factor in their surveys and showed that safety performance is influenced by the level of communication in an organization. Thus, safety communication and feedback as a management practice may be included in the safety planning.

**Proper implementation of internal Audit**
Auditing is an essential process in the safety management cycle and it provides managers with further information on compliance with standards. It is important to initiate safe work practices that are stemming from reliable and continuing feedback on the safety level observed.

**Conduction of regular Management review**
Safety planning shall be reviewed from the overall operation of the safety management system periodic to ensure its continuing suitability, adequacy and effectiveness. The management review shall address the possible need for changes to policy, objectives and other elements of the safety plan (Fernandez-Muniz et al, 2007).

### 3.6.4 Incentive aspect

**Introduction of safety incentive program**
In Hong Kong, incentives are commonly used either for giving monetary returns for safety performance of personnel and for supervisory safety incentives plan. Through the implication of Safety promotion in the safety planning, raise on the employees’ interest and motivation to their own safety and well-being can be revealed (Anton, 1988).

So, in safety planning, contractors may consider the use of incentives, awards and recognition to motivate employees to perform safely. As studies have
been advocated that they can add interest to the hazard control programme and enhance self-protection action on the part of the construction worksite, a well-designed reward system should be characterized by high level of visibility in the organization, offering recognition, which can help modify behaviour (Vredenburgh, 2002).

In addition, Hinze and Harrison identified that safety award was an effective tool to mitigate site accidents. In other words, employees should be motivated by incentive scheme to make them aware of site safety matters.

Nonetheless, how the incentives are being allocated is the key criteria on reducing workplace injuries effectively. Type of safety incentives used should be dependent upon the different relationships of the groups’ and individuals’ expectations and reactions towards safety incentives.

### Introduction of disincentive program

Disincentives method includes monetary, suspension from work, demolition in position, termination of service and report to relevant authorities (Teo and Ling, 2006). Establishing effective disincentives and reward systems can be seen to support the correct safety behaviours, challenge poor safety practices and reward those who exhibit the right behaviours (A O’Dea and Flin, 2000).

Therefore, the safety plan should provide for penalties in the event of breaching safety conditions. Measures can include withholding payments; and stopping work, and to enhance deterrent effect, it should be made clear to contractors that poor safety performance may lead to their chances of tendering future contracts being reduced. However, punishment should not be too harsh as it may give rise to further problem.
3.7. Framework of ūSPM 2013

3.7.1 Integrated ūSPM 2013 in BIM-safety

The “ū” in ūSPM 2013 stands for integrated safety planning. It includes all the major factors in safety planning. The “ū” also stands for the innovative tool as it is objected to incorporate into the BIM technology. Safety aspect in the BIM is still rare. With the classification of the 4 aspect in the model, the policy and the process aspects can be fully integrating into the BIM to generate the visual programs. It is expected that a 3D-safety plan can be produced from this integrated safety planning model with the innovative application on BIM. Detail will be discussed in Chapter 8.

3.7.2 Framework of ūSPM 2013

From the literature, there are 24 elements identified and shall be included in order to from a rigorous safety planning model that completely cover each site safety. Figure 3.2 shows the frame work of the safety planning model, ūSPM 2013. In order to investigate the importance of each factor, survey will be conducted and the model will modify afterward.
Figure 3.2 Framework of i-SPM 2013

- Safety Policy
- Construction Safety related Legislation and Regulations
- In-house safety rules and regulations
- Policy Factors
  - Internal Audit
  - Communication and information flow
  - Documentation
  - Sub-contractor Management
  - Management review
  - Safety promotion
  - Emergency Response
  - Accidents and Incidents
  - Process Factors
    - Initial review
    - PPE
    - H&S assurance program
    - Risk assessment and control
    - Hazardous inspection program
    - Delegation of responsibility and accountability
    - Good working relationship and environment
  - Personnel Factors
    - Incentive program
    - Disincentive program
    - Incentive Factors
    - Safety Committee
    - S&H training program
    - Top management's leadership
    - Worker's safety culture
  - Policy Factors
- Policy Factors
- Policy Factors
Chapter Four - Research Methodology

4.1. Introduction

The purpose of the study is to develop i-SPM 2013 as a sub-model for BIM by identifying the importance of the contributing elements in construction safety planning and the current utilization of BIM in contractors’ aspect.

This chapter included descriptions of the methods of data collection, data processing, and data analysis. This chapter was divided into three sections: introduction, design of research and statistical procedures.

4.2. Quantitative Research- Questionnaire Survey

Quantitative research method was used in the study. Questionnaire survey was used in this study. One set of the questionnaire was used for this project as a means of collecting data. It was an effective method for quantitative analysis by to seeking a large sample size (Hox et al., 2008).

4.3. Reason for the adopting Questionnaire Survey

Quantitative research method was used in the study. According to May (1997), survey is a method of collecting the data from a large number of people, which is the representative sample to explain and describe the characteristics or the issues. In a quantitative research, numbers and statistical methods were used. Based on numerical measurements of specific aspects of phenomena and abstracts from particular instances, general descriptions can be sorted out or testing on the causal hypothesis is done (King, et al., 1994).
4.4. Selection of target population group

In this study, as the main objectives are to design and develop construction safety planning model, the sample unit chosen was the safety professional including safety officer, assistance safety officers, safety supervisors, safety advisors and safety managers.

The safety officer was the main target group chosen. According to the ‘A Guide for safety management’ (1999), one of the safety officer’s roles is to monitor the compliance and implementation of safety plans and programmes. Therefore, this individual can be expected to have most information about the specific practices and procedures that are being carried out within the firm, and be familiar with the difficulties involved in implementing the safety planning. Moreover, safety officers can be expected to have access to all types of information concerning potential dangers to the health and safety of the workers. Meanwhile, these safety officers occupy an intermediate position between the management and the workers in construction site, so their information can be considered to be less biased and more accurate.

4.5. Distribution Progress in Collecting Data

The questionnaire was sent to 100 construction firms listed under the General Building Contractors’ Register and the member list under the Hong Kong Construction Association by personal, fax, mail and e-mail to collect the quantitative data.

4.6. Structure of the Questionnaire

The questionnaire (see Appendix A) consisted of three main parts as follow:

- The first parts of the survey (part A) collected the general information of demographic factors, e.g. career position, gender, year of construction safety experience, education level, project nature and project sum.
- The second parts of the survey (part B) collected respondents’ views of the importance of the 24 factors for developing safety plan.
- The third parts of the survey (Part C) collected respondents’ information
on the current utilization of the BIM in construction project and their view on integrating safety in BIM.

4.7. Format of the Questionnaire

In the first part of the survey, both numerical and multiple-choice questions are used. Multiple-choice question is question for participants to pick up a choice that most suitable for them out of the suggestions. Comparison would be made to the other types of question to formalize relationship. For numerical question, it is question consists on number only, such as working experience. Comparison would be made to the other types of question to formalize relationship.

In the second part of the survey, Likert-type format question were used. The respondent was required to assign a mark on each of the 24 factors to reveal their importance in safety planning. Likert-type format of seven-point scale was used. ‘1’ means strongly disagree and ‘7’ means strongly agree.

In the third part of the survey, there were a total of 6 questions designed including 4 multiple choices with one or more than one answers type question and 1 Yes/No question. Yes/No question involves question only with answer yes or no. Percentage is used for interpretation. Choice question is question for participants to pick up a choice that most suitable for them out of the suggestions. Comparison would be made to the other types of question to formalize relationship.

4.8. Data Analysis

With a small sample size (N=50), data analyses were performed by utilizing the “MS Excel 2007” in order to obtain a reliable result. Tables and charts were formed. Fundamental data description and analysis will be discussed in Chapter 5.
4.9. Qualitative Research- Interview

Semi-structured interview is conducted after the first modified \textit{\textit{i}}-SPM 2013 was developed. It is the last method conducted in this research. It aims to verify the model developed through interview with professional. Questions will be divided into 2 sections. Section 1 is about the overall presentation of the model and in-depth discussion on the questionnaires’ findings. Section 2 includes discussion on the further implementation of the model into BIM.

From a semi-structured interview, quantitative and qualitative information from a sample of the population can be obtained. Besides, general information relevant to specific issues, (i.e. to probe for what is not known) and a range of insights on specific issues can be gained.

Through this semi-structured interview, quantitative and qualitative information on the content of the research, comment on the methodology used and questionnaires findings from professionals can be obtained. Moreover, general information relevant to safety planning and BIM may also identify through asking follow-up questions flexibly. During the interview, complex data can be collected through direct face-to-face communication or via telephone, clarifications on the quarries or follow-ups on interviewees’ answers. It can also enhance the accuracy of the collected data.
Figure 4.1 Research Methodology

Literature Review

- Investigate the deficiency of current safety planning by over viewing safety management in Hong Kong & Comparison on 6 SMSs
- Tailoring the concept of integrating i-SPM 2013 into BIM

Identification of the importance factors in i-SPM 2013 for BIM

Questionnaire Development

- Questionnaire survey among safety professionals
- Prioritize the factors & Validate the implementation of BIM

Interview with safety professionals

- Verify i-SPM 2013 & Discussion on integration of i-SPM 2013 in BIM

Quantitative Method - Questionnaire Survey

Qualitative Method - Interview
Chapter Five - Data Descriptions of Survey

5.1. Introduction

To identify the importance factors in i-SPM 2013, a questionnaire was conducted to investigate the prioritizing of those factors in different size of organizations and the degree of using and integrating safety into BIM in Hong Kong. The data collection process was started in February 2012. A total of 50 effective responses were finally collected at the end of the data collection period.

5.2. Demography of Survey Participants

The survey was conducted from February 2011 to March 2011. The respondents included Safety Manager, Safety Officer, Safety Advisor, Assistant Safety Officer and Safety Supervisor. There were 18 out of 100 construction firm with a total of 50 participants joined this survey, in which there were 3 (6%) Safety Managers, 29 (58%) Safety Officers, 1 (2%) Safety Advisor, 9 (18%) Assistant Safety Officers and 8 (16%) Safety Supervisors (Figure 5.1)

![Career Positions of the Respondents](image)

*Figure 5.1 Career positions of the respondents*
Following were the basic information of the respondents: For the respondents’ gender, 88% and 12% of them were male (N=44) and female (N=6) respectively. (Figure 5.2) For the education level, 18% of respondents were degree holders (N=9), 26% of respondents with high school level (N=13), 26% with high diploma certificate (N=13), and 30% with diploma certificate (N=15). (Figure 5.3)
For the years of experience in construction industry, 22 respondents were from 0 to 5 years (44%), 15 respondents were from 6 to 10 years (30%), 6 respondents were from 11 to 15 years (12%), 4 respondents were from 16 to 20 years (8%), 3 respondents were from 21 to 30 years (6%). (Figure 5.4)

For the years of experience in safety profession, 52% of respondents were from 0 to 5 years (N=26), 26% of respondents were from 6 to 10 years (N=13), 8% of respondents were from 11 to 15 years (N=4), 8% of respondents were from 16 to 20 years (N=4), 6% of respondents were from 21 to 30 years (N=3). (Figure 5.5)
The respondents were also required to provide information about the recent project as a base of the survey (Q6 to Q8). For the types of project of the respondents, 40% of respondents were in Government’s Building Project (N=20), 40% of respondents were in the Private Building Project (N=20), and 20% of respondents were in the Civil Works (N=10) (Figure 5.6).

For the number of employees involved in the recent project of the respondents,
50% of respondents were in the project of more than 300 employees (N=25), 32% of respondents were in the project of 100-299 employees (N=16), 12% of respondents were in the project of 50-100 employees (N=6), and 6% of respondents were in the project of less than 50 employees (N=3). (Figure 5.7)

![Pie chart showing the distribution of respondents by project size](image)

**Figure 5.7 Number of employees the respondents involved in the recent project**

**Classification method of the contract sum**

<table>
<thead>
<tr>
<th>Project size</th>
<th>Contract Sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>million</td>
</tr>
<tr>
<td>Medium</td>
<td>Class (I) 50-100 million</td>
</tr>
<tr>
<td></td>
<td>Class (II) 0.1-0.5 billion</td>
</tr>
<tr>
<td>Large</td>
<td>0.5 billion or above</td>
</tr>
</tbody>
</table>

*Table 5.1 Classification method of the contract sum*

The above classification method is based on the writer’s own opinion. The Development Bureau classifies contractors into Group A, B and C in which representing contractors who can tender for works of value up to HK$ 20 million, up to $ 50 million and exceeding 50 million respectively. Notwithstanding, these traditional value ranges have been used for many
years and no longer reflect the true capacity of contractors when considering the gigantic inflation rate for the past 10 years.

In 2011, the total value of construction works in nominal term was up to 91331 million for all the 1143 construction sites (HK monthly Digest of Statistics 02/2012, p96). Hence the average construction value of each site amounted to 79.9 million. Classification scale in Table 5.1 is made after considering the mean value of the construction works.

Under the above classification of the contract sum, 52% of respondents were classified under large project size (N=26), 32% of were classified under medium project size (N=16) in which 4% (n=2) were projects within 50-100 millions and 28% (n=14) projects were between 0.1 to 0.5 billion HKD, and 16% of were classified under small project size (N=8). (Figure 5.8)
5.3. Result of the i-SPM 2013 for BIM Survey - Safety Planning Components

The main content of the survey was basically divided into two parts. The first part was to identify the importance of the 24 factors in i-SPM among three types of project.

For the 24 scale-type questions, the respondents were asked to choose one answer among seven point scales, "strongly disagree" to "strongly agree". The results are presented and compared in the form of histograms and tables.

For ease of reference, the 24 factors were numbered according to their aspect. For example, Policy 01 in which the first letter refer to the policy aspect and the number refer to the first factor in the questionnaire.
5.3.1. Policy 01- Understanding of Legislations and Regulations

Regarding the importance of Policy 01, “Understanding of Legislations and Regulations”, 11% provide strongly agree response, 44% gave agree response, 15% gave slightly agree response and 3% give neutral with the statement (Fig. 5.9).

![Figure 5.9 Descriptive Distribution of Policy 01-Understanding of the Factories and industrial undertakings (Safety Management) Regulation](image)

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Slightly Disagree</th>
<th>Neutral</th>
<th>Slightly Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>1 (10%)</td>
<td>4 (40%)</td>
<td>5 (50%)</td>
<td>10 (100%)</td>
</tr>
<tr>
<td>Medium (I+II)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>1 (7.1%)</td>
<td>3 (21.4%)</td>
<td>8 (57.1%)</td>
<td>2 (14.3%)</td>
<td>14 (100%)</td>
</tr>
<tr>
<td>Large</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>2 (7.7%)</td>
<td>11 (42.3%)</td>
<td>9 (34.6%)</td>
<td>4 (15.4%)</td>
<td>26 (100%)</td>
</tr>
<tr>
<td>Total</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>3 (6%)</td>
<td>15 (30%)</td>
<td>21 (44%)</td>
<td>11 (22%)</td>
<td>50 (100%)</td>
</tr>
</tbody>
</table>

Table 5.2 Descriptive Distribution of Policy 01- Understanding of the Factories and industrial undertakings (Safety Management) Regulation
5.3.2. Policy 02- Proper implementation of Safety Policy

Regarding or not the safety policy is considered as a pre-requisite for ω-SPM 2013, 46 out of 50 respondents slightly agree, agree or strongly agree while 4 respondents hold a neutral opinion on this matter. Fig 5.10 shows the summary of their responses.

![Figure 5.10 Descriptive Distribution of Policy 02 “Proper implementation of Safety Policy”](image)

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Slightly Disagree</th>
<th>Neutral</th>
<th>Slightly Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>4 (40%)</td>
<td>5 (50%)</td>
<td>1 (10%)</td>
<td>0 (0%)</td>
<td>10 (100%)</td>
</tr>
<tr>
<td>Medium (I+II)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>3 (21.4%)</td>
<td>8 (57.1%)</td>
<td>3 (32.4%)</td>
<td>14 (100%)</td>
<td></td>
</tr>
<tr>
<td>Large</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>4 (15.4%)</td>
<td>12 (46.2%)</td>
<td>10 (38.5%)</td>
<td>26 (100%)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>4 (8%)</td>
<td>12 (24%)</td>
<td>21 (42%)</td>
<td>13 (26%)</td>
<td>50 (100%)</td>
</tr>
</tbody>
</table>

Table 5.3 Descriptive Distribution of Policy 02 “Proper implementation of Safety Policy”
5.3.3. Policy 03-Proper implementation of In-house safety rules and regulations

Regarding the importance of Policy 03, “Proper implementation of In-house safety rules and regulations”, 26% provide strongly agree response, 42% gave agree response, 26% gave slightly agree response and 6% give neutral with the statement (Fig. 5.11).

![Figure 5.11 Descriptive Distribution of Policy 03 “Proper implementation of in-house safety rules and regulations”](image)

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Slightly Disagree</th>
<th>Neutral</th>
<th>Slightly Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>1(10%)</td>
<td>4 (40%)</td>
<td>3 (30%)</td>
<td>2(20%)</td>
<td>10(100%)</td>
</tr>
<tr>
<td>Medium (I+II)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>1(7.1%)</td>
<td>6 (42.9%)</td>
<td>5 (35.7%)</td>
<td>2(14.3%)</td>
<td>14(100%)</td>
</tr>
<tr>
<td>Large</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>1(3.8%)</td>
<td>3 (11.5%)</td>
<td>13 (50%)</td>
<td>9(34.6%)</td>
<td>26(100%)</td>
</tr>
<tr>
<td>Total</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>3(6%)</td>
<td>13(26%)</td>
<td>21(42%)</td>
<td>13(26%)</td>
<td>50(100%)</td>
</tr>
</tbody>
</table>

Table 5.4 Descriptive Distribution of Policy 03 “Proper implementation of In-house safety rules and regulations”
5.3.4. Personnel 01-Top management’s leadership in safety planning process

Regarding to Personnel 01, “Top management’s leadership in safety planning process”, 26% provide strongly agree response, 36% gave agree response, 26% gave slightly agree response and 6% give neutral with the statement (Fig. 5.12).

![Top management’s leadership in safety planning process](image)

**Figure 5.12 Descriptive Distribution of Personnel 01-Top management’s leadership in safety planning process**

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Slightly Disagree</th>
<th>Neutral</th>
<th>Slightly Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>3(30%)</td>
<td>4(40%)</td>
<td>3(30%)</td>
<td>10(100%)</td>
</tr>
<tr>
<td>Medium (II+II)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>3(21.4%)</td>
<td>7(50%)</td>
<td>4(28.6%)</td>
<td>14(100%)</td>
</tr>
<tr>
<td>Large</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>6(23.1%)</td>
<td>7(26.9%)</td>
<td>7(26.9%)</td>
<td>6(23.1%)</td>
<td>26(100%)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>6(12%)</td>
<td>13(26%)</td>
<td>18(36%)</td>
<td>13(26%)</td>
<td>50(100%)</td>
</tr>
</tbody>
</table>

**Table 5.5 Descriptive Distribution of Personnel 01-Top management’s leadership in safety planning process**
5.3.5. Personnel 02-Proper consideration on worker’s safety culture

Regarding to Personnel 01, “Proper consideration on worker’s safety culture”, 24% provide strongly agree response, 32% gave agree response, 30% gave slightly agree response and 14% give neutral with the statement (Fig. 5.13).

![Proper consideration on worker’s safety culture](image)

**Figure 5.13 Descriptive Distribution of Personnel 02-“Proper consideration on worker’s safety culture”**

<table>
<thead>
<tr>
<th>Small</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Slightly Disagree</th>
<th>Neutral</th>
<th>Slightly Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2 (20%)</td>
<td>2 (20%)</td>
<td>4 (40%)</td>
<td>2 (20%)</td>
<td>10 (100%)</td>
</tr>
<tr>
<td>Medium (I+II)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>2 (14.3%)</td>
<td>7 (50%)</td>
<td>2 (14.3%)</td>
<td>3 (21.4%)</td>
<td>14 (100%)</td>
</tr>
<tr>
<td>Large</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>3 (11.5%)</td>
<td>6 (23.1%)</td>
<td>10 (38.5)</td>
<td>7 (26.9%)</td>
<td>26 (100%)</td>
</tr>
<tr>
<td>Total</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>7 (14%)</td>
<td>15 (30%)</td>
<td>16 (32%)</td>
<td>12 (24%)</td>
<td>50 (100%)</td>
</tr>
</tbody>
</table>

**Table 5.6 Descriptive Distribution of Personnel 02-“Proper consideration on worker’s safety culture”**
5.3.6. Personnel 03- Proper implementation on good working relationship and environment

Regarding to Personnel 03, “Proper implementation on good working relationship and environment”, 10% provide strongly agree response, 28% gave agree response, 52% gave slightly agree response and 10% give neutral with the statement. (Fig. 5.14 and Table 5.7)

![Figure 5.14 Descriptive Distribution of Personnel 03 “Proper implementation on good working relationship and environment”](image)

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Slightly Disagree</th>
<th>Neutral</th>
<th>Slightly Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>2(20%)</td>
<td>4(40%)</td>
<td>3(30%)</td>
<td>1(1%)</td>
<td>10(100%)</td>
</tr>
<tr>
<td>Medium</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>2(14.3%)</td>
<td>7(50%)</td>
<td>3(21.4%)</td>
<td>2(14.3%)</td>
<td>14(100%)</td>
</tr>
<tr>
<td>Large</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>1(3.8%)</td>
<td>15(57.7%)</td>
<td>8(30.8%)</td>
<td>2(7.7%)</td>
<td>26(100%)</td>
</tr>
<tr>
<td>Total</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>5(10%)</td>
<td>26(52%)</td>
<td>14(28%)</td>
<td>5(10%)</td>
<td>50(100%)</td>
</tr>
</tbody>
</table>

Table 5.7 Descriptive Distribution of Personnel 03 “Proper implementation on good working relationship and environment”
5.3.7. Personnel 04 - Proper Establishment of Safety Committee

Regarding to Personnel 04, “Proper Establishment of Safety Committee”, 56% provide strongly agree response, 24% gave agree response, 14% gave slightly agree response and 6% give neutral with the statement. There is a strong trend towards “Strongly Agree” (Fig. 5.15 and Table 5.8)

![Figure 5.15 Descriptive Distribution of Personnel 04- Proper establishment of Safety Committee]

Table 5.8 Descriptive Distribution of Personnel 04- Proper establishment of Safety Committee
5.3.8. Personnel 05- Proper Delegation of responsibility and accountability in safety organization

Regarding to Personnel 05, “Proper Delegation of responsibility and accountability in safety organization”, 26% provide strongly agree response, 26% gave agree response, 26% gave slightly agree response and 22% gave neutral with the statement. The trend is not obvious and tends to have a positive response. (Fig. 5.16 and Table 5.9)

![Proper Delegation of responsibility and accountability in safety organization](image)

**Figure 5.16 Descriptive Distribution of Personnel 05- Proper Delegation of responsibility and accountability in safety organization**

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Slightly Disagree</th>
<th>Neutral</th>
<th>Slightly Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>3(30%)</td>
<td>2(20%)</td>
<td>3(30%)</td>
<td>2(20%)</td>
<td>10(100%)</td>
</tr>
<tr>
<td>Medium (I+II)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>4(28.6%)</td>
<td>5(35.7%)</td>
<td>3(21.4%)</td>
<td>2(14.3%)</td>
<td>14(100%)</td>
</tr>
<tr>
<td>Large</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>4(15.4%)</td>
<td>6(23.1%)</td>
<td>7(26.9%)</td>
<td>9(34.6%)</td>
<td>26(100%)</td>
</tr>
<tr>
<td>Total</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>11(22%)</td>
<td>13(26%)</td>
<td>13(26%)</td>
<td>13(26%)</td>
<td>50(100%)</td>
</tr>
</tbody>
</table>

**Table 5.9 Descriptive Distribution of Personnel 05- Proper Delegation of responsibility and accountability in safety organization**
5.3.9. Personnel 06- Systematic Safety and Health training program

Regarding to Personnel 06, “Systematic Safety and Health training program”, 10% provide strongly agree response, 26% gave agree response, 46% gave slightly agree response and 18% give neutral with the statement. The trend is significant in “Slightly Agree”. (Fig. 5.17 and Table 5.10)

![Systematic Safety and Health training program](image)

Figure 5.17 Descriptive Distribution of Personnel 06- Systematic Safety and Health training program

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Slightly Disagree</th>
<th>Neutral</th>
<th>Slightly Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>3(30%)</td>
<td>3(30%)</td>
<td>4(40%)</td>
<td>0(0%)</td>
<td>10(100%)</td>
</tr>
<tr>
<td>Medium (I+II)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>3(21.4%)</td>
<td>3(21.4%)</td>
<td>6(42.9%)</td>
<td>2(14.3%)</td>
<td>14(100%)</td>
</tr>
<tr>
<td>Large</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>3(11.5%)</td>
<td>17(65.4%)</td>
<td>3(11.5%)</td>
<td>3(11.5%)</td>
<td>26(100%)</td>
</tr>
<tr>
<td>Total</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>9(18%)</td>
<td>23(46%)</td>
<td>13(26%)</td>
<td>5(10%)</td>
<td>50(100%)</td>
</tr>
</tbody>
</table>

Table 5.10 Descriptive Distribution of Personnel 06-Systematic Safety and Health training program
5.3.10. Process 01-Implementation of initial review

Regarding to Process 01, “Implementation of initial review”, 14% provide strongly agree response, 22% gave agree response, 42% gave slightly agree response and 20% give neutral with the statement. Furthermore, 2% respondent provide a slightly disagree value. The trend is significant in “Slightly Agree”. (Fig. 5.18 and Table 5.11)

![Implementation of initial review](image)

**Figure 5.18 Descriptive Distribution of Process 01 “Implementation of initial review”**

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Slightly Disagree</th>
<th>Neutral</th>
<th>Slightly Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>1(10%)</td>
<td>2(20%)</td>
<td>5(50%)</td>
<td>1(10%)</td>
<td>1(10%)</td>
<td>10(100%)</td>
</tr>
<tr>
<td>Medium (I+II)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>4(28.6%)</td>
<td>4(28.6%)</td>
<td>4(28.6%)</td>
<td>2(14.3%)</td>
<td>14(100%)</td>
</tr>
<tr>
<td>Large</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>4(15.4%)</td>
<td>12(46.2%)</td>
<td>6(23.1%)</td>
<td>4(15.4%)</td>
<td>26(100%)</td>
</tr>
<tr>
<td>Total</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>1(2%)</td>
<td>10(20%)</td>
<td>21(42%)</td>
<td>11(22%)</td>
<td>7(14%)</td>
<td>50(100%)</td>
</tr>
</tbody>
</table>

**Table 5.11 Descriptive Distribution of Process 01 “Implementation of initial review”**
5.3.11. Process 02- Proper implementation of hazardous inspection program

Regarding to Process 02, “Proper implementation of hazardous inspection program”, 38% provide strongly agree response, 22% gave agree response, 28% gave slightly agree response and 12% give neutral with the statement. The increasing trend is observed from “Neutral” to “Strongly Agree”. (Fig. 5.19 and Table 5.12)

![Figure 5.19 Descriptive Distribution of Process 02 “Proper implementation of hazardous inspection program”](image)

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Slightly Disagree</th>
<th>Neutral</th>
<th>Slightly Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>2(20%)</td>
<td>4(40%)</td>
<td>2(20%)</td>
<td>2(20%)</td>
<td>10(100%)</td>
</tr>
<tr>
<td>Medium (I+II)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>1(7.1%)</td>
<td>4(28.6%)</td>
<td>3(21.4%)</td>
<td>6(42.9%)</td>
<td>14(100%)</td>
</tr>
<tr>
<td>Large</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>3(11.5%)</td>
<td>6(23.1%)</td>
<td>6(23.1%)</td>
<td>11(42.3%)</td>
<td>26(100%)</td>
</tr>
<tr>
<td>Total</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>6(12%)</td>
<td>14(28%)</td>
<td>11(22%)</td>
<td>19(38%)</td>
<td>50(100%)</td>
</tr>
</tbody>
</table>

Table 5.12 Descriptive Distribution of Process 02 “Proper implementation of hazardous inspection program”
5.3.12. Process 03- Proper implementation of health and safety assurance program

Regarding to Process 03, “Proper implementation of hazardous inspection program”, 30% provide strongly agree response, 22% gave agree response, 28% gave slightly agree response and 20% give neutral with the statement. (Fig. 5.20 and Table 5.13)

![Figure 5.20 Descriptive Distribution of Process 03 “Proper implementation of health and safety assurance program”](image)

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Slightly Disagree</th>
<th>Neutral</th>
<th>Slightly Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>3(30%)</td>
<td>3(30%)</td>
<td>2(20%)</td>
<td>2(20%)</td>
<td>10(100%)</td>
</tr>
<tr>
<td>Medium</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>2(14.3%)</td>
<td>5(35.7%)</td>
<td>3(21.4%)</td>
<td>4(28.6%)</td>
<td>14(100%)</td>
</tr>
<tr>
<td>Large</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>5(19.2%)</td>
<td>6(23.1%)</td>
<td>6(23.1%)</td>
<td>9(34.6%)</td>
<td>26(100%)</td>
</tr>
<tr>
<td>Total</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>10(20%)</td>
<td>14(28%)</td>
<td>11(22%)</td>
<td>15(30%)</td>
<td>50(100%)</td>
</tr>
</tbody>
</table>
5.3.13. Process 04-Proper Risk Assessment to hazardous and dangerous activities

Regarding to Process 04, “Proper Risk Assessment to hazardous and dangerous activities”, 48% provide strongly agree response, 24% gave agree response, 22% gave slightly agree response and 6% gave neutral with the statement. (Fig. 5.21 and Table 5.14)

![Proper Risk assessment to hazardous and dangerous activities](image)

Table 5.14 Descriptive Distribution of Process 04-Proper Risk assessment to hazardous and dangerous activities
5.3.14. Process 05-Proper implementation of Emergency Response Plan

Regarding to Process 05, “Proper implementation of Emergency Response Plan”, 48% provide strongly agree response, 28% gave agree response and 24% gave slightly agree response. (Fig. 5.21 and Table 5.14)

![Descriptive Distribution of Process 05- Proper implementation of Emergency Response Plan](image)

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Slightly Disagree</th>
<th>Neutral</th>
<th>Slightly Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>4(40%)</td>
<td>3(30%)</td>
<td>3(30%)</td>
<td>10(100%)</td>
</tr>
<tr>
<td>Medium (I+II)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>3(21.4%)</td>
<td>5(35.7%)</td>
<td>6(42.9%)</td>
<td>14(100%)</td>
</tr>
<tr>
<td>Large</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>5(19.2%)</td>
<td>6(23.1%)</td>
<td>15(57.7%)</td>
<td>26(100%)</td>
</tr>
<tr>
<td>Total</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>12(24%)</td>
<td>14(28%)</td>
<td>24(48%)</td>
<td>50(100%)</td>
</tr>
</tbody>
</table>

Table 5.15 Descriptive Distribution of Process 05- Proper implementation of Emergency Response Plan
5.3.15. Process 06-Proper implementation Accidents and Incidents Investigation

Regarding to Process 06, “Proper implementation Accidents and Incidents Investigation”, 22% provide strongly agree response, 38% gave agree response, 24% gave slightly agree response and 16% give neutral with the statement. (Fig. 5.23 and Table 5.16)

![Proper implementation accidents and incidents investigation](image)

Figure 5.23 Descriptive Distribution of Process 06-Proper implementation Accidents and Incidents Investigation

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Slightly Disagree</th>
<th>Neutral</th>
<th>Slightly Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>3(30%)</td>
<td>4(40%)</td>
<td>3(30%)</td>
<td>0(0%)</td>
<td>10(100%)</td>
</tr>
<tr>
<td>Medium (I+II)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>2(14.3%)</td>
<td>3(21.4%)</td>
<td>4(28.6%)</td>
<td>5(35.7%)</td>
<td>14(100%)</td>
</tr>
<tr>
<td>Large</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>3(11.5%)</td>
<td>5(19.2%)</td>
<td>12(46.2%)</td>
<td>6(23.1%)</td>
<td>26(100%)</td>
</tr>
<tr>
<td>Total</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>8(16%)</td>
<td>12(24%)</td>
<td>19(38%)</td>
<td>11(22%)</td>
<td>50(100%)</td>
</tr>
</tbody>
</table>

Table 5.16 Descriptive Distribution of Process 06-Proper implementation Accidents and Incidents Investigation
5.3.16. Process 07- Proper Provisions of Personal Protective Equipment

Regarding to Process 07, “Proper Provisions of Personal Protective Equipment”, 24% provide strongly agree response, 32% gave agree response, 32% gave slightly agree response and 12% give neutral with the statement. (Fig. 5.24 and Table 5.17)
5.3.17. Process 08-Proper implementation on safety promotion

Regarding to Process 08, “Proper implementation on safety promotion”, 42% provide strongly agree response, 57% gave agree response, 18% gave slightly agree response and 10% give neutral with the statement. (Fig. 5.25 and Table 5.18)

![Figure 5.25 Descriptive Distribution of Process 08-Proper implementation on safety promotion](image)

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Slightly Disagree</th>
<th>Neutral</th>
<th>Slightly Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>1(10%)</td>
<td>3(30%)</td>
<td>3(30%)</td>
<td>3(30%)</td>
<td>10(100%)</td>
</tr>
<tr>
<td>Medium</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>1(7.1%)</td>
<td>2(14.3%)</td>
<td>7(50%)</td>
<td>4(28.6%)</td>
<td>14(100%)</td>
</tr>
<tr>
<td>Large</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>3(15.4%)</td>
<td>4(15.4%)</td>
<td>5(19.2%)</td>
<td>14(53.8%)</td>
<td>26(100%)</td>
</tr>
<tr>
<td>Total</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>5(10%)</td>
<td>9(18%)</td>
<td>15(57.7%)</td>
<td>21(42%)</td>
<td>50(100%)</td>
</tr>
</tbody>
</table>

Table 5.18 Descriptive Distribution of Process 08-Proper implementation on safety promotion
5.3.18. Process 09- Proper selection and management of subcontractors

Regarding to Process 09, “Proper selection and management of subcontractors”, 20% provide strongly agree response, 22% gave agree response, 36% gave slightly agree response and 20% give neutral with the statement. And 2% was slightly disagree on this factor. (Fig. 5.26 and Table 5.19)

![Figure 5.26 Descriptive Distribution of Process 09- Proper selection and management of subcontractors](image)

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Slightly Disagree</th>
<th>Neutral</th>
<th>Slightly Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>2(20%)</td>
<td>2(20%)</td>
<td>3(30%)</td>
<td>3(30%)</td>
<td>10(100%)</td>
</tr>
<tr>
<td>Medium (I+II)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>2(14.3%)</td>
<td>4(28.6%)</td>
<td>5(35.7%)</td>
<td>3(21.4%)</td>
<td>14(100%)</td>
</tr>
<tr>
<td>Large</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>1(3.8%)</td>
<td>6(23.1%)</td>
<td>12(46.2%)</td>
<td>3(11.5%)</td>
<td>4(15.4%)</td>
<td>26(100%)</td>
</tr>
<tr>
<td>Total</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>1(2%)</td>
<td>10(20%)</td>
<td>18(36%)</td>
<td>11(22%)</td>
<td>10(20%)</td>
<td>50(100%)</td>
</tr>
</tbody>
</table>

Table 5.19 Descriptive Distribution of Process 09- Proper selection and management of subcontractors
5.3.19. Process 10- Proper implementation of Communication and information flow

Regarding to Process 10, “Proper implementation of Communication and information flow”, 24% provide strongly agree response, 18% gave agree response, 40% gave slightly agree response and 18% give neutral with the statement. (Fig. 5.27 and Table 5.20)

![Figure 5.27 Descriptive Distribution of Process 10- Proper implementation of Communication and information flow](image)

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Slightly Disagree</th>
<th>Neutral</th>
<th>Slightly Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>2(20%)</td>
<td>3(30%)</td>
<td>2(20%)</td>
<td>3(30%)</td>
<td>10(100%)</td>
</tr>
<tr>
<td>Medium (I+II)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>3(21.4%)</td>
<td>5(35.7%)</td>
<td>3(21.4%)</td>
<td>3(21.4%)</td>
<td>14(100%)</td>
</tr>
<tr>
<td>Large</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>4(15.4%)</td>
<td>12(46.2%)</td>
<td>4(15.4%)</td>
<td>6(23.1%)</td>
<td>26(100%)</td>
</tr>
<tr>
<td>Total</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>9(18%)</td>
<td>20(40%)</td>
<td>9(18%)</td>
<td>12(24%)</td>
<td>50(100%)</td>
</tr>
</tbody>
</table>

Table 5.20 Descriptive Distribution of Process 10- Proper implementation of Communication and information flow
5.3.20. Process 11-Maintenance and tight control on the documentation

Regarding to Process 11, “Maintenance and tight control on the documentation”, 4% provide strongly agree response, 20% gave agree response, 36% gave slightly agree response and 30% give neutral with the statement. Moreover, there were 2% provide a slightly disagree response. (Fig. 5.28 and Table 5.21)

![Maintenance and tight control on the documentation](image)

**Table 5.21 Descriptive Distribution of Process 11- Maintenance and tight control on the documentation**

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Slightly Disagree</th>
<th>Neutral</th>
<th>Slightly Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>2 (20%)</td>
<td>5(50%)</td>
<td>2 (20%)</td>
<td>1 (10%)</td>
<td>0 (0%)</td>
<td>10(100%)</td>
</tr>
<tr>
<td>Medium (I+II)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>2 (14.3%)</td>
<td>3(21.4%)</td>
<td>4 (28.9%)</td>
<td>5(35.7%)</td>
<td>0(0%)</td>
<td>14(100%)</td>
</tr>
<tr>
<td>Large</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>1 (3.85%)</td>
<td>7 (26.9%)</td>
<td>12 (46.2%)</td>
<td>4 (15.3%)</td>
<td>2 (7.69%)</td>
<td>26(100%)</td>
</tr>
<tr>
<td>Total</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>5 (1%)</td>
<td>15 (30%)</td>
<td>18 (36%)</td>
<td>10 (20%)</td>
<td>2(4%)</td>
<td>50(100%)</td>
</tr>
</tbody>
</table>
5.3.21. Process 12- Proper implementation of internal Audit

Regarding to Process 12, “Proper implementation of internal Audit”, 12% provide strongly agree response, 24% gave agree response, 42% gave slightly agree response and 20% give neutral with the statement. (Fig. 5.29 and Table 5.22)

![Figure 5.29 Descriptive Distribution of Process 12- Proper implementation of internal Audit](image)

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Slightly Disagree</th>
<th>Neutral</th>
<th>Slightly Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>2(2%)</td>
<td>3(30%)</td>
<td>4(40%)</td>
<td>1(10%)</td>
<td>10(100%)</td>
</tr>
<tr>
<td>Medium (I+II)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>4(28.6%)</td>
<td>6(42.9%)</td>
<td>3(21.4%)</td>
<td>1(7.1%)</td>
<td>14(100%)</td>
</tr>
<tr>
<td>Large</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>5(19.2%)</td>
<td>12(46.2%)</td>
<td>5(19.2%)</td>
<td>4(15.4%)</td>
<td>26(100%)</td>
</tr>
<tr>
<td>Total</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>11(22%)</td>
<td>21(42%)</td>
<td>12(24%)</td>
<td>6(12%)</td>
<td>50(100%)</td>
</tr>
</tbody>
</table>

*Table 5.22 Descriptive Distribution of Process 12- Proper implementation of internal Audit*
5.3.22. Process 13- Conduct regular Management Review

Regarding to Process 13, “Conduct regular Management Review”, 16% provide strongly agree response, 30% gave agree response, 32% gave slightly agree response and 22% give neutral with the statement. (Fig. 5.30 and Table 5.23)

![Figure 5.30 Descriptive Distribution of Process 13- Conduct regular Management Review](image)

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Slightly Disagree</th>
<th>Neutral</th>
<th>Slightly Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>3(30%)</td>
<td>2(20%)</td>
<td>4(40%)</td>
<td>1(10%)</td>
<td>10(100%)</td>
</tr>
<tr>
<td>Medium (I+II)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>4(28.6%)</td>
<td>4(28.6%)</td>
<td>4(28.6%)</td>
<td>2(14.3%)</td>
<td>14(100%)</td>
</tr>
<tr>
<td>Large</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>4(15.4%)</td>
<td>10(38.5%)</td>
<td>7(26.9%)</td>
<td>5(19.2%)</td>
<td>26(100%)</td>
</tr>
<tr>
<td>Total</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>11(22%)</td>
<td>16(32%)</td>
<td>15(30%)</td>
<td>8(16%)</td>
<td>50(100%)</td>
</tr>
</tbody>
</table>

Table 5.22 Descriptive Distribution of Process 13- Conduct regular Management Review
5.3.23. Incentive 01-Introduction of safety incentive program

Regarding to Incentive 01, “Introduction of safety incentive program”, 22% provide strongly agree response, 24% gave agree response, 38% gave slightly agree response and 16% give neutral with the statement. (Fig. 5.31 and Table 5.24)

![Figure 5.31 Descriptive Distribution of Incentive 01-Introduction of safety incentive program](image)

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Slightly Disagree</th>
<th>Neutral</th>
<th>Slightly Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>4(40%)</td>
<td>4(40%)</td>
<td>2(20%)</td>
<td>10(100%)</td>
</tr>
<tr>
<td>Medium (I+II)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>3(21.4%)</td>
<td>7(50%)</td>
<td>2(14.3%)</td>
<td>2(14.3%)</td>
<td>14(100%)</td>
</tr>
<tr>
<td>Large</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>5(19.2%)</td>
<td>8(30.8%)</td>
<td>6(23.1%)</td>
<td>7(26.9%)</td>
<td>26(100%)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>0(0%)</strong></td>
<td><strong>0(0%)</strong></td>
<td><strong>0(0%)</strong></td>
<td><strong>8(16%)</strong></td>
<td><strong>19(38%)</strong></td>
<td><strong>12(24%)</strong></td>
<td><strong>11(22%)</strong></td>
<td><strong>50(100%)</strong></td>
</tr>
</tbody>
</table>

Table 5.24 Descriptive Distribution of Incentive 01-Introduction of safety incentive program
5.3.24. Incentive 02-Introduction of disincentive program

Regarding to Incentive 02, “Introduction of disincentive program”, 20% provide strongly agree response, 24% gave agree response, 34% gave slightly agree response and 22% give neutral with the statement. (Fig. 5.32 and Table 5.25)

![Image of Figure 5.32 Descriptive Distribution of Incentive 02-Introduction of disincentive program]

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Slightly Disagree</th>
<th>Neutral</th>
<th>Slightly Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Small</strong></td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>3(30%)</td>
<td>5(50%)</td>
<td>1(10%)</td>
<td>1(10%)</td>
<td>10(100%)</td>
</tr>
<tr>
<td><strong>Medium (I+II)</strong></td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>4(28.6%)</td>
<td>4(28.6%)</td>
<td>3(21.4%)</td>
<td>3(21.4%)</td>
<td>14(100%)</td>
</tr>
<tr>
<td><strong>Large</strong></td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>4(15.4%)</td>
<td>8(30.8%)</td>
<td>8(30.8%)</td>
<td>6(23.1%)</td>
<td>26(100%)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>11(22%)</td>
<td>17(34%)</td>
<td>12(24%)</td>
<td>10(20%)</td>
<td>50(100%)</td>
</tr>
</tbody>
</table>

*Table 5.25 Descriptive Distribution of Incentive 02—Introduction of disincentive program*
5.4. 5.4 Result of 2013 for BIM Survey- BIM

In part C of the questionnaire, 6 questions were asked about the use of BIM in construction project.

Regarding to the level of knowledge and respondents' awareness of BIM, 18% of respondents never heard of BIM approach while 54% of the respondents heard of BIM but never applied it. For those respondents who use BIM, 22% respondents applied it on limited basis. Only 6% of the respondents applied BIM on regular basic. (Refer to Figure 5.35)

40% of respondents or his/her company has applied BIM in 1-3 construction projects. Moreover, 16% of the respondents have applied BIM on 4-5 projects. Meanwhile, 44% of them and or their companies have no experience on using BIM. (Refer to Figure 5.36)

Fig. 5.37 indicates the area of which the respondents or respondents' companies have been applied in BIM, some respondents choose more than 1 area and some may not choose any. Hence the total number of responses against each item of choices may not add up to the total no. of respondent, i.e. 10 small contract-sum project, 14 medium contract sum project and 26 large contract-sum project. From the figure, the most applied area in BIM is “Planning” (20%), the second high is “Estimating” (17%), and following is “Construction sequence” (14%), “Mechanical and Electrical ”(13%), “Architectural designing” (14%) and “Structural Designing” (13%). The least area applied is “Safety”, with only 7 % of the respondents applied on it. (Refer to Figure 5.37 and Table 5.38)
**Level of knowledge and awareness of Building Information Modeling (BIM) of the Respondents**

- Never heard of BIM approach: 6%
- Heard of BIM but never applied it: 18%
- Applied BIM on limited basis: 54%
- Applied BIM on regular basis: 22%

*Fig. 5.33 Level of knowledge and awareness of Building Information Modeling (BIM) of the Respondents*

**Numbers of construction projects completed using BIM**

- None: 44%
- 1-3 Projects: 40%
- 4-5 Projects: 16%

*Fig. 5.34 Numbers of construction projects completed using BIM*
Fig. 5.35 Area(s) the respondents /respondents' company have been using the BIM approach on a project

<table>
<thead>
<tr>
<th>Area(s)</th>
<th>No. of Respondents</th>
<th>% of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architectural designing</td>
<td>10</td>
<td>14%</td>
</tr>
<tr>
<td>Structural Designing</td>
<td>9</td>
<td>13%</td>
</tr>
<tr>
<td>Construction Sequence</td>
<td>10</td>
<td>14%</td>
</tr>
<tr>
<td>Mechanical and Electrical</td>
<td>9</td>
<td>13%</td>
</tr>
<tr>
<td>Safety</td>
<td>5</td>
<td>7%</td>
</tr>
<tr>
<td>Planning</td>
<td>14</td>
<td>20%</td>
</tr>
<tr>
<td>Estimating</td>
<td>12</td>
<td>17%</td>
</tr>
<tr>
<td>Others</td>
<td>0</td>
<td>0%</td>
</tr>
</tbody>
</table>

Table. 5.26 Area(s) the respondents /respondents' company have been using the BIM approach on a project

Over 60% of Respondents thought that implementing BIM in the construction project help in increasing the collaboration of between all parties, followed by achieving a better safety performance (16%). Besides, more liability (%) was also expected by the respondents. Other reasons were reduction on time, reduction of project overall cost
and better liability. Only 40% of respondents thought safety training cost will be increased (6%) and hinder the design (2%). (Refer to Figure 5.38 and Table 5.39)

Furthermore, 29 respondents thought that there will be an increasing demand on the use of BIM for construction safety (64%), while 21 respondents (36%) thought there will not.

![Diagram](image)

**Figure 5.36 Respondents’ think about implementing BIM in their current/future project**
What do you think about implementing BIM in your current/ future project?

<table>
<thead>
<tr>
<th>Reason</th>
<th>No. of Respondents</th>
<th>% of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase training cost</td>
<td>6</td>
<td>6%</td>
</tr>
<tr>
<td>Reduction on Time</td>
<td>13</td>
<td>14%</td>
</tr>
<tr>
<td>Hinder the Design</td>
<td>2</td>
<td>2%</td>
</tr>
<tr>
<td>Better safety performance</td>
<td>15</td>
<td>16%</td>
</tr>
<tr>
<td>Better quality</td>
<td>10</td>
<td>11%</td>
</tr>
<tr>
<td>More Liability</td>
<td>14</td>
<td>15%</td>
</tr>
<tr>
<td>Reduction of project overall cost</td>
<td>11</td>
<td>12%</td>
</tr>
<tr>
<td>Increase collaboration between parties within project</td>
<td>22</td>
<td>24%</td>
</tr>
<tr>
<td>Others</td>
<td>0</td>
<td>0%</td>
</tr>
</tbody>
</table>

Table 5.27 Respondents’ think about implementing BIM in their current/ future project

Will there be an increasing demand on the use of BIM for construction safety?

Figure 5.37 Respondents’ opinion on increasing demand on the use of BIM in construction safety
Chapter Six - Data Analysis and Discussion on \( \ddot{i}\)-SPM 2013

6.1. Introduction

This chapter conducted the comparison on the relationship of result of survey, by focusing on the questions with single answer. Firstly, 24 factors in \( \ddot{i}\)-SPM 2013 will be prioritized according to the three different contract sum groups by relative important ranking method. Secondly, comparison of rank agreement factors (RAFs), PA and PD will be conducted to test the degree of agreement in ranking between different groups. Thirdly, summary on the key findings on the ranking will be discussed and modified in \( \ddot{i}\)-SPM 2013.

6.2. Ranking by Relative Important Ranking Method

To prioritize the respondents’ opinions on the importance of a list of 24 factors affecting the safety planning model \( \ddot{i}\)-SPM 2013, Relative Important Ranking method was used.

Ratings made against the seven-point scale described previously were combined and converted into relative importance indices for each factor, adopting the ‘relative importance index’ ranking technique. This determined the relative ranking of the different factors by comparing the individual relative importance indices for different factors in descending order of significance. These rankings also made it possible to cross-compare the relative importance of the factors as advocated by the three different groups of respondents (i.e. small project sum, medium project sum and large project sum).

As seven-scale measurement was used in the survey where “1” represents the least level of agreement and “7” represents the most level of agreement. To determine the
relative ranking of the factors, the score were then transformed to importance indices based on the following formula (Tam et al., 2000):

Relative important index = \[ \frac{\sum W}{(A \times N)} \]…………………………………… (1)

Where,
W = weights given to each factor by the respondents, ranging from 1 to 7.
A = highest weight (i.e. 7 in this case), and N = total number of respondents.

The analysis was done independently for the three categories of respondents. To obtain the final ranking of these factors, overall average of the three different categories was taken. It is calculated using the following expression:

\[ \text{Overall Average} = \frac{[N_1 \times \text{RII of small contract sum group} + N_2 \times \text{RII of medium (I+II) contract sum group} + N_3 \times \text{RII of large contract sum group}]}{\text{Total number of respondents}} \]…………………………………… (2)

Where,  N1 = number of small contract sum group responded
N2 = number of medium (I+II) contract sum group responded
N3 = number of large contract sum group responded

Based on the equation (1) and (2), the relative important index (RII) can be normalized to fall within 0-1. Table 6.1 indicates the RII and ranking of the factors considered in i-SPM. The last column of the table indicates the overall average of relative importance index and final ranking of each factor.

The ranking of the three project contract sum’s groups are illustrated in Table 6.2. The 24 factors are categorized into Policy, Personnel, Process and Incentive aspects as proposed in the model.
### Table 6.1 Relative Important Indices (RII) and Ranking of Factors in three contract sum projects

<table>
<thead>
<tr>
<th></th>
<th>small contract-sum projects</th>
<th>medium (I+II) contract-sum projects</th>
<th>Large contract-sum projects</th>
<th>Overall Average of projects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RII</td>
<td>Rank within aspect</td>
<td>RII</td>
<td>Rank within aspect</td>
</tr>
<tr>
<td>Policy 01</td>
<td>0.91</td>
<td>1</td>
<td>0.83</td>
<td>10</td>
</tr>
<tr>
<td>Policy 02</td>
<td>0.67</td>
<td>23</td>
<td>0.86</td>
<td>4</td>
</tr>
<tr>
<td>Policy 03</td>
<td>0.80</td>
<td>9</td>
<td>0.80</td>
<td>13</td>
</tr>
<tr>
<td>Personnel 01</td>
<td>0.86</td>
<td>2</td>
<td>0.87</td>
<td>3</td>
</tr>
<tr>
<td>Personnel 02</td>
<td>0.80</td>
<td>9</td>
<td>0.78</td>
<td>15</td>
</tr>
<tr>
<td>Personnel 03</td>
<td>0.76</td>
<td>16</td>
<td>0.77</td>
<td>17</td>
</tr>
<tr>
<td>Personnel 04</td>
<td>0.81</td>
<td>6</td>
<td>0.88</td>
<td>2</td>
</tr>
<tr>
<td>Personnel 05</td>
<td>0.77</td>
<td>12</td>
<td>0.74</td>
<td>21</td>
</tr>
<tr>
<td>Personnel 06</td>
<td>0.73</td>
<td>19</td>
<td>0.79</td>
<td>14</td>
</tr>
<tr>
<td>Process 01</td>
<td>0.70</td>
<td>22</td>
<td>0.76</td>
<td>19</td>
</tr>
<tr>
<td>Process 02</td>
<td>0.77</td>
<td>12</td>
<td>0.86</td>
<td>4</td>
</tr>
<tr>
<td>Process 03</td>
<td>0.76</td>
<td>16</td>
<td>0.81</td>
<td>11</td>
</tr>
<tr>
<td>Process 04</td>
<td>0.81</td>
<td>6</td>
<td>0.84</td>
<td>8</td>
</tr>
<tr>
<td>Process 05</td>
<td>0.84</td>
<td>3</td>
<td>0.89</td>
<td>1</td>
</tr>
<tr>
<td>Process 06</td>
<td>0.71</td>
<td>20</td>
<td>0.84</td>
<td>5</td>
</tr>
<tr>
<td>Process 07</td>
<td>0.77</td>
<td>12</td>
<td>0.86</td>
<td>4</td>
</tr>
<tr>
<td>Process 08</td>
<td>0.83</td>
<td>4</td>
<td>0.86</td>
<td>4</td>
</tr>
<tr>
<td>Process 09</td>
<td>0.81</td>
<td>6</td>
<td>0.81</td>
<td>11</td>
</tr>
<tr>
<td>Process 10</td>
<td>0.80</td>
<td>9</td>
<td>0.78</td>
<td>15</td>
</tr>
<tr>
<td>Process 11</td>
<td>0.60</td>
<td>24</td>
<td>0.69</td>
<td>24</td>
</tr>
<tr>
<td>Process 12</td>
<td>0.77</td>
<td>12</td>
<td>0.72</td>
<td>23</td>
</tr>
<tr>
<td>Process 13</td>
<td>0.76</td>
<td>16</td>
<td>0.76</td>
<td>19</td>
</tr>
<tr>
<td>Incentive 01</td>
<td>0.83</td>
<td>4</td>
<td>0.74</td>
<td>21</td>
</tr>
<tr>
<td>Incentive 02</td>
<td>0.71</td>
<td>20</td>
<td>0.77</td>
<td>17</td>
</tr>
<tr>
<td>Rank</td>
<td>Small contract-sum projects</td>
<td>Medium contract-sum projects</td>
<td>Large contract-sum projects</td>
<td>Overall Average of projects</td>
</tr>
<tr>
<td>------</td>
<td>-----------------------------</td>
<td>-----------------------------</td>
<td>-----------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td><strong>Policy Aspect</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Construction legislation and Regulation</td>
<td>Safety Policy</td>
<td>Safety Policy</td>
<td>Safety Policy</td>
</tr>
<tr>
<td>2</td>
<td>In-house safety rules and regulations</td>
<td>Construction legislation and Regulation</td>
<td>In-house safety rules and regulations</td>
<td>In-house safety rules and regulations</td>
</tr>
<tr>
<td>3</td>
<td>Safety Policy</td>
<td>In-house safety rules and regulations</td>
<td>Construction legislation and Regulation</td>
<td>Construction Safety related legislation and Regulation</td>
</tr>
<tr>
<td><strong>Personnel Aspect</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Top management’s leadership</td>
<td>Safety Committee</td>
<td>Safety Committee</td>
<td>Safety Committee</td>
</tr>
<tr>
<td>2</td>
<td>Safety Committee</td>
<td>Top management’s leadership</td>
<td>-Worker’s safety culture -Delegation of responsibility and accountability</td>
<td>Top management’s leadership</td>
</tr>
<tr>
<td>3</td>
<td>Worker’s safety culture</td>
<td>Safety and Health training program</td>
<td>Worker’s safety culture</td>
<td>Worker’s safety culture</td>
</tr>
<tr>
<td>4</td>
<td>Delegation of responsibility and accountability</td>
<td>Worker’s safety culture</td>
<td>Top management’s leadership</td>
<td>Delegation of responsibility and accountability</td>
</tr>
<tr>
<td>5</td>
<td>Good working relationship and environment</td>
<td>Good working relationship and environment</td>
<td>Good working relationship and environment</td>
<td>Good working relationship and environment</td>
</tr>
<tr>
<td>6</td>
<td>Safety and Health training program</td>
<td>Delegation of responsibility and accountability</td>
<td>Safety and Health training program</td>
<td>Safety and Health training program</td>
</tr>
<tr>
<td><strong>Process Aspect</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Emergency Response Plan</td>
<td>Emergency Response Plan</td>
<td>Risk assessment and control</td>
<td>Emergency Response Plan</td>
</tr>
<tr>
<td>2</td>
<td>Safety promotion</td>
<td>-Hazardous inspection program -Provision of PPE -Safety promotion</td>
<td>Emergency Response Plan</td>
<td>Risk assessment and control</td>
</tr>
<tr>
<td>3</td>
<td>-Risk assessment and control -Selection and management of subcontractors</td>
<td>Safety promotion</td>
<td>Safety promotion</td>
<td>Safety promotion</td>
</tr>
<tr>
<td>4</td>
<td>Hazardous inspection program</td>
<td>Hazardous inspection program</td>
<td>Hazardous inspection program</td>
<td>Hazardous inspection program</td>
</tr>
</tbody>
</table>
### Table 6.2 Ranking of the 24 factor in four aspects among three project contract sum groups

<table>
<thead>
<tr>
<th>Rank</th>
<th>Small contract-sum projects</th>
<th>Medium contract-sum projects</th>
<th>Large contract-sum projects</th>
<th>Overall Average of projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Communication and information flow</td>
<td>-Risk assessment and control -Accidents and Incidents Investigation</td>
<td>Accidents and Incidents Investigation</td>
<td>Provision of PPE</td>
</tr>
<tr>
<td>6</td>
<td>-Hazardous inspection program -Provision of PPE</td>
<td>-Provision of PPE</td>
<td>H&amp;S assurance program</td>
<td>Accidents and Incidents Investigation</td>
</tr>
<tr>
<td>7</td>
<td>-Internal Audit</td>
<td>-H&amp;S assurance program -Selection and management of subcontractors</td>
<td>Provision of PPE</td>
<td>H&amp;S assurance program</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>Communication and information flow -Selection and management of subcontractors</td>
<td>Management review</td>
<td>Communication and information flow</td>
</tr>
<tr>
<td>9</td>
<td>-H&amp;S assurance program -Management review</td>
<td>Communication and information flow -Management review</td>
<td>Management review</td>
<td>-Selection and management of subcontractors</td>
</tr>
<tr>
<td>10</td>
<td>Initial review</td>
<td>Initial review</td>
<td>-Management review</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Accidents and Incidents Investigation</td>
<td>Management review</td>
<td>Internal Audit</td>
<td>-Initial review -Internal Audit</td>
</tr>
<tr>
<td>12</td>
<td>Initial review</td>
<td>Internal Audit</td>
<td>Selection and management of subcontractors</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Maintenance and tight control on the documentation</td>
<td>Maintenance and tight control on the documentation</td>
<td>Maintenance and tight control on the documentation</td>
<td>Maintenance and tight control on the documentation</td>
</tr>
</tbody>
</table>

#### Incentive Aspect

<table>
<thead>
<tr>
<th>Rank</th>
<th>Safety incentive program</th>
<th>Disincentive program</th>
<th>Disincentive program</th>
<th>Safety incentive program</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Safety incentive program</td>
<td></td>
<td></td>
<td>Safety incentive program</td>
</tr>
<tr>
<td>2</td>
<td>Disincentive program</td>
<td></td>
<td></td>
<td>Disincentive program</td>
</tr>
</tbody>
</table>
6.3. Rank Agreement Factor (RAF), Percentage Agreement (PA) and Disagreement (PD) between group of participants

It was next decided to test for the degree of agreement in the rankings between various groups of project participants. The ‘rank agreement factor’ method used by Okpala and Aniekwu (1988) was found to be useful in estimating the degree of agreement/disagreement between any two groups.

The rank agreement factors (RAFs) were computed using the formula,

\[
RAF = \frac{\sum_{i=1}^{N} |R_{i1} - R_{i2}|}{N}
\]

for the two groups, assuming the ranks of the ith item in group 1 be \(R_{i1}\) and in group 2 be \(R_{i2}\) and the absolute difference (\(D_i\)) becomes \(D_i = |R_{i1} - R_{i2}|\) where \(i = 1, 2, \ldots N\) items. The RAF is ranged from 0 which indicates perfect agreement while the degree of disagreement would be increased with the value of RAF. In this study, the degree of disagreement and RAF was used to reflect the extent of difference in ranks of the significant of the factors on different types of construction project and the mean scores of the respondents.

The percentage agreement and percentage disagreement can also be calculated accordingly (Okpala, 1986). The percentage disagreement is calculated as shown below (Equation 3). The percentage agreement (PA) is defined as \(PA = 100 - PD\).

\[
PD = 100 \times \frac{\sum_{i=1}^{N} |R_{i1} - R_{i2}|}{\sum_{i=1}^{N} D_{\text{max} i}}
\]

\[
PA = 100 - PD
\]

Table 6.3 shows the results of average RAF, PA and PD for different group pairs. The percentage agreement of 63% and rank agreement factor of 4.33 for the medium (I+II) contract sum group and the large contract sum group reflected that the construction safety practitioners in both group have similar perception in rating each factors for the model.
While for the small contract sum group, the percentage agreement to the medium (class I and II) and that to the large contract sum were very low were 28% and 32% respectively. It revealed that respondents in small contract sum group have different opinions in rating the 24 factors for i-SPM 2013 among others respondents.

<table>
<thead>
<tr>
<th>Group</th>
<th>Rank Agreement Factor (RAF)</th>
<th>Percentage Agreement (PA)</th>
<th>Percentage Disagreement (PD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small contract sum group and Medium (I+II) contract sum group</td>
<td>5.83</td>
<td>28%</td>
<td>72%</td>
</tr>
<tr>
<td>Small contract sum group and Large contract sum group</td>
<td>5.83</td>
<td>32%</td>
<td>68%</td>
</tr>
<tr>
<td>Medium (I+II) contract sum group and Large contract sum group</td>
<td>4.33</td>
<td>63%</td>
<td>37%</td>
</tr>
</tbody>
</table>

Table 6.3: Average Rank Agreement Factor (RAF), Percentage Agreement (PA) and Percentage Disagreement (PD) on three different contractor sum group

6.4. Discussion- Cross-comparisons on three contract-sum group

Although overall average rank of i-SPM 2013 was analyzed from RII method, it was unjustifiable to conduct direct quantitative comparisons by means of the RII across factors only. This was because difference in the sample composition within groups will affect the ranking. A qualitative comparison of perceived important factors should also be considered which can provide specific insight and priorities for an integrated model.

6.4.1 Ranking and Findings in Policy Aspect

The rank of the 3 factors in policy aspect obtained from the survey and modified i-SPM 2013 was shown below:

<table>
<thead>
<tr>
<th>Ranking from the survey</th>
<th>Modified ranking in i-SPM 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety Policy (RII=0.84)</td>
<td>Construction Safety related legislation and regulation</td>
</tr>
<tr>
<td>In-house safety rules</td>
<td>Safety Policy</td>
</tr>
<tr>
<td>and regulations (RII=0.84)</td>
<td>In-house safety rules and regulations</td>
</tr>
<tr>
<td>Construction Safety</td>
<td></td>
</tr>
<tr>
<td>related legislation</td>
<td></td>
</tr>
<tr>
<td>and regulation (RII=0.83)</td>
<td>In-house safety rules and regulations</td>
</tr>
</tbody>
</table>

Table 6.4 Modified ranking of the factors in policy aspects in i-SPM 2013 from the survey
The 3 factors show a relatively high and similar statistic as shown on table 6.4. In i-SPM 2013, the ranking of Construction Safety related legislation and regulation is the highest to ensure the contractors have a well-rounded basic knowledge on the mandatory requirements in order to develop a comprehensive safety planning strategy.

Safety related legislation and regulation
For small contract sum group, a significantly high RII (0.91) on “Understanding of the safety related legislation and regulation” was shown compared with the other 2 groups. It is the highest RII among all the factors in the small contract sum group. This may reveal that their objective of establishing safety planning is to fulfill the legislation requirement rather than carrying out of a continuous improvement in safety management. This is supported with the low rank score of the Process 12 and 13.

Safety policy
There is a great divergence between small contract-sum project group (RII=0.67) and the medium (RII=0.86) & large contract sum groups (RII= 0.89). This difference agrees with the previous finding that small scale contractors always keep a lower profile on safety policy compared with medium and large scale contractors (Franco, 2003).

In-house Safety Rules and Regulations
With a high RII in the three groups, ranging from 0.80 to 0.88, factor of “proper implementation of in-house safety rules and regulations” agrees with the previous study that absence of safety rules and regulations would greatly affect the proper enforcement of site safety. So, the safety performance of contractors is influenced by the extent of which the workers’ perceived safety rules and procedures (Teo, 2005).

6.4.2 Ranking and Findings in Personnel Aspect
The rank of the 6 factors in personnel aspect obtained from the survey and modified i-SPM 2013 was shown below:
### Table 6.5 Modified ranking of the factors in personnel aspects in i-SPM 2013 from the survey

<table>
<thead>
<tr>
<th>Ranking from the survey</th>
<th>Modified ranking in i-SPM 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety Committee (RII=0.90)</td>
<td>Safety Committee</td>
</tr>
<tr>
<td>Top management’s leadership (RII=0.82)</td>
<td>Top management’s leadership</td>
</tr>
<tr>
<td>Worker’s safety culture (RII=0.81)</td>
<td>Worker’s safety culture</td>
</tr>
<tr>
<td>Delegation of responsibility and accountability (RII=0.79)</td>
<td>Delegation of responsibility and accountability in organization</td>
</tr>
<tr>
<td>Good working relationship and environment (RII=0.77)</td>
<td>Good working relationship and environment</td>
</tr>
<tr>
<td>Safety and Health training program (RII=0.75)</td>
<td>Safety and Health training program</td>
</tr>
</tbody>
</table>

Safety and Health training program

Low ranking in safety and health training program in all three groups (RII= 0.73-0.79) indicate that there might be a problem area that needs to address in the safety planning model. In fact, this result is not surprising. It agrees with the studies (Tam 2004; Chan et al. 2004) that a tight schedule of the construction projects result in contractor’s low tendency in releasing the employees to attend safety training in working time. Besides, low participation and the perfunctory attitude in the top management towards safety training program also support the low RII result. However, Tam (2004) has emphasized on a systematic training programs. It helps personnel carry out various activities effectively, establish a positive safety attitude, and integrate safety with the construction and quality goal. As a result, increase in its ranking is required for addressing the needs on systematic safety and health training programs.

Top management’s leadership

Respondents from larger contract sum group demonstrate a lower RII on top management leadership and commitment in safety planning (RII= 0.80 for small contract sum group while RII=0.79 for large contract sum group).
Although high ranking in safety committee is obtained (RII= 0.81-0.95), with low attention on the delegation of the responsibility and accountability (RII= 0.77-0.79), the function of safety committee and safety organization cannot be fully operated.

6.4.3 Ranking and Findings in Process Aspect

The rank of the 13 factors in process aspect obtained from the survey and modified one was shown below:

<table>
<thead>
<tr>
<th>Ranking from the survey</th>
<th>Modified ranking in i-SPM 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergency Response Plan (RII=0.89)</td>
<td>Risk assessment and control</td>
</tr>
<tr>
<td>Risk assessment and control (RII=0.88)</td>
<td>Safety promotion</td>
</tr>
<tr>
<td>Safety promotion (RII=0.86)</td>
<td>Hazardous inspection program</td>
</tr>
<tr>
<td>Hazardous inspection program (RII=0.84)</td>
<td>Management of tools, plants and equipment, including Personal Protective Equipment</td>
</tr>
<tr>
<td>Provision of Personal Protective Equipment (RII=0.81)</td>
<td>Accidents and Incidents Investigation</td>
</tr>
<tr>
<td>Accidents and Incidents Investigation (RII=0.81)</td>
<td>Selection and management of subcontractors</td>
</tr>
<tr>
<td>Health and safety assurance program (RII=0.80)</td>
<td>Health and safety assurance program</td>
</tr>
<tr>
<td>Communication and information flow (RII=0.78)</td>
<td>Emergency Response Plan</td>
</tr>
<tr>
<td>Selection and management of subcontractors (RII=0.77)</td>
<td>Communication and information flow</td>
</tr>
<tr>
<td>Management review (RII=0.77)</td>
<td>Management review</td>
</tr>
<tr>
<td>Initial review (RII=0.75)</td>
<td>Initial review</td>
</tr>
<tr>
<td>Internal Audit (RII=0.75)</td>
<td>Internal Audit</td>
</tr>
<tr>
<td>Maintenance and tight control on the documentation (RII=0.68)</td>
<td>Maintenance and tight control on the documentation</td>
</tr>
</tbody>
</table>

Table 6.6 Modified ranking of the factors in Process aspects in i-SPM 2013 from the survey
Risk assessment and control
The overall rank of “Risk assessment and control” is 2. With a consistently high level of RII in small contract sum group (0.84), medium (I+II) group (0.89) and large group (0.91), it shows that the respondents notice the essentialness of risk assessment in safety planning.

Hazardous inspection program
The result shows that it is essential for the safety officers to be familiar with various types and methods of construction which yield different safety requirements. Thus, safety officers must be well trained and experienced enough to deal with safety concerns of different construction activities.

Emergency Response Plan
The result of the “Emergency response plan” stand high in small, medium and large contract sum group (RII=0.84-0.91). The high priority may also due to the requirement of this plan in very early stage of the construction projects before the commencement of the project. However, it also reveals that the construction industry is still in a reactive attitude towards managing safety, therefore, the position of the emergency response plan will be ranked lower (Rank 8).

Provision of Personal Protective Equipment
The overall rank of this factor is 5 among the 13 Process factors (RII=0.81). The lower the contract sum group gives a lower index. Shortcomings with equipment, including PPE were identified in over half of the accident in the study. In fact, some of the respondents raised the problem that the cause of the accident may not only be the deficiency of the PPE provided, but also the lack of suitability and condition of the material. So, in order to emphasize it into i-SPM 2013, this factor will changed from “Provision of Personal Protective Equipment” to “Management of tools, plants and equipment, including Personal Protective Equipment”

Management review and the initial review
The low priority of the management review and the initial review support the previous literature that contactors did not pay much attention on updating the safety planning
in order to have a project- specify safety planning.

Safety promotion
All three groups projected a high RII in safety promotion (RII= 0.83, 0.86, 0.88). Most respondents knew the importance of safety promotion, even in small contract sum group. However, such superior high indexes agree with the previous studies that tradition safety management are still exist in nowadays. Most contractors are still relying on the promotional campaigns to promote safety. Meanwhile, this may due to the benefit of promoting safety in such a high risk construction industry. The large company which is willing to invest more on the safety promotion can gain the corporate image. For the medium sized group without many resources, low profile safety promotion is conducted in order to raise the workforce’s safety awareness and develop a safety culture.

Selection and management of subcontractors
The overall ranking of the “Selection and management of subcontractors” is quite low (RII=0.77, Rank=9). Besides, with a lower RII in large contract sum group (RII=0.73), this may reveal that practice on shifting most safety responsibilities of main to subcontractors are still common. The probability of the lack of communication, coordination and control between sub-contractors and contractors will increase (Rolwinson 2003). Therefore, for a high chain of contracting system in Hong Kong construction industry, the ranking of “Selection and management of subcontractors” should be adjusted higher to rank 7.

6.4.4 Ranking and Findings in Incentive Aspect
The ranking of the 2 factors in incentive aspect is the same as that obtained from the survey (Table 6.7).

<table>
<thead>
<tr>
<th>Ranking from the survey</th>
<th>Modified ranking in i-SPM 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety incentive program (RII= 0.79)</td>
<td>Safety incentive program</td>
</tr>
<tr>
<td>Disincentive program (RII= 0.77)</td>
<td>Disincentive program</td>
</tr>
</tbody>
</table>

Table 6.7 Modified ranking of the factors in incentive aspects in i-SPM 2013 from the survey
Compare with the ranking of disincentive program, safety incentive program is at a little higher rank. And the RII of the incentive program (RII=0.79) and disincentive program (RII=0.77), it shows that the importance of the incentive aspect is comparative less weighted to the other aspects. This result agrees with the previous chapter that although the incentive program helps mitigate site accidents, how the incentives are being allocated is the key criteria on reducing workplace injuries effectively (Hinze and Harrison). So, type of the safety incentives used should be dependent upon the different relationships of the groups’ and individuals’ expectations and reactions towards safety incentives. Same approach on the disincentive program was found. The objective of the disincentive program is to promote safety but not to discourage or dampen the workforce’s morale. Therefore, from the lower ranking of the disincentive program in both groups (Rank 20, 17 and 13 respectively), the respondents agrees with the general studies (A O’Dea and Flin (2000))

6.5. Findings on comparisons with different demography information

Work experience
Apart from comparing the different contract sum groups, trends on other demography information also observed. For example, for the safety professional with 5-10 years working experience in safety profession tend to rate at the high level (6 or 7 in the scale), while for more experienced safety professional give a varied pattern on the survey. One of the possible reasons is that the experienced safety professional (i.e. working experience >10 years) would tend to believe in their own decision and judgment which only based on their past working experience.

6.6. Modified $\omega$-SPM 2013

Figure 6.1 shows the modified $\omega$-SPM 2013 with priority of the factor.
Fig. 6.1 Modified i-SPM 2013

Policy Factors
1. Construction Safety related Legislation and Regulation
2. Safety Policy
3. In-house safety rules and regulations

Incentive Factors
1. Safety incentive program
2. Disincentive program

Process Factors
1. Risk assessment and control
2. Safety promotion
3. Hazardous inspection program
4. Management of tools, plants and equipment, including Personal Protective Equipment
5. Accidents and Incidents Investigation
6. Selection and management of subcontractors
7. Health and safety assurance program
8. Emergency Response Plan
9. Communication and information flow
10. Management review
11. Initial review
12. Internal Audit
13. Maintenance and tight control on the documentation

Personnel Factors
1. Safety Committee
2. Top management’s leadership
3. Worker’s safety culture
4. Delegation of responsibility and accountability in organization
5. Safety and Health training program
6. Good working relationship and environment
Chapter Seven - Interview for Verification of ĭSPM 2013

7.1. Introduction

Since the framework of ĭSPM 2013 is developed from the analysis of the respondents in Chapter 6, follow up interviews on the findings and discussion on implementation of ĭSPM 2013 and BIM are initiated. This chapter aims to analyze the data collected from the semi-structured interviews.

7.2. Data Collection

Semi-structured interview were adopted to collect the required data as discussed in Chapter 4. The interviews were conducted one on one via face-to-face interview. The interviewees who had experience or knowledge on BIM were selected. The interviews were conducted on March, 2012. A total of three interviews (A, B and C) were successfully conducted.

7.3. Result Analysis

7.3.1 Necessity of reviewing ĭSPM 2013 model regularly

Interviewee B suggested that the model shall be reviewed every 5 years. With a regular assessing process of enhancing the safety planning model, it ensures the achievement of overall safety performance that is consistent with the organizations’ policy and government’s legislations.

Besides, due to rapid development in China, more and more Hong Kong’s construction companies have set up their branch on mainland. Under such condition, ĭSPM 2013 need to be adjusted by considering the divergences on safety culture, safe work’s attitude of employees and top management. It should emphasize that the model shall be reviewed before adoption for the
sake of suitability to both external and internal organization’s environment.

7.3.2 Risk assessment and controlling process as the prime objective in safety planning
Three interviewees agreed that contractors shall pay more attention and resource on assessing risk and hazardous activities on planning stage before project commencement. Interviewee A even suggested that safety plan should be maintained as early as in design stage. If one risk is highlighted during the design stage, problem can be solved by amending the design. This practice not only reduces one problem in construction site, but also with less re-working and occurrence of delay.

However, under current management as discussed in Chapter 2, communication between construction parties is weak. This adds difficulties in developing an effective safety plan right at the design or tender stage. Supported by Interviewee C, this requires proactive approach among parties.

7.3.3 Arguments on the inclusion of disincentive program
Interviewee A disagreed the inclusion of disincentive program independently in safety planning. The aim of the promotion program is to positively promote safety awareness among employees and managerial staffs. Focusing on disincentive program may result in negative effect. They may feel “forced” to comply with safety issue. In fact, this discussion has been figured out in Chapter 3.

Interviewee C had another opinion that whether the disincentive program shall be included in safety planning depends on the organization’s policy and objective towards safety promotion.
7.3.4 Positive expectation on the integration of safety into BIM by highlighting the hazards through clash detection and visualization earlier

The three interviewees showed their support on the integration of safety into BIM. Interviewee A expressed his positive comment. Under the clash detection functioned in BIM, a majority of high risk activities can be highlighted earlier before the construction process. Designers can make use of this for design for safety approach. This also helps the new safety professionals in judging and identifying the hazards.

Interviewee C gave his comment with support on recent research in BIM for safety. He pointed out that as strong industry demand on safety existed, effective tools on pushing safety shall be developed. BIM is an excellent technology for this purpose. He further said that although current technology access is available, promotion on the use of BIM is not strong. Contractor shall be encouraged to use it. Interviewee B supported that construction safety should not be imaging but virtually observed.

7.3.5 Requirement on strong communication between safety and construction technology experts to solve interface’s problems between components on model and construction process

Interviewee B raised another viewpoint. He thought that there still a path for success on integrating safety into BIM. Problem in how to match the construction components with safety planning is still in an initial research among academic and industrial areas. Although an integrated ν-SPM 2013 is developed, it cannot be fully utilized unless a construction technology with relative standard is supplemented. To ascertain the compliance of each technical drawing with components in ν-SPM 2013, strong communication between safety and construction technology experts is essential required.
7.3.6 Continuous evaluation on the process

Interviewee B further suggested a proactive and systematic testing on monitoring the development process shall continuously carry out. Construction safety should be addressed as primal importance elements in management as cost of safety is huge. It involve not only economic, but also human’s limbs and lives. Therefore, safety should be one of the components in BIM and should be cooperate with the construction components tightly without misconnection.
Chapter Eight - Discussion - How to introduce *ν*-SPM 2013 into BIM

8.1. Positive attitude on integrating safety into BIM

Result reflected that most respondents recognized risk assessment as an important component in safety planning but fail in other essential measures such as systematic training program, safe work’s culture and working environment. These findings are critical as it support the introduction of *ν*-SPM 2013 into a visualization technology, BIM.

In fact, respondents have shown their awareness on implementing BIM into construction project. 82% respondents express their awareness on use of BIM and 34% of these respondents have even applied BIM. Only a few have applied safety into BIM (7%), this may due to the lack of safety tools available in BIM. This result also supports to the general study on the separation between project management and safety in construction industry compare with the vast majority in the use of planning (20%) and estimating (17%).

Most respondents have a positive attitude towards BIM, with only 6 and 2 votes on the “increase of training cost” and “hinder the design” respectively. These findings strengthen future study on investigating feature and implementation of BIM in construction industry to form an integrated and sophisticated database, especially for Hong Kong.

Meanwhile, training cost may not be huge and can be covered in a long run. According to the investigation on introducing BIM in Hong Kong’s tertiary education, Wong (2011) found that students learning BIM design process were shorten compared to those using ‘traditional’ methods. With the gradually increase in the implementation of BIM learning in tertiary construction education, the new blooded workforces may already cater for the BIM technology.
Vast majority agreed that implementation of BIM in construction project can increase collaboration between all parties (24%). This agrees with the objective of the design of safety (Dfs) in Chapter 2. Therefore, integrating \textit{\textit{\textit{\textit{i}}-SPM 2013}} into BIM can comprehend the awareness of designer and project planners in site safety issue.

As a result, with high awareness and tendency on the use of BIM in construction (64%), \textit{\textit{\textit{\textit{i}}-SPM 2013}} may further help contractors or even whole project team to maintain safe site environment. This belief was also supported by recent studies (McGraw Hill Construction, 2008; Taiebat’s studies, 2011).

\textbf{8.2. How to introduce \textit{\textit{\textit{\textit{i}}-SPM 2013}} into BIM}

In order to understand the ways \textit{\textit{\textit{\textit{i}}-SPM 2013}} incorporates into BIM, visual minds will be illustrated. This conceptual introduction provides a reference for future study to work out the features and components.

Similar to Structural, Architectural, and Mechanical, Electrical & Plumbing, Safety Planning will form one of the BIM’s sub-models to ensure the projects are under a safety track. An overview on the component of the BIM is shown on Fig.8.1.

The general principal of each component is the same. Contractors shall firstly input information such as construction regulations, risk assessment template and hazardous identification activities into BIM to form a safety database. The database shall update regularly or even interconnected to websites such as Building Department or companies intranet for automatic update. This database even can circulate within different companies for improvements and ensuring of most updated information.
DISCUSSION- HOW to INTRODUCE i-SPM2013 into BIM

CHAPTER EIGHT

Design and Development of Construction Safety Planning Model for BIM in Hong Kong Construction Industry

Figure 8.1 An overview on the BIM showing the additional of Safety Planning sub-model (http://sikafutu.com/Delivery/Deliver.html)

Details on how i-SPM 2013 present in BIM is illustrated as follow. Figures shown are visual only which aim at explicit the simplest form model presented in BIM technology.

“Safety” icon shall be appeared in the tool bar. (Figure 8.2) Pressing this “safety” icon will pop out a selection box on the side of the window. Selections in the properties box will be the components of i-SPM 2013. (Figure 8.3) Then, 24 factors on i-SPM 2013 will show as the content of the safety planning, pressing each button will immediately shows the required information in 2D or 3D view.

Figure 8.2 Safety icon added in the toolbar
Use “Construction safety related legislations and regulations” as an example. After pressing the button from the sidebar (Step 1 on Figure 8.4) and press the staircase in 2D or 3D view, a box will appear showing the related regulation or code of practice (Step 2 on Figure 8.4). A compliance box will be allocated at the bottom of the text box. A tick indicates that the design is complied. (Step 3 on Figure 8.4)
8.3. BIM-σ-SPM 2013 functionalities

8.3.1 Form a project-specific safety plan

σ-SPM 2013, a sub-model for BIM-safety management, is designed to facilitate safety professional to develop a project-specific safety plan. To complete this purpose, information related to safety planning is stored in a database. Construction planners can retrieve this information when they need it. With geotechnical information stored in BIM, comprehensive decision making and project-specific safety plan will result.

8.3.2 Form a safety library function

Actually, a safety plan can be automatically generated from the safety library. A safety library contain several safety data collected from regulatory standards and safety professionals’ experience, such as installing a guardrail to protect workers from falling from an open slab. However, safety data may be a chunk of words. Under the classification of 4 aspects in σ-SPM 2013, it helps safety professional in categorizing things effectively. For example, unsafe working environment and practices are not easily clarified in traditional PDCA model, however, under σ-SPM 2013, there is one special title for this. Besides, it can further develop into 3D animation for training or safety promotion purpose.

8.3.3 Create a Risk Assessment template

Create a Risk Assessment template where user can input risk related information to each activity and incorporate it into activity planning.

8.3.4 Safety analysis on hazard activities

Assess the probability of risk in workspace area on construction sites through the assistant of the visualization of the site walk in the developed 3D model. This can further improve the identification of hazards. This function supports the previous studies that the more the hazardous activities are planned, the
more the chance for developing their relative control measures. This definitely helps the mitigation of the construction accidents.

From the current research, tools for “fall from height” has been investigate. Apart from fall from height, other commonly found accidents includes Stepping on or striking against object, Hazards associated with operation of machinery, transport and earth moving equipment such as concrete mixing plants, trucks, bulldozers, excavators etc., and Hazards associated with lifting of materials, both mechanical and manual. All these activities shall be assessed under the safety planning stage.

8.3.5 Converting a traditional safety planning into more interactive in construction site

Since paper-formed safety plan is now integrated into a 3D model, this facilitates safety professionals in visualizing spatial and physical information of construction activities. This also assists their decision in analyzing the required safety measures to be installed, prepared, or provided for current activities and where, when, as well as why they are needed.

Safety officers can further utilize it into safety promotion, safety training and other related programs to increase workforce’s participation in safety. From the survey, safety promotion was one of the respondents’ most concern parts among three contract-sum groups. Safety awareness among workforce can be further strengthened by introducing BIM application. For example, television provided in rest room can present company’s safety policy, in-house safety rule and regulations or those highlighted from safety plans. Also it can address importance on the specific week, relevant for this specific site, and related to occupational site safety. Similar method can be used in training program and safety oriented construction process.

8.3.6 Provide effective communication and information flow

Furthermore, communication among parties involved in the construction
projects can be improved. Kiviniemi (2011) proofed that clear visual object and process in BIM can eliminate disparity in different interpretation caused by participants' experience or knowledge. The use of visualization not only presents a more comprehensive construction process, but also the communication between different project stakeholders.
Chapter Nine - Conclusion and Recommendation

9.1. Conclusion and Recommendation

This study successfully developed an integrated safety planning model, i-SPM 2013 for Hong Kong construction industry that could be the “nuts and bolts” for safety professionals, as they could be the reference managing construction site safety management. It could help with safety plan preparation. The study investigated 24 main components that significantly affect the safety planning (refer to Figure 6.1).

The main finding of this study was that safety planning was affected by four main factors: policy; construction process; personnel; and incentives aspects.

1. In term of POLICY ASPECT, high priority was assigned on “construction safety related legislation and code of practice” and “safety policy”.

2. In term of PERSONNEL ASPECT, high ranking in “management’s leadership and commitment” was chosen but relatively low priority in “safety and health training program” reflected that the government and relevant authority may need to review the existing policy on safety training and resources allocation in construction industry.

3. In term of PROCESS ASPECT, high priority in “emergency response plan” and low rank of “safety promotion” and “continuous improvement” reflected that most contractors were still far away from proactive safety management. Meanwhile, high ranking in “risk assessment and risk control” may indicate that contractors understood the roots purpose of safety planning, but they could not work out a comprehensive safety plan with little guideline provided from the government.

4. In term of INCENTIVE ASPECT, this study showed that disincentive program is at similar importance as incentive program which acted as a source of motivation to the enhancement of safety for the workers.
However, forms of disincentive may require further discussion.

Safety planning which was an initial element in safety management could be further introduced into BIM to solve the problem of separation between safety and construction project management. With the merits of designing for construction safety were evident, implementation in safety practice in Hong Kong was minimal to nonexistent.

The developed *i*-SPM 2013 was also important because this study pointed out that integrating it into BIM helped simulate safety hazards associated with construction activities, thus improving safety by a visualization of processes. Furthermore, designers could get involved early in the construction process to incorporate codes and regulations and assist contractors with tying safety plans into the definable features of work. They knew that construction safety would not be solitary the responsibility of contractor or employer. It supported the design and construction teams to better recognize hazards and handle the complexity of specific jobsite conditions.

However, further research would be required as there were difficulties in ascertaining all safety planning information matched with the construction components. An integrated *i*-SPM 2013 could only be fully utilized unless relative standard's construction technology was supported. It is recommended that safety and construction technology experts shall have effective communication and continuous testing on the development of the model in BIM.

### 9.2. Limitation and further study

#### 9.2.1 Limited Sample Size

In this study, the questionnaires are the major resources for the priority of *i*-SPM 2013. The obtained results can not represent the whole construction
industry as the sample size is not large enough (N=50). Besides, the perception on the importance of factors in safety planning varied from experience and age of the safety professionals. To obtain a more valid and reliable statistical analysis, more data should be collected.

9.2.2 Limited Number of Safety Attitude Questions
In the questionnaires, besides the basic information of respondents, one question on each factor was set. 2 to 3 questions on each factor could be asked to ensure the consistency of rating. However, if too many questions included, respondents may loss incentive to provide actual information.

9.3. Further Study
Base on the framework of i-SPM 2013, more comprehensive safety planning model with sub-factors can be developed. It is worth studying further with larger sample size to explicit the weakness in the current safety planning management. It assists the safety professionals in developing effective safety planning.

Testing on the integration of developed model into BIM shall be carried out. This model may need further modification in order to suit the technical implication to BIM.

Besides, investigation on the virtual safety planning tool can be invented. The technology tool shall ensure the content of the safety planning model can be fully utilized with the interface of technical drawings. With the appearance of an opening or an edge in the technical drawing, safety related information in the planning model can be automatically generated. With such technology developed, safety professional and designers can participant in safety planning and provide valuable feedback for further development in maintaining a safe construction environment.
Reference and Bibliographies


Hong Kong Labour Department (1999), A guide to safety management, 1st Edition, Occupational Safety and Health Branch, Hong Kong.


National Safety Council (1994), 14 Elements of A Successful Safety & Health Program, National Safety Council, USA


Steve Rowlinson, (2003), Hong Kong construction: safety management and the law, Hong Kong : Sweet & Maxwell Asia, 2nd Edition


Syed M. Ahmed, Member, ASCE, Jack Chu Kwan, Fox Young Wei Ming, and Derrick Chong Pui Ho (2000), Site Safety Management in Hong Kong, Journal of management in engineering/ November/ December 34-42


APPENDIX A- F&IU (SM) R

Factories and industrial undertakings (Safety Management) Regulation

Proprietors and contractors who are required to have safety management systems:

- An aggregate of 100 or more workers in a day working in a single construction site or a contractor in relation to construction work with a contract value of $100 million or more;
- An aggregate of 50 or more but less than 100 workers in a day working in a single construction site;
- An aggregate of 100 or more workers in a day working in 2 or more construction sites;
- An aggregate of 50 or more but less than 100 workers in a day working in 2 or more construction sites.

Such contractors are required, under the regulation, to adopt SMS. The elements of SMS are defined into three parts:

Part I

- A safety policy which states the commitment of the proprietor or contractor to safety and health at work.
- A structure to assure implementation of the commitment to safety and health at work.
- Training to equip personnel with knowledge to work safely and without risk to health.
- In-house safety rules to provide instruction for achieving safety management objectives.
- A programme of inspection to identify hazardous conditions and for the rectification of any such conditions at regular intervals or as appropriate.
- A programme to identify hazardous exposure or the risk of such exposure to the workers and to provide suitable personal protective equipment as a last resort where engineering control methods are not feasible.
- Investigation of accidents or incidents to find out the cause of any accident or incident and to develop prompt arrangements to prevent recurrence.
- Emergency preparedness to develop, communicate and execute plans
prescribing the effective management of emergency situations.

Part II

- Evaluation, selection and control of sub-contractors to ensure that subcontractors are fully aware of their safety obligations and are in fact meeting them.
- Safety committees.

Part III

- Evaluation of job related hazards or potential hazards and development of safety procedures.
- Promotion, development and maintenance of safety and health awareness in a workplace.
- A programme for accident control and elimination of hazards before exposing workers to any adverse work environment.
- A programme to protect workers from occupational health hazards.
APPENDIX B- Various Safety Management Systems

B-1 Hong Kong Safety Management System

Figure B.1 is the model summarizing various aspects of management functions in developing, implementing and maintaining a SMS.

Figure B.1 Hong Kong Safety Management System (Occupational Safety and Health Branch, 1999)
Concept in each stage

“Planning” stage is the process of determining what should be accomplished in advance. Contractors are required to conduct initial status analysis, periodic status analysis and risk assessment in the development of SMS to identify “where are we now?” and “what do we want to be?”

“Development” stage is the process of determining how the objectives should be realized in order to achieve an effective SMS. Contractor is required to define, document and endorse a policy, and to prepare an effective safety plan which sets out the policy in specific terms.

“Organizing” stage is the process of prescribing formal relations between people and resources in the organization so as to accomplish the objective.

“Implementing” stage is the process of carrying out the plan to achieve the desired objectives, with appropriate and adequate control to ensure proper performance in accordance with the plan.

“Measuring” stage is the process of checking performance against standard to reveal when and where improvement is needed, and is a means of monitoring the extent to which polices and objectives are being met. The “feedback loop” on measuring stage is provided that help the contractor to reinforce and maintain its ability to reduce risks to the fullest extent and to ensure the continued efficiency, effectiveness and reliability of the SMS.

“Auditing/ Reviewing” carry out the assessment on performance in addition to routine monitoring of occupational safety and health performance. Feedback loop is also constitutes which enable the ability in reinforcement, maintenance and development to reduce risks to the fullest SMS.

In addition, information flows between development, implementation and maintenance stages and the auditing /reviewing stage to ensure a correct operation can be achieved.
Elements included in safety management system

Every element in SMS should be adopted in the development, implementation and maintenance stage. The safety audits or safety review should assess whether or not the SMS, including each of the 14 elements, has been developed, implemented and maintained in accordance with the standards set out in the Code of Practice. The 14 elements of a safety management system, specified in the Safety Management Regulation, are as follows:

1. A safety policy which states the commitment of the proprietor or contractor to safety and health at works.
2. A structure to ensure implementation of the commitment to safety and health at work.
3. Training to equip personnel with knowledge to work safely and without risk to health.
4. In-house safety rules to provide instruction for achieving safety management objectives.
5. A programme of inspection to identify hazardous conditions and for the rectification of any such conditions at regular intervals or as appropriate.
6. A programme to identify hazardous exposure or the risk of such exposure to the workers and to provide suitable personal protective equipment as a last resort where engineering control methods are not feasible.
7. Investigation of accidents or incidents to find out the cause of any accident or incident and to develop prompt arrangement to prevent recurrence.
8. Emergency preparedness to develop, communicate and execute plans prescribing the effective management of emergency situations.
9. Evaluation, selection and control of sub-contractors to ensure that subcontractors are fully aware of their safety obligations and are in fact meeting them.
10. Safety committees to provide a forum for all those involved to discuss issues and pass on information.
11. Evaluation of job related hazards or potential hazards and development of safety procedures.
12. Promotion, development and maintenance of safety and health awareness in a workplace.
13. A programme for accident control and elimination of hazards before exposing workers to any adverse work environment.
B.2 “Successful Health and Safety Management”, HS(G)65

United Kingdom (UK) first prepared “Successful Health and Safety Management”, HS(G)65 in 1991 as a practical guidance for directors, managers, health and safety professionals and employee representatives (HSG, 1991).

It describes the principles and management practices which provide the basic of effective health and safety management, sets out the issues which need to be addressed; and develop improvement programs, self-audit or self-assessment. Companies need to manage health and safety with the same degree of expertise and to the same standards as their other core business activities.

Under HS(G)65, five inter-linked key elements of successful H&S Management. Figure B.2 shows the main elements of the HSG 65 and their relationship. It is useful on suggesting the content of each element of health and safety management system (HSMS), however, it is not a structured and auditable approach.
Figure 2.2 Successful Health and Safety Management (HSG65)

As a result of the demand on a structured and auditable approach on SMS, the British Standard Institute (BSI) published the BS8800: 1996, ‘A Guide to Occupational Health and Safety Management Systems (OHSMS)’. The Health and Safety Executive (HSE) of United Kingdom under the direction of the Management Systems Sector Board introduced this standard (Nimi, 2002). It perhaps is the first formalized template of a global OHSMS framework.

Figure B.3 shows the main elements of the BS 8800 and their relationship. The guide has recently been revised to produce the BS8800: 2004. The major elements of the guidelines covered management commitment, employee involvement, worksite analysis, hazard prevention and control, and safety and health training. The breakdown of the elements and sub-elements for the OHS management system are as shown in Figure B.4
Figure B.4 OHS management system elements of BS 8800: 1996

- Policy
  - a) Recognition of integral part of business performance.
  - b) Compliance to legal requirements.
  - c) Continual cost-effective improvement in performance.
  - d) Adequate & appropriate resources.
  - e) Setting & appropriate OHS objective.
  - f) OHS management as prime responsibility of line management.
  - g) Understanding, implementation, and maintenance at all levels.
  - h) Employee involvement and consultation.
  - i) Periodic review.
  - j) Training for employees.

- Organizing
  - a) Responsibilities
  - b) Organization arrangements
  - c) OHS documents

- Planning and implementing
  - a) General
  - b) Risk assessment
  - c) Legal and other requirements

- Measuring performance
  - a) Qualitative and quantitative measure
  - b) Proactive and reactive performance measurement

- Audit
  - a) Conduct by competent persons periodically
  - b) Result communicated to all relevant personnel.

- Initial and periodic status review
  - a) Overall performance of OSHMS
  - b) Performance of individual elements
  - c) Audit findings
  - d) Identify action to remedy any deficiencies.
B.4 Continuous Improvement Model (NSC 1994)

In 1994, the continuous improvement model (Figure B.5) was introduced by the National Safety Council (NSC 1994) of the United States.

In order to achieve specified goals, 14 major elements are included in the safety and health program, including Hazard Recognition, Evaluation and Control; Workplace Design and Engineering; Safety Performance Management; Regulatory Compliance Management; Occupational Health; Information Collection; Employee Involvement; Motivation, Behaviour and Attitudes; Training and Orientation; Organizational Communications; Management and Control of External Exposures; Environmental Management; Workplace Planning and Staffing and Assessments, Audits and Evaluation.
B.5 OHSAS 18001:1999

In 1999, OHSAS 18001 was created via the concerted effort from a number of the world’s leading national bodies, certification bodies, and specialist consultancies. OHSAS 18001 gives requirements to enable an organization to consistently identify and control its health and safety risks, to reduce the potential for accidents, aid legislative compliance and to improve its performance. 5 important elements of OHSAS 18001 were shown on Figure B.6 and Figure B.7.

![Figure B.6 Key process of OHS management system in OHSAS 18001](image-url)
Figure B.7 Elements of OHS management system in OHSAS 18001

In 2002, international Labour Organization (ILO) developed an OSH management system according to internationally agreed principles defined by the ILO’s tripartite constituents. The benefit of having a tripartite approach can provide strength, flexibility and appropriate basic for the development of a sustainable culture in the organization. Figure B.8 shows the basic structure and arrangements for ILO- OHS-2001 (2001) in an organization.

It is a practical tool for assisting organizations as a means of achieving continual improvement in OSH performance. The objective of the guidelines is to protect workers from hazards and to eliminate work-related injuries, ill-health, disease, incidents and deaths. Figure B.9 shows the elements and sub-elements of the OHS management system.

![Figure B.8 Main Elements of the SMSs (ILO- OSH, 2001)](image-url)
Figure B.9 OSH management system of ILO-OSH 2001
APPENDIX C - Questionnaire

“Design and Development of Construction Safety Planning Model for BIM in Hong Kong”

Aim: To conduct a survey on safety professionals including safety officers and assistance safety officers of Hong Kong Construction Industry for investigating factors on designing and developing safety plan for Building Information Modeling (BIM).

All information provided by you will be treated as CONFIDENTIAL and will only be used for compiling statistics in academic studies. After completion of the survey, please return the questionnaire to the person who distributes it to you or by email to ____@student.cityu.edu.hk

Part A. Recent Project /Personal Information
1. Post/Title: ____________________ 2. Gender: □ Male  □ Female
3. Education Level: □ <F.5  □ Diploma □ F.5-F.7 □ High diploma and above
4. Year(s) of experience in Construction industry: __________________________ year(s)
5. Year(s) of experience in Construction Safety profession: ___________________year(s)
6. Type of project: □ Government Building Project □ Private Building Project □ Civil Work
7. Number of Employees: □ Less than 50  □ 50-100 □ 100-299 □ More than 300
8. Project contract sum: ___________________

Part B. Importance on the following factors on designing the safety plan
On a scale of 1-7, please rate the extent to the agreement on the importance of the following factors for developing an effective safety plan.

<table>
<thead>
<tr>
<th>Policy Aspect</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Slightly Disagree</th>
<th>Neutral</th>
<th>Slightly Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Understanding of Legislations and Regulations e.g. Factories and Industry Undertakings (Safety Management) Regulation</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Proper implementation of Safety Policy</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Proper implementation of In-house safety rules and regulations</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Personnel Aspect

<table>
<thead>
<tr>
<th>Personnel Aspect</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Slightly Disagree</th>
<th>Neutral</th>
<th>Slightly Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Top management’s leadership in safety planning process</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Proper consideration on worker’s safety culture</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Proper implementation on good working relationship and</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Process Aspect

<table>
<thead>
<tr>
<th>Process</th>
<th>Description</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Implementation of initial review</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>2.</td>
<td>Proper implementation of hazardous inspection program</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>3.</td>
<td>Proper implementation of health and safety assurance program</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>4.</td>
<td>Proper risk assessment and control</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>5.</td>
<td>Proper implementation of emergency response plan</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>6.</td>
<td>Proper implementation accidents and incidents investigation</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>7.</td>
<td>Proper provision of personal protective equipment</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>8.</td>
<td>Proper implementation on safety promotion</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>9.</td>
<td>Proper selection and management of subcontractors</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>10.</td>
<td>Proper implementation of Communication and information flow</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>11.</td>
<td>Maintenance and tight control on the documentation</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>12.</td>
<td>Proper implementation of internal Audit</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>13.</td>
<td>Conduction of regular Management review</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
</tbody>
</table>

### Incentive Aspects

<table>
<thead>
<tr>
<th>Incentive</th>
<th>Description</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Introduction of safety incentive program (e.g. bonus, rewards, etc.)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>2.</td>
<td>Introduction of disincentive program (e.g. fines, suspension of work, etc.)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
</tbody>
</table>

In your experience, are there any other important factors to do with the safety planning that have not been identified above? If any, please state:

____________________________________________________________________________________

____________________________________________________________________________________

____________________________________________________________________________________

Design and Development of Construction Safety Planning Model for BIM in Hong Kong Construction Industry

-136-
Part C Questions about the use of BIM* (建築資訊模型)

*BIM = Building Information Modelling is the process of generating and managing building data during its life cycle. Building information modeling covers geometry, spatial relationships, light analysis, geographic information, quantities and properties of building components (for example manufacturers' details). BIM can be used to demonstrate the entire building life cycle, including the processes of construction and facility operation. Quantities and shared properties of materials can be extracted easily. Scopes of work can be isolated and defined. Systems, assemblies and sequences can be shown in a relative scale with the entire facility or group of facilities. Dynamic information of the building, such as sensor measurements and control signals from the building systems, can also be incorporated within BIM to support analysis of building operation and maintenance. Wikipedia®

1. Please indicate your level of knowledge and awareness of Building Information Modeling (BIM).
   - Never heard of BIM approach
   - Heard of BIM but never applied it
   - Applied BIM on limited basis
   - Applied BIM on regular basis

2. How many construction projects have you/your company completed using BIM?
   - None
   - 1-3 Projects
   - 4-5 Projects
   - 6-10 Projects
   - 11+ Projects

3. In which of the area(s) have you/your company been using the BIM approach on a project?
   - Architectural designing
   - Structural designing
   - Construction sequence
   - Mechanical and Electrical
   - Safety
   - Planning
   - Estimating
   - Others________

4. What do you think about implementing BIM in your current/future project?
   - Increase training cost
   - Reduction on Time
   - Hinder the Design
   - Better safety performance
   - Better quality
   - More Liability
   - Increase collaboration between all parties within project
   - Reduction of project overall cost
   - Others, please specific: ____________________________

5. Will there be an increasing demand on the usage of BIM in construction safety?
   - Yes
   - No

6. Please provide any comments and suggestions.
   __________________________________________________________
   __________________________________________________________
   __________________________________________________________

- END -

Thank You for Your Help
APPENDIX D - Interview Questionnaire

“Design and Development of Construction Safety Planning Model for BIM in Hong Kong”

INTRODUCTION

This research is to evaluate the importance factors for safety planning and develop a safety planning model, i-SPM 2013 with the purpose of further integrating it into the Building Information Modeling (BIM) for raising the awareness on construction site safety among safety professionals and designers.

The research methodology consists of 3 parts. In the first part, 24 importance factors in safety planning, which classified into 4 aspects- Policy, Personnel, Process and Incentive, have been identified through Literature Review (Figure 1). Then, in the second part, perception on the importance of 23 factors derived in safety planning among safety professionals in construction site has been investigated through questionnaire survey.

*Findings have shown that understanding on the (1) construction safety related legislation and code of practice and (2) safety policy ranked high in the POLICY ASPECT; (3) highest ranking in Management’s leadership and commitment but (4) relatively low rank in safety and health training program were found in PERSONNEL ASPECT; (5) highest ranking in emergency response plan, (6) high ranking in risk assessment and risk control, and (7) safety promotion but comparatively low rank in (8) continuous improvement and (9) subcontractor management were found in the PROCESS ASPECT; (10) similar importance on both incentive and disincentive program were found in INCENTIVE ASPECT. Frameworks based on the survey’s finding were further adjusted to form a modified i-SPM 2013 (Figure 2).

The last part of this research is to verify the model through interview with professional. Questions will be divided into 2 sections. Section 1 is about the overall presentation of the model and in-depth discussion on the questionnaires’ findings. Section 2 includes discussion on the further implementation of the model into BIM.
Part 1 SAFETY PLANNING MODEL, i-SPM 2013

Format and presentation of the model (Please refer to Figure 2)
Q1. What do you think about the presentation of the model?

Discussion on the questionnaires' findings (Refer to * in introduction and figure 2)
Q2. Do you think the current risk assessment and controlling process in safety planning are enough? What can be done to improve their performance?

Q3 Apart from the risk assessment and controlling process, what are your opinions on others findings*?

Part 2 INTEGRATION OF i-SPM 2013 into BIM (refer to extraction of Ch.8)
Q4. What do you think about the impact of integrating i-SPM 2013 into BIM? In term of:
Change on the safety planning’s practice in contractors
Among all construction project’s parties
Overall construction safety management’s performance such as in
1. Risk assessment
2. Safety and health training program
3. Safety Promotion

Q5. Any comment on the objective or methodology used in this study? Any recommendations on future study?

-Thank You-
Figure 1 factors purposed in safety planning model after Literature Review

Figure 2 Safety Planning model with modification after questionnaire survey
Extraction from Ch.8

8.2 How to introduce \(i\)-SPM 2013 into BIM

The general principal of each component is the more or less the same. Information such as the construction regulations, risk assessment template, hazardous identification activities etc. shall be put in BIM to form a safety database and updated regularly or even circulated in different contractor’s companies.

“Safety” icon shall be appeared in the tool bar. Pressing this “safety” icon will pop out a selection box on the side of the software. Selections in the properties box will be the components of \(i\)-SPM 2013. (Figure 8.4) Then, 24 factors on \(i\)-SPM 2013 will be show as the content of the safety planning, pressing each button will immediately shows the required information in 2D or 3D view.

Use “Construction safety related legislations and regulations” as an example. After pressing the button “1 Construction safety related legislations and regulations” from the content of the safety planning (Step 1 on Figure 8.5) and press the staircase in 2D or 3D view, a text box will appear showing the required regulation or code of practice (Step 2 on Figure 8.5). Moreover, at the bottom of the text box, a compliance box will be allocated. A tick indicates that the design is complying with the construction safety related legislations and regulations. (Step 3 on Figure 8.5)
8.3 BIM-ISP-SPM 2013 functionalities

1. Form a project-specific safety plan with the benefit of geotechnical information stored in BIM.
2. Form a safety library function contain several safety data collected from regulatory standards and safety professionals’ experience to automatically generate a safety plan.
3. Create a Risk Assessment template where user can input Risk related information to each activity and incorporate the risk information into activity planning.
4. Safety analysis on hazard activities by assessing the probability of risk in workspace area on construction sites through the assistant of the visualization of the site walks in the developed 3D model.
5. Converting a traditional safety planning into more interactive 3D safety plan in construction site.
6. To facilitates safety professionals to visualize spatial and physical information of construction activities.
7. To allow safety officers further utilize it into the safety promotion, safety training and other related programs that can increase the participation of the workforce in safety dimension.
8. Provide effective communication and information flow with a clear visual object and process in the BIM.
APPENDIX E - Samples of Safety Plan from Local Main Contractors

1. Government Building Project
2. Private Building Project
3. Civil Works