CAUSATIVE FACTORS OF CONSTRUCTION AND DEMOLITION WASTE GENERATION IN IRAQ CONSTRUCTION INDUSTRY

MAYTHAM KADHIM OBAID

A thesis submitted in
fulfilment of the requirement for the award of the
Doctor of Philosophy in Civil Engineering

Faculty of Civil Engineering and Built Environment
Universiti Tun Hussein Onn Malaysia

OCTOBER 2021
DEDICATION

To the soul of my demised wife and also, to my lovely daughters, Ban and Huda.
ACKNOWLEDGEMENT

First of all, I am much more thankful for ALLAH SWT, for his special blessings over me. Even if I spend my whole life thanking his blessings, it is still very little effort to be thankful for his blessings. All my achievements thus far only because of him. Then, I would like to illustrate my heartfelt gratefulness to all those who have contributed to completing this project. I would like to express my gratitude to UTHM for giving me such a prestigious opportunity to take my Ph.D., which is an important step in my professional career and one of my UTHM.

In particular, I am thankful to my supervisor, Prof. Dr. Hj. Ismail Abdul Rahman and Dr. Sasitharan Nagapan, for their trust in me. And I am also thankful for their social, technical encouragement and guidance, and recommendations. Supervision by my supervisors, their care, and their support and comfort always encourage me to produce a supreme output. Without their continuous interest and motivation, this study would not have been the same as presented here.

The most important acknowledgment is that I am thankful to my beloved wife and siblings, who always support me to do higher education at a crucial time (when they needed my support). I don’t know how I can show gratitude for their sacrifices, in their lives for me. Last but not least; I am thankful to my friends, for their positive attitude, support, and encouragement.
ABSTRACT

The construction industry has hurt the environment from the waste generated during construction activities. Thus, it calls for serious measures to determine the causative factors of construction waste generated. There are limited studies on factors causing construction, and demolition (C&D) waste generation, and these limited studies only focused on the quantification of construction waste. This study took the opportunity to identify the causative factors for the C&D waste generation and also to determine the risk level of each causal factor, and the most important minimization methods to avoiding generating waste. This study was carried out based on the quantitative approach. A total of 39 factors that causes construction waste generation that has been identified from the literature review were considered which were then clustered into 4 groups. Improved questionnaire surveys by 38 construction experts (consultants, contractors and clients) during the pilot study. The actual survey was conducted with a total of 380 questionnaires, received with a response rate of 83.3%. Data analysis was performed using SPSS software. Ranking analysis using the mean score approach found the five most significant causative factors which are poor site management, poor planning, lack of experience, rework and poor controlling. The result also indicated that the majority of the identified factors having a high-risk level, in addition, the better minimization method is environmental awareness. A structural model was developed based on the 4 groups of causative factors using the Partial Least Squared-Structural Equation Modelling (PLS-SEM) technique. It was found that the model fits due to the goodness of fit (GOF ≥ 0.36= 0.658, substantial). Based on the outcome of this study, 39 factors were relevant to the generation of construction and demolition waste in Iraq. These groups of factors should be avoided during construction works to reduce the waste generated. The findings of this study are helpful to authorities and stakeholders in formulating laws and regulations. Furthermore, it provides opportunities for future researchers to conduct additional research’s on the factors that contribute to construction waste generation.
ABSTRAK

CONTENTS

STATUS CONFIRMATION i
DECLARATION ii
DEDICATION iii
ACKNOWLEDGEMENT iv
ABSTRACT v
ABSTRAK vi
TABLE OF CONTENT vii
LIST OF TABLES xiv
LIST OF FIGURES xvi
LIST OF FORMULAE xviii
LIST OF SYMBOLS AND ABBREVIATIONS xix
LIST OF APPENDIXES xx

CHAPTER 1 INTRODUCTION 1
1.1 Research background 1
1.2 Problem statement 6
1.3 Research questions 7
1.4 Objectives of the study 8
1.5 Scope of work 8
1.6 Thesis organization 8

CHAPTER 2 INTRODUCTION 10
2.1 Construction Industry in Iraq 10
2.2 Category of C&D waste 12
2.2.1 Non-physical waste 12
2.2.2 Physical waste 13
2.3 Amount of waste generated in Iraq 14
<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.3.1</td>
<td>Amount of solid waste</td>
<td>16</td>
</tr>
<tr>
<td>2.3.2</td>
<td>Amount of C&amp;D waste</td>
<td>19</td>
</tr>
<tr>
<td>2.4</td>
<td>Issues on construction waste in Iraq</td>
<td>20</td>
</tr>
<tr>
<td>2.5</td>
<td>Groups factors of C&amp;D waste generation</td>
<td>23</td>
</tr>
<tr>
<td>2.6</td>
<td>Causative factors of C&amp;D waste generation</td>
<td>25</td>
</tr>
<tr>
<td>2.6.1</td>
<td>Design factors</td>
<td>25</td>
</tr>
<tr>
<td>2.6.1.1</td>
<td>Frequent design changes</td>
<td>26</td>
</tr>
<tr>
<td>2.6.1.2</td>
<td>Design error</td>
<td>26</td>
</tr>
<tr>
<td>2.6.1.3</td>
<td>Poor design quality</td>
<td>27</td>
</tr>
<tr>
<td>2.6.1.4</td>
<td>Error in contract documentation</td>
<td>27</td>
</tr>
<tr>
<td>2.6.1.5</td>
<td>Lack of design information</td>
<td>27</td>
</tr>
<tr>
<td>2.6.1.6</td>
<td>Inexperience designer</td>
<td>28</td>
</tr>
<tr>
<td>2.6.1.7</td>
<td>Incomplete contract document</td>
<td>28</td>
</tr>
<tr>
<td>2.6.1.8</td>
<td>Slow drawing distribution</td>
<td>29</td>
</tr>
<tr>
<td>2.6.1.9</td>
<td>Mistake in quantity</td>
<td>29</td>
</tr>
<tr>
<td>2.6.1.10</td>
<td>Complicated design</td>
<td>29</td>
</tr>
<tr>
<td>2.6.2</td>
<td>Workers, material and equipment factors</td>
<td>30</td>
</tr>
<tr>
<td>2.6.2.1</td>
<td>Workers mistakes</td>
<td>30</td>
</tr>
<tr>
<td>2.6.2.2</td>
<td>Poor workmanship</td>
<td>31</td>
</tr>
<tr>
<td>2.6.2.3</td>
<td>Incompetent worker</td>
<td>31</td>
</tr>
<tr>
<td>2.6.2.4</td>
<td>Poor quality of materials</td>
<td>31</td>
</tr>
<tr>
<td>2.6.2.5</td>
<td>Shortage of skilled workers</td>
<td>32</td>
</tr>
<tr>
<td>2.6.2.6</td>
<td>Damage caused by workers</td>
<td>32</td>
</tr>
<tr>
<td>2.6.2.7</td>
<td>Poor material handling</td>
<td>32</td>
</tr>
<tr>
<td>2.6.2.8</td>
<td>Too much overtime worker</td>
<td>33</td>
</tr>
<tr>
<td>2.6.2.9</td>
<td>Inappropriate use of materials</td>
<td>33</td>
</tr>
<tr>
<td>2.6.2.10</td>
<td>Equipment failure</td>
<td>33</td>
</tr>
<tr>
<td>2.6.3</td>
<td>Management factors</td>
<td>34</td>
</tr>
<tr>
<td>2.6.3.1</td>
<td>Poor planning</td>
<td>34</td>
</tr>
<tr>
<td>2.6.3.2</td>
<td>Poor supervision</td>
<td>35</td>
</tr>
<tr>
<td>2.6.3.3</td>
<td>Poor controlling</td>
<td>35</td>
</tr>
<tr>
<td>2.6.3.4</td>
<td>Lack of experience</td>
<td>35</td>
</tr>
<tr>
<td>2.6.3.5</td>
<td>Poor site management</td>
<td>36</td>
</tr>
<tr>
<td>2.6.3.6</td>
<td>Communication problems</td>
<td>36</td>
</tr>
</tbody>
</table>
2.6.3.7 Rework 36
2.6.3.8 Lack of waste management plans 36

2.6.4 External factors 37
2.6.4.1 Effect of weather 37
2.6.4.2 Damage caused by third parties 38
2.6.4.3 Wars 38
2.6.4.4 Error in shopping 39
2.6.4.5 Accidents 39
2.6.4.6 Waiting periods 39
2.6.4.7 Pilferage 40
2.6.4.8 Festival celebration 40
2.6.4.9 Lack of legislative enforcement 40
2.6.4.10 Damage during transportation 40
2.6.4.11 Vandalism 41

2.6.5 Risk of causative factors 41

2.7 Effect factors of construction waste 42
2.7.1 Environment 42
2.7.2 Economy 43
2.7.3 Social 43

2.8 Minimization method of construction waste 44
2.8.1 Technology 44
2.8.1.1 Building information modeling 44
2.8.1.2 Automation 45
2.8.1.3 Industrialized building system (IBS) 45
2.8.1.4 Green products & processes 46
2.8.1.5 Advanced technology 46

2.8.2 Management 47
2.8.2.1 Lean construction approach 47
2.8.2.2 Just on time technique 47
2.8.2.3 Waste management 48
2.8.2.4 Improve design and procurement 48
2.8.2.5 Policy and regulation 49
2.8.2.6 Environmental awareness 49
2.8.2.7 Training and information 49
2.9 Theory of structural equation modeling 50
2.10 Importance of development of structural relationship of causative factors. 52
2.11 Summary 52

CHAPTER 3 INTRODUCTION 54
3.1 Introduction 54
3.2 Research plan 54
  3.2.1 Literature review 56
  3.2.2 Questionnaire design 57
  3.2.3 Measurement scales 58
3.3 Questionnaire design 58
  3.3.1 Pilot study 59
  3.3.2 Analysis of pilot study 59
  3.3.3 Sampling technique 61
  3.3.4 Sample size 61
  3.3.5 Actual survey 62
  3.3.6 Reliability test 62
  3.3.7 Descriptive analysis 63
  3.3.8 Risk assessment 63
3.4 Partial Least Squares Structural Equation Modelling technique 64
  3.4.1 Why PLS-SEM? 66
3.5 Execute modelling process 68
  3.5.1 Assessment of measurement model 68
  3.5.2 Assessment of structural model 69
  3.5.3 Goodness-of-fit (GoF) 71
  3.5.4 Practitioners’ verification 72
3.6 Summary 74

CHAPTER 4 INTRODUCTION 75
4.1 Introduction 75
4.2 Results of pilot study 75
  4.2.1 Demography of respondents 75
CHAPTER 5 INTRODUCTION 101

5.1 Introduction 101

5.2 Development of a hypothetical model 101

5.2.1 Input data 102

5.2.2 Assign manifest to latent variable 103

5.2.3 Execute modelling process 105

5.3 Assessment of measurement model 106

5.3.1 Individual item reliability 106
5.3.2 Convergent validity 108
5.3.3 Discriminant validity of the measurement model 109
  5.3.3.1 Cross-loading 109
  5.3.3.2 Fornell & Larcker Criterion 110
5.3.4 Overall performance of measurement model 112
5.4 Assessment of structural model 113
  5.4.1 Hypothesis testing 114
  5.4.2 Coefficient of determination (R²) 115
  5.4.3 Effect size (f²) approach 116
  5.4.4 Predictive relevancy (q²) 118
  5.4.5 Overall performance of structural model 119
  5.4.6 Goodness-of-fit (GoF) 121
5.5 Expert opinion validation 122
5.6 Summary 126

CHAPTER 6 INTRODUCTION 128
  6.1 Introduction 128
  6.2 Conclusion of the results 128
    6.2.1 Objective 1: Identify the C&D waste generation causative factors. 128
    6.2.2 Objective 2: Determine the risk level of each C&D waste generation causative factor 130
    6.2.3 Objective 3: Evaluate the minimization methods of C&D waste generation. 131
    6.2.4 Objective 4: Develop structural Model of causative factors of C&D waste generation 133
  6.3 Limitation of the study 133
  6.4 Contribution to industry 133
  6.5 Recommendations for future research 134

REFERENCES 135
APPENDICES 159
PUBLICATIONS 176
VITA 177
LIST OF TABLES

2.1 Examples of non-physical waste 13
2.2 Percentage of construction and demolition waste of areas and districts in Basra 15
2.3 Shows the amount of construction waste for Iraq 16
2.4 Discharged waste of Iraqi cities, 2015 17
2.5 Amount of recorded waste discharged from Iraqi cities 18
2.6 Percentage of C&D waste over the total solid waste 19
2.7 Issues of construction waste in Iraq 22
2.8 Proposed groups of factors by previous researchers 24
2.9 Factors in design group 25
2.10 Workers material and equipment factors 30
2.11 Management group factors 34
2.12 External group factors 37
2.13 Environment group 42
2.14 Economy group 43
2.15 Social group 44
2.16 PLS-SEM and CB-SEM 51
3.1 Significant Scale’s level 58
3.2 Cut-off point method 60
3.3 Indices for measurement model analysis using PLS-SEM 68
3.4 Indices for Structural Model Analysis using PLS-SEM 70
3.5 Profile of experts 73
4.1 Practitioners demography 76
4.2 Cronbach's alpha for pilot study 79
4.3 Design-related causative factors 80
4.4 External-related causative factors 80
4.5 Management-related causative factors 81
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.6</td>
<td>Workers material and equipment-related causative factors</td>
<td>81</td>
</tr>
<tr>
<td>4.7</td>
<td>Result of technology and management (M1, M2) groups</td>
<td>82</td>
</tr>
<tr>
<td>4.8</td>
<td>Results of reliability test (causative factors)</td>
<td>86</td>
</tr>
<tr>
<td>4.9</td>
<td>Results of reliability test (Minimization methods)</td>
<td>86</td>
</tr>
<tr>
<td>4.10</td>
<td>Ranking of causative factors [occurrence]</td>
<td>88</td>
</tr>
<tr>
<td>4.11</td>
<td>Ranking of causative factors [severity]</td>
<td>89</td>
</tr>
<tr>
<td>4.12</td>
<td>Risk level for design group factors</td>
<td>90</td>
</tr>
<tr>
<td>4.13</td>
<td>Risk level for management group factors</td>
<td>91</td>
</tr>
<tr>
<td>4.14</td>
<td>Risk level for worker’s material and equipment factors</td>
<td>93</td>
</tr>
<tr>
<td>4.15</td>
<td>Risk level for external group factors</td>
<td>94</td>
</tr>
<tr>
<td>4.16</td>
<td>Rank of effectiveness of the minimization methods</td>
<td>96</td>
</tr>
<tr>
<td>5.1(a)</td>
<td>Causative factors in [DESN] and [EXT] groups</td>
<td>104</td>
</tr>
<tr>
<td>5.1(b)</td>
<td>Factors in [MGMT] group are as follows</td>
<td>105</td>
</tr>
<tr>
<td>5.1(c)</td>
<td>Minimization methods of construction waste generation</td>
<td>105</td>
</tr>
<tr>
<td>5.2</td>
<td>Deleted items at each iteration</td>
<td>107</td>
</tr>
<tr>
<td>5.3</td>
<td>Convergent validity</td>
<td>108</td>
</tr>
<tr>
<td>5.4</td>
<td>Cross loading analysis</td>
<td>110</td>
</tr>
<tr>
<td>5.5</td>
<td>Latent variable correlation</td>
<td>111</td>
</tr>
<tr>
<td>5.6</td>
<td>Overall performance of measurement model</td>
<td>112</td>
</tr>
<tr>
<td>5.7</td>
<td>Results of a hypothesis test</td>
<td>115</td>
</tr>
<tr>
<td>5.8</td>
<td>Result of model’s coefficient of determination</td>
<td>116</td>
</tr>
<tr>
<td>5.9</td>
<td>Evaluation of effect size of the constructed model</td>
<td>117</td>
</tr>
<tr>
<td>5.10</td>
<td>Result of effect size (f2) evaluation</td>
<td>117</td>
</tr>
<tr>
<td>5.11</td>
<td>Q2 Value for predictive relevancy</td>
<td>119</td>
</tr>
<tr>
<td>5.12</td>
<td>Overall performance of structural model</td>
<td>120</td>
</tr>
<tr>
<td>5.13</td>
<td>Evaluation of GoF value</td>
<td>121</td>
</tr>
<tr>
<td>5.14</td>
<td>Profile of experts</td>
<td>122</td>
</tr>
<tr>
<td>5.15</td>
<td>Frequency results for experts opinion validation</td>
<td>124</td>
</tr>
<tr>
<td>6.1</td>
<td>Rank of effectiveness of the minimization methods</td>
<td>131</td>
</tr>
</tbody>
</table>
LIST OF FIGURES

1.1 C&D waste generation in Iraq (Babylon city) 2
1.2 Shows the amount of C&D waste in governorates of Iraq 3
2.1 Construction sector growth trend in Iraq 10
2.2 Construction waste classification 12
2.3 Physical construction waste generation in Babylon town 14
2.4 Percentage of waste generated by all Iraq cities excluding Baghdad 15
2.5 Percentage of C&D compared to the total waste of each governorate in Iraq for 2015 20
2.6 Percentage of C&D compared to the total of each governorate in Iraq for 2016 24
2.7 Construction and demolition waste from the war in Iraq (Ninewa city) 38
2.8 PLS-SEM path model 50
3.1 Flowchart of research methodology 55
3.2 Risk matrix 64
3.3 Steps of model development in PLS-SEM model 65
3.4 Assessment steps of structural model 69
3.5 Image of experts through the questionnaire 74
4.1 Qualification of participating in the study 77
4.2 Respondents with construction experience 77
4.3 Type of organization 83
4.4 Experience of respondents involved in the actual study 84
4.5 Shows the summary of the respondent’s qualification 85
4.6 Location of the risk level of design group factors 91
4.7 Location of the risk level of management group factors 92
4.8 Location of the risk level of workers, material and
equipment group 94

4.9  Location of the risk level of external group factors 95

5.1  Hypothetic model 102

5.2  Creating the project worksheet in Smart PLS (Data input) 103

5.3  Assign manifest screenshot of smart PLS 104

5.4  First iteration 106

5.5  Final model 108

5.6  Final structural of model 113

5.7  Result of bootstrapping 114

6.1  Risk level of the causative factors 130
LIST OF FORMULAE

(3.1) 60
(3.2) 61
(3.3) 71
(5.1) 116
(5.2) 118
(5.3) 121
LIST OF SYMBOLS AND ABBREVIATIONS

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C&amp;D</td>
<td>Construction and demolition wastes</td>
<td></td>
</tr>
<tr>
<td>GDP</td>
<td>Gross domestic product</td>
<td></td>
</tr>
<tr>
<td>USEPA</td>
<td>United state environmental protection agency</td>
<td></td>
</tr>
<tr>
<td>OSC</td>
<td>Off-site construction</td>
<td></td>
</tr>
<tr>
<td>PLS-SEM</td>
<td>Partial least squares structural equation modeling</td>
<td></td>
</tr>
<tr>
<td>IBS</td>
<td>Industrial building systems</td>
<td></td>
</tr>
<tr>
<td>BIM</td>
<td>Building industrial management</td>
<td></td>
</tr>
<tr>
<td>MMC</td>
<td>Modern method of construction</td>
<td></td>
</tr>
<tr>
<td>OSM</td>
<td>Off-site manufacturing</td>
<td></td>
</tr>
<tr>
<td>OSP</td>
<td>Off-site production</td>
<td></td>
</tr>
<tr>
<td>GOF</td>
<td>Goodness of fit</td>
<td></td>
</tr>
</tbody>
</table>
## LIST OF APPENDICES

<table>
<thead>
<tr>
<th>APPENDIX</th>
<th>TITLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Section A: Respondents details</td>
<td>159</td>
</tr>
<tr>
<td>B</td>
<td>Section A: Respondents details</td>
<td>165</td>
</tr>
<tr>
<td>C</td>
<td>Section B: Model validation.</td>
<td>170</td>
</tr>
<tr>
<td>D</td>
<td>Example of CVS. file format used in pls-sem analysis</td>
<td>175</td>
</tr>
</tbody>
</table>
CHAPTER 1

INTRODUCTION

1.1 Research background

Construction is an imperative industry that plays a vital role in the socio-economic growth of a country. It provides the necessary infrastructure and physical structure for activities such as commerce, services, and utilities. Besides that, it also generates employment opportunities and enhances the nation’s economy by creating foreign and local investment opportunities (Low & Ong 2014; Asgari, et al., 2017).

It has long been proven that the construction sector is one of most important most successful industries globally and remains so with the continuation of the development process, especially in developing countries. Despite this success, industry produces significant quantities of waste known as construction and demolition (C&D) waste, which is a major challenge in some countries, because treatment of this waste is costly. A vast amount of C&D waste is detrimental to the environment, social well-being and economy of a country if it is poorly handled (Saadi, et al., 2016; Husnain et al., 2017; Meng et al., 2018). According to “Global Waste Management Outlook” prepared by United Nations Environmental Programme (UNEP), and “International Solid Waste Association (ISWA)”, construction waste generated by areas such as construction industry, and other industries makes up seven to ten billion tons of waste annually. Almost 85% of waste generated worldwide is disposed to landfills and level of waste re-use and recycling of waste is critically low (UNEP, 2015). A significant amount of industrial waste is created by the construction industry, which is generally categorized as construction & demolition waste C&D,
which has become a concern of governments and, consequently of construction companies (Jin et al., 2019; Ferronato et al., 2019).

Construction industry is estimated to be accountable for using around two-fifths of the world’s energy and materials flow, one-sixth of fresh water reserves and one-quarter of global wood harvest (Thongkamsuk et al., 2017), while contributing to 13–30% to total waste generated worldwide (Giannis et al., 2017). The exact figures regarding the share of C&D waste in total solid waste (SW) stream can be very high and also vary significantly among different countries, for example, in Europe, 25-30% in 2016 (EC Waste, 2019); in Hong Kong, 23% in 2014 (EPD Statistics Unit, 2015); in the United Arab Emirates, 80% in 2010 (Rogers, 2011); and, in Singapore, 59% in 2011 (Giannis et al., 2017). The high speed of urbanization entails the increased demand for housing and transportation; therefore, the volume of C&D waste continues its increase (Mistri, 2015). Figure 1.1 shows the huge amount of C&D waste in Iraq generated by construction activities.

Unfortunately, in Iraq, the share of C&D waste in total solid waste (SW) is inaccurate and unavailable, in the majority of years, and also varies widely across cities; For instance, in 2005 it was 1,111,788 tons/year (Abdul-Amir, 2014), in 2013 it was 11,315,000 tons/year Mustafa et al., (2017), at 2014 the amount of waste decrease to
8,272,0 tons/year, in 2015 it was 14,349,428 tons/year. According to the Central Statistical Organization-Iraq (Iraqi ministry of planning), the waste of C&D in 2016 was 14,545,692 tons/year Central Statistical Organization - Iraq (2017), in 2017 it is 15,138,812 tons/year Central Statistical Organization - Iraq (2018), in 2018 it was 16,841,963 tons/year Central Statistical Organization - Iraq (2019), except for three governorates which are Nineveh, Anbar, and Salah al-Din out of control from 2014 to 2018. Figure 1.2 shows the amount of C&D for governorates of Iraq.

**Figure 1.2.** Shows the amount of C&D waste in governorates of Iraq

Reference to Figure 1.2 shows the amount of construction waste from the governorates of Iraq from 2013 to 2018, with the exception of the three governors of Nineveh, Anbar, and Salah al-Din. This amount of waste is a result due to increased demand for housing development, Iraq reconstruction plan, commercial buildings, and infrastructure improvement. The aim of the table was to estimate the huge amount of construction debris generated in Iraqi cities that need to be addressed.

Referring to waste generated in the process of dismantling, repair, and/or construction of buildings, the conventional preferred way of C&D waste management in most countries is disposal to designated landfills. It should be noted that the disposal to landfill is associated with costs, the largest and most visible ones being transportation costs and landfill tipping fees (Khandelwal et al., 2018) for example, the collection and sanitary landfill disposal costs for lower-mid income countries (such as Iraq) being in the range of 15–40 USD, while for high-income countries being in the range of 85–250 USD (Jia et al., 2018).

Various concerns on environmental pollution and rapid depletion of natural resources as well as sustainability programs being implemented have urged many other
countries to set aside the approach of landfill disposal and rather consider alternative ways for more efficient waste management such as: applying life cycle assessment to municipal solid waste management especially in European and some Asian countries for waste disposal reduction (Khandelwal et al., 2018), reducing illegal waste via C&D models using system dynamics and grey model theory (Jia et al., 2018), and mixing inorganic construction wastes containing CaO (e.g., waste gypsum) to Portland cement in appropriate proportions to promote recycling and thus to reduce disposal (Kim et al., 2018). On the contrary, companies are seeking more efficient ways of waste management most often in terms of economical sustainability more than in their urban environments (UNEP, 2017).

Among middle east countries, construction industry has been experiencing rapid growth in Iraq since 2003. Construction sector has been one of driver of economic growth in Iraq, while the research that has been carried out in the area of industrial and municipal construction waste management practices in Iraq is quite limited and a few published research related to C&D waste generation could have been found (Abdulameer, 2014; Khaleel et al., 2018). Environmental Code of Republic of Iraq is the main directive that regulate the waste management including construction and demolition waste management (Al-ageeli et al., 2016). Besides, issued in 2006 by “Ministry of Health and Environment”, Program of Modernization of Municipal Solid Waste Management aiming at improving management and control of municipal solid waste system also deals with the issues, management and regulations linked to the country-wide construction waste management practices (Khaleel et al., 2018).

Although the primary focus is on addressing the damage to the environment caused by these streams of waste, this represents significant economic losses. In this context, the effective management of these wastes in order to reduce their environmental and economic impacts is one of the most important issues of the twenty-first century. This is because the most beneficial, most economical, and most environmentally sustainable approach within the waste management hierarchy is to prevent/minimize waste Nikmehr et al., (2017). Consuming natural resources and increasing waste production require solutions to protect the quality of the natural and built environments. For these solutions to be effective waste management methods must be developed to prevent economic and environmental losses, it is important to prevent/reduce construction waste in the construction industry. To achieve this target, various site management strategies have been developed throughout the world. there
are several methods used to reduce waste generation such as BIM, IBS, policy and regulation, environmental awareness, training and information, construction waste management approach, etc. in managing construction waste. Although it is a completely new approach, it is gradually gaining recognition among construction professionals.

The industrialized building system (IBS) is one in which all building components, such as walls, slabs, beams, columns, and staircases, are mass-produced in a factory or on the job site under strict quality control and with minimal waste. As early as the 1960s, industrialized building systems (IBS) were introduced into the construction industry Nikmehr et al., (2017). Our construction industry is facing challenges due to a shortage of skilled labor and the high cost of construction. As a result, the concept of construction using IBS is proposed in order to reduce our reliance on intensive labor work and construction waste generation. Therefore, this study aims to identifying causative factors and minimization methods to reducing/preventing construction waste in construction activities (Amu & Adesanya, 2016).

BIM technology is a technological development that can be very useful in construction waste management. However, BIM is an emerging technology. It is envisaged that the construction waste that is generated consciously and/or unconsciously during the construction process can be minimized by the possibilities of technology. At this point, it is thought that BIM technology, which can create the whole project on a digital interface, can be utilized with a systemic approach. One of the dynamic sectors where technological developments are put into practice as quickly as possible is undoubtedly the construction sector, although it is still slow compared to some sectors where industrialized production is carried out. The results of the race to follow innovations in order to make a difference in the competitive conditions of the world are followed with interest in architecture and the construction world Akinade et al., (2018). BIM is one of the technological developments that has been increasingly seen in recent years in the acceleration of adoption by construction project stakeholders, which are closely related to the construction industry. As the most comprehensive of the existing conditions, BIM can be thought of as a new project management concept that allows all participants to stimulate and share data on a single model (Hasmori et al., 2020).
REFERENCES


Malaysian Technical Universities Conference on Engineering and Technology (MUCET). Pahang, Malaysia.


sustainable Construction Industry in Developing Countries, South Africa, 41(2), 305-315.


Randell, P. Pickin, J. Grant, B. (2014). Waste generation and resource recovery in Australia, Australian Government Department of Sustainability, Environment, Water, Population and Communities and Blue Environment Pty Ltd, Melbourne,


