

**THE DEVELOPMENT OF GREEN CONSTRUCTION SITE INDEX**

**FERRY FIRMAWAN**

**UNIVERSITI TEKNOLOGI MALAYSIA**

THE DEVELOPMENT OF GREEN CONSTRUCTION SITE INDEX

FERRY FIRMAWAN

A thesis submitted in fulfilment of the  
requirements for the award of the degree of  
Doctor of Philosophy (Civil Engineering)

Faculty of Civil Engineering  
Universiti Teknologi Malaysia

APRIL 2016

Special Dedication  
for My Professor, My Supervisor and My Father

Prof. Dr. Hj. Fadil Othman, Dr. Khairulzan Yahya and Ir. H. Sumantri

who has accompanied my heart and mind during my journey of life, especially my arrangement of this thesis. I have learned the meanings of life until reached my dreams. With my sincerity, thank you for the guidance, assistance and everything.

You are my impeccable hero.

## ACKNOWLEDGEMENT

Thank You for Lord's blessing in helping me to complete this sustainable struggle study.

In preparing this thesis, I was in contact with many people, researchers, academicians and practitioners. They have contributed towards my understanding and thoughts.

In particular, I wish to express my sincere appreciation to my thesis supervisor, Dr. Khairulzan Yahya, for encouragement, guidance, critics and friendship. I am also very thankful to my ex-supervisor Professor Dr. Hj. Fadil Othman for their guidance, advices and motivation. I would like to present my special appreciation and gratitude for DR. H.M. Rofiq Anwar who has given me the opportunity to take my PhD study during his periode Rector of Univesitas Islam Sultan Agung (Unissula) Semarang-Indonesia, which has given me the opportunity. Without their continued support and interest, this thesis would not have been the same as presented here.

I am grateful to all my family members, My Father; Ir. H. Sumantri, My Mother; R. A. Hj. Azminawati, My lovely soulmate: Retno Pujiyanti, Akbar, Aulia, Aurel and Surau Akbar's member.

My fellow postgraduate students, Pak Qomar, Pak Imam and Pak Arief should also be recognized for their support.

My sincere appreciation also extends to all my colleagues: Dato' Ismail Muhammad, Uda Suherman Saleh, Kakanda Edward Sofiananda, Bang Wawan Syakir Darmawan MS, Adinda Sumardany, Mas Johan Rochayat, Pak Kuscahyo Prayogo, Add Yuan Syahputra, Add Ali Subkan, Add Muh Ary Anshory Hadi and others who have provided assistance at various occasions. Their views and tips are useful indeed. Unfortunately, it is not possible to list all of them in this limited space.

## ABSTRACT

The development of construction industry in Indonesia has been substantially contributing to the enhancement of social and economy of the country. However, its expansion may also give negative effects to the environment if the practices of implementing the construction project neglected the rules and regulations of sustainable construction concept. The aim of this study is to develop Green Construction Site Index (GCSI) with the consideration of assessing the staff commitment level on the implementation of the sustainable construction practices. Therefore, Project Organizational Commitment Index (POCI) is also developed. Data were collected by on site direct observation, distribution of questionnaire and interview with key personnel and project documentation review. All the data were tabulated and analyzed by using descriptive elaboration method. The development of GCSI and POCI was based on the opinion and validation of selective experts in the importance of sustainable elements in construction by using Average Index Analysis. Evaluations of GCSI and POCI have been conducted toward ten selected construction projects in Indonesia. The findings have revealed that the overall GCSI value of all ten construction projects was 3.39 which indicated that level of sustainability was in a good category. Meanwhile, the POCI value of all the projects was 3.31 showing that the commitment level of staffs in implementing the sustainable construction project practices was also in a good category. The result shows and proves that the establishment of GCSI and POCI were able to be used to assess level of sustainability construction project in the perspective of project progress and level of staff commitment. It shows that the capability of GCSI and POCI in assessing level of sustainability construction project, based on sustainability concept of construction project. In conclusions, GCSI and POCI are beneficial and suitable to be used in measuring level of sustainability in construction project by respective construction stakeholders like government bodies, local authorities and contractor.

## ABSTRAK

Pembangunan industri pembinaan di Indonesia telah memberi sumbangan yang besar kepada peningkatan sosial dan ekonomi negara. Walau bagaimanapun, kemajuan ini juga boleh menyebabkan terjadinya kesan-kesan negatif pada alam sekitar, jika terdapatnya amalan-amalan projek pembinaan yang tidak mematuhi peraturan dan undang-undang berkenaan konsep kelestarian dalam pembinaan. Matlamat kajian ini adalah untuk membangun *Green Construction Site index* (GCSI) dengan mengambil kira tahap komitmen kakitangan terhadap pelaksanaan projek pembinaan secara lestari yang diukur menggunakan *Project Organizational Commitment Index* (POCI) yang turut dibangunkan dalam kajian. Pengumpulan data dan maklumat telah dijalankan dengan beberapa cara termasuklah kaedah pemantauan di tapak bina, kajiselidik dan temubual pemain utama industri serta penelitian dokumentasi projek. Data-data yang diperolehi telah dianalisis menggunakan kaedah penghuraian deskriptif. Selanjutnya pembangunan GCSI dan POCI dibuat menggunakan kaedah Index Purata (Average Index) berdasarkan pendapat dan validasi pakar-pakar yang dipilih bidang pembinaan. Bagi tujuan penelitian GCSI dan POCI yang dibangunkan, sepuluh projek pembinaan di Indonesia telah dipilih untuk dianalisis tahap kelestarian projek pembinaan tersebut. Hasil kajian menunjukkan bahawa nilai keseluruhan GCSI bagi kesemua sepuluh projek yang dinilai adalah 3.39. Ini menunjukkan tahap kelestarian keseluruhan projek adalah dalam kategori yang baik. Sementara itu, nilai POCI pula didapati sebanyak 3.31, yaitu menunjukkan tahap komitmen pekerja-pekerja ke arah pelaksanaan projek pembinaan secara lestari adalah juga dalam kategori yang baik. Keputusan menunjukkan bahawa kedua-dua GCSI dan POCI boleh digunakan untuk menilai aktiviti-aktiviti kelestarian projek pembinaan dari perspektif prestasi projek dan komitmen pekerja. GCSI dan POCI terbukti mampu menilai tahap kelestarian sesuatu projek pembinaan berdasarkan konsep kelestarian projek pembinaan. Kesimpulannya, GCSI dan POCI amat bermanfaat dan sesuai dijadikan sebagai alat pengukur tahap kelestarian projek pembinaan bagi pihak-pihak berkaitan seperti badan-badan kerajaan, pihak berkuasa tempatan dan kontraktor.

## TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	<b>DECLARATION</b>	i
	<b>DEDICATION</b>	ii
	<b>ACKNOWLEDGEMENTS</b>	iii
	<b>ABSTRACT</b>	iv
	<b>ABSTRAK</b>	v
	<b>TABLE OF CONTENTS</b>	vi
	<b>LIST OF TABLES</b>	xi
	<b>LIST OF FIGURES</b>	xiv
	<b>LIST OF EQUATION</b>	xv
<b>1</b>	<b>INTRODUCTION</b>	<b>1</b>
	1.1 Background	1
	1.2 Problem Statement	4
	1.3 Research Aim and Objectives	5
	1.4 The Scope of Research	6
	1.5 Research Outputs	7
<b>2</b>	<b>LITERATURE REVIEW</b>	<b>9</b>
	2.1 Introduction	9

2.2	Definition of Construction Waste	11
2.3	Construction Waste Generation and Characteristics	12
2.4	Classification of C and D Waste	13
2.5	Overview of Assessment Tools	15
2.5.1	Leadership in Energy and Environmental Design (LEED/USA)	16
2.5.2	High Performance Building Guideline (HPBG/New York)	17
2.5.3	Guide to Green Construction Practice (GGCP/Hong Kong)	18
2.5.4	Building Research Establishment Environmental Assessment Method (BREEAM/UK)	19
2.5.5	Hong Kong Building Research Establishment Environmental Assessment Method (HK-BEAM/Hong Kong)	20
2.5.6	Waste Management Factors (WMF/Malaysia)	20
2.5.7	Environmental Performance Assessment – Environmental Operational Indicators (EPA-EOIs/Hong Kong & Australia)	21
2.5.8	Building Waste Assessment Scores (BWAS/Singapore)	22
2.5.9	Waste Management Performance Evaluation Tools (WMPET/Korea )	23
2.5.10	Construction Industry Development Board (CIDB/Malaysia) & Waste Management Performance (WMP/Malaysia)	25
2.5.11	Green Construction Factor (GCF/Glavinich and Kibert)	26
2.5.12	Firmawan, Arief & Egbu, Marta, Legget, Dorran, Tolba El Kholi and Wooley.	27
2.6	Green Construction Concept	28



2.6.1	Waste Minimization	28
2.6.2	Sustainable Green Construction	35
2.6.3	Material Handling Management	36
2.6.4	Construction Waste Management	38
2.6.5	Construction Site Performance	41
2.7	Overview of Construction Issues in Indonesia	42
2.8	Classification of Building Construction	48
2.9	Summary	48
<b>3</b>	<b>METHODOLOGY</b>	<b>50</b>
3.1	Introduction	52
3.2	Phase I: Concept Development	52
3.3	Phase II: Tool Development	53
3.3.1	Stage 1: Tool Construction	56
3.3.2	Stage 2: Tool Performance Assessment	62
3.4	Phase III: Recommendation Development	65
<b>4</b>	<b>RESULT AND DISCUSSION OF THE GREEN CONSTRUCTION SITE INDEX</b>	<b>66</b>
4.1.	Introduction	66
4.2	Tool Construction	68
4.3	Tool Performance Assessment	72
4.3.1	Efficiency	73
4.3.1.1	Waste Minimization	76
4.3.1.2	Sustainable Green Construction	77
4.4	Productivity	79
4.4.1	Material Handling Management	81

4.5	Awareness	83
4.5.1	Construction Waste Management	85
4.5.2	Construction Site Performance	88
4.6	The Green Construction Site Index	90
4.7	Summary	93
<b>5</b>	<b>RESULT AND DISCUSSION OF THE PROJECT</b>	
	<b>ORGANIZATIONAL COMMITMENT INDEX (POCI)</b>	<b>95</b>
5.1.	Efficiency	101
5.2.	Productivity	107
5.3.	Awareness	107
5.4	Summary	110
<b>6</b>	<b>CONCLUSION &amp; RECOMENDATION</b>	<b>112</b>
6.1.	Conclusion	112
6.2.	Recommendation	113
6.2.1.	For Contractor	103
6.2.2.	For Authorities	114
	<b>REFERENCES</b>	<b>115</b>
	Appendices A – H	126 -181

## LIST OF TABLES

TABLE NO.	TITLE	PAGE
2.1	The Factors taken from LEED	16
2.2	The Factors taken from HPBG (New York)	17
2.3	The Factors taken from GGCP (Hong Kong)	18
2.4	The Factors taken from BREEAM	19
2.5	The Factors taken from HK-BEAM (Hong Kong)	20
2.6	The Factors taken from WMF (Malaysia)	21
2.7	The Factors taken from EPA-EOIs (Hong Kong & Australia)	22
2.8	The Factors taken from BWAS (Singapore)	23
2.9	The Factors taken from WMPET (Korea)	24
2.10	The Factors taken from CIDB and WMP (Malaysia)	25
2.11	The Factors taken from Glavinich and Kibert	26
2.12	The Factors taken from Firmawan, Arief & Egbu, Marta, Legget, Dorrان, Tolba El Kholi and Wooley.	27
2.13	WMPET – Manpower Major Factor - Kim (2006)	33
2.14	WMPET – Material Major Factor - Kim (2006)	37
2.15	Building Waste Assessment Score [BWAS] ( Ekanayake and Ofori: 2004)	37
2.16	WMPET - Management and Policy Major Factor – Kim (2006)	39
2.17	Environmental Performance score [EPS] - Li- Yiin Shen, et al (2005)	40
2.18	Material Wastage Assessment	44
2.19	The Controlling of Reinforcement Bar (Rebar) Waste	44

2.20	The Controlling of Concrete Waste	44
2.21	Green Building Features	46
2.22	Green Construction Features	47
3.1	The Development of The Concept	53
3.2	Tool Construction	56
3.3	Likert Table	59
3.4	Factor Questionnaire Form	60
3.5	Factor Analysis Questionnaire Faorm	61
3.6	Tool Performance Assessment	62
3.7	The Degree of Achievement	64
4.1	Efficiency Index of 10 projects observed	74
4.2	Waste Minimization Index	76
4.3	Sustainable Green Construction Site Index	78
4.4	Productifity Index based on Material Handling Management	81
4.5	The Awareness Index of 10 projects observed	85
4.6	Construction Performance Site Index	87
4.7	Construction Waste Management Index	89
4.8	The Performance of 10 Projects Assessed Using Green Construction Site Index	91
5.1	POCI from the perspective of Policy Level	96
5.2	The POCI from the perspective of Procedure Level	98
5.3	The POCI from the perspective of Practice Level	99
5.4	The Commitment of the Organization Measured by POCI	100
5.5	The POCI of Ten Project upon the Indicator of efficiency.	104
5.6	The POCI of Ten Project upon the Indicator of productivity.	107

5.7	The POCI of Ten Project upon the awareness indicator.	108
5.8	The Project Organizational Commitment Index (POCI) to the indicator of the Green Construction Site Index.	109

**LIST OF FIGURES**

<b>FIGURE NO.</b>	<b>TITLE</b>	<b>PAGE</b>
2.1	Classification of construction waste generated in the implementation of the CCM according to hazard	30
2.2	Waste Management Hierarchy	30
2.3	Construction Waste Minimization Techniques system	45
4.1	Average Value Index on Element Identification Questionnaire	68
4.2	Average Value Index on QAT's Element Questionnaire	70
4.3	Validity Test of Factor Analysis	72
4.4	Efficiency Analysis Diagram	73
4.5	Productivity Analysis Diagram	80
4.6	Awaareness Analysis Diagram	84

**LIST OF EQUATION**

<b>EQUATION NO.</b>	<b>EQUATION</b>	<b>PAGE</b>
3.1	Average Index	58
3.2	Strugess Formula	61
4.1	Average Index	64
4.2	Product moment Pearson	67

## LIST OF APPENDICES

<b>APPENDIX</b>	<b>TITLE</b>	<b>PAGE</b>
A	Factor Identification Questionnaire	114
B	Summary: Result of Factor Identification Questionnaire	128
C	Determining of QAT's Factor Questionnaire	145
D	Summary of Result Determining of QAT's Factor Questionnaire	169
E	Photo Documentation FGD I	186
F	Photo Documentation FGD II	187
G	Factor Analysis Questionnaire Factor – Major Factor – Element	188
H	Summary of Result Factor Analysis Questionnaire Factor – Major Factor – Element	202
I	Green Construction Site Index Assessment Tool	210
J	Summary of Result Green Construction Site Index Assessment Tool ongoing Project	223
K	Green Construction Site Index – Assessment Tool	236



## **CHAPTER 1**

### **INTRODUCTION**

#### **1.1 Background**

The steadily increase of social and economy of Indonesian has stimulate the stable development of construction industry in many areas. The growth of the construction industry has triggered many supporting system related construction industry that compel the government to control those industries to follow rules and regulations in order to protect both the industries and the environment from possible negative impact generated by tight competition among the industries.

As the demand of housing, for example, increases the activities of the construction industry will also multiply. The multiplier effect sometime force the construction industry to disregard the negative implication exposed to the environment. As a result, the deterioration of the environment has become the central issue and the construction industry will be blamed to be responsible that create that situation.

Therefore, both the construction industry and the government should be working together and function dependently in resolving the adverse impact of the development to the environment. To develop this mutual understanding, both sides, besides law and order, need a tool that function as a controlling system to fulfill any requirement toward the achievement of sustainable green construction concept.

The negative impact of the construction industry to the environment has been realized as one of the world's problem because it is taken place in many countries. Many scholars appreciate the existence of this industry; however, although the establishment of an infrastructure for the development of economy influenced by construction industry that directly shared to the development of a nation (Firmawan *et al.*, 2012a), Bossink and Brouwers (1996) claimed that it generates severe impacts to the environment. A considerable number of studies concerning environmental problems associated with construction activities has been carried out (Shen *et al.*, 2005; Tam and Lee, 2007; Ofori and Ekanayake, 2004, Gangoellis *et al.*, 2009); such as the fact that resource depletion, considerable amount of waste and high energy consumption are needed by construction industry (Kim *et al.*, 2006) that lead the industry becomes one of the biggest environmental polluters (Yahya and Boussabaine, 2006). Most of the findings concluded that in order to serve the industrial activities, high number of raw materials is consumed by construction industry such as soil, aggregates, sand and water to manufacture goods such as bricks, cement, plasterboard, metals (steel and iron), timber, concrete and plaster that generate large quantity of construction waste that has significant negative impacts to the environment.

The negative impact of the construction waste to the environment becomes more serious as the quantity of solid waste increases, while the availability of land to dump the waste decreases. As a result, the exhausted landfill and severe ecological impact increases. High demands of infrastructure and building projects, particularly commercial and dwellings are the key contributors to the construction waste generation (Begum *et al.*, 2009a). The construction waste can be accounted for more than 50% of UK's landfill area (Ferguson 1995) and in 2001, 44% of the solid waste disposed at municipal landfill sites in Hong Kong is C&D waste (Poon, 2001a).

The design, material handling, operational and procurement are among the major sources of construction waste generation (Ofori and Ekanayake, 2000). However, the most frequent causes of the construction waste generation are design changes and leftover scrap (Ofori and Ekanayake, 2000), type of building, design, size of project and site management (Masudi *et al.*, 2011). In addition, the lack of utilizing the environmentally friendly construction materials resulted in poor

sustainability in the Indonesian construction sector (Siagian, 2005) and the status of waste management in the Indonesian construction industry is very limited to disposal only; minimum efforts are made to actually manage, reuse and recycle waste materials (Suprpto and Wulandari, 2009).

The construction waste related problems can also be observed from management perspective as Tam (2008b) and Gavilan and Bernold (1994) conclude that reducing waste is the utmost important measure in waste management plan. In contrast, in Malaysia, contractors put less emphasis on awareness as shown by lack of waste record-keeping and illegal practices of waste disposal (Masudi *et al.*, 2011 and Begum *et al.*, 2009). The contractors regard the waste and its impact to the environmental least important, but duration and cost as the most important. (Poon *et al.*, 2004). In the same case, Alwi (2003) documented that one of the main problems suffered by the Indonesian construction industry is productivity; particularly waste management and the key contributing factors were the characteristic of contractors, inadequate management strategy and organizational focus. Meanwhile, Poon *et al.*, (2001a, 2001b) and Tam (2008) put great emphasis on sound and proven the waste management plan during on-site operational phase of the construction, including effective measures in reducing waste such as waste segregation and applying prefabricated building system.

Accordingly, the construction waste management has to be carefully maintained to achieve high productivity in regard to some consideration as some scholars suggested. Green construction practice seems to be the solution for the problems associated with the waste generation (Erviyanto *et al.*, 2011) and institutions are expected to play a major role in determining the waste management practice (Nitivattananon and Borongan, 2007). Therefore, the construction waste generation must be quantitatively measured for assessing environmental performance of construction project (Lau *et al.*, 2008 and Masudi *et al.*, 2011).

## 1.2 Problem Statement

The quantitative measurement is a significance indicator that can be implemented as a benchmark for contractors' performance. The benefits of the benchmark are to develop good planning on resources and environmental management, to reduce the wastes generated in all stages of construction project (Poon *et al.*, 2001b) and to achieve more sustainable and innovative practices in industry (Jalali, 2006). A quantitative measurement called waste index calculations has been used to anticipate the quantity of waste in order to establish the awareness of waste minimization. Hong Kong, for instance, has established the "construction waste index" and "wastage level".

However, the construction waste index is not accountable, project size-dependant and does not reflect the overall productivity and the environmental performance of a construction project. The waste index calculation illustrates a very generic approach in waste quantification (Poon *et al.*, 2001b; Jalali, 2006; Masudi *et al.*, 2011); as a result, simplified approaches were employed which resulted in type of building and size of project as the main factors for construction waste generation.

Thus, a specific and accurate approach is required to assess quantitatively the waste reduction performance in respect to the productivity of the construction project. In this perspective, efficient consumption of materials is considered the pillar of the construction waste minimization and the overall project productivity. The quantitative approach is applied by catering the need for benchmarking of the waste generation rate in order to achieve an additional efficiency and productivity of the construction industry. In addition, prefabrication or Industrialized Building System (IBS) is popularly recognized as the solution for minimizing construction waste generation (Poon, 2001b). Recently, considerable extent of IBS system is adopted in Indonesian construction industry. Nevertheless, further studies must be carried out to assess quantitatively the effectiveness of IBS towards efficiency of the material use, the waste generation and the overall productivity.

It can be summarized that the importance to quantitatively measure the construction waste generation is to understand the real problem caused by the

construction industry and to determine the mitigation actions as the quantification provides an essential means for evaluating the exact amount of the waste and therefore, resulting a proper decision for their reduction and sustainable management (Poon *et al.*, 2001b; Jalali, 2006; De Silva, 2008). Moreover, the construction waste reduction requires characterization and quantification of waste (Jalali, 2006; Martinez-Lage *et al.*, 2009). However, the accurate quantity and the type of waste, which is anticipated about 5-10% of materials purchased, are unidentified (Bossink and Brouers, 1996; Poon *et al.*, 2001b, 2009; Jalali, 2006). As a consequence, waste management decisions are often based on guesses and simplified conclusions made by site personnel (Jalali, 2006).

In the near future, the management decision based on bias information input should not be taken into account. The accurate and reliable record of onsite problems should be taken into consideration as part of the controlling mechanism that flow in two ways system. Therefore, it is believed that the Indonesian construction industry needs to strive for the establishment of a quantitative measurement tool that is capable of assessing the performance of an ongoing construction project from several aspects and perspective and to immediately present the result to be employed for making a significant decision to mitigation efforts.

### **1.3 Research Aim and Objectives**

The aim of this study is to develop Green Construction Site Index as quantitative assessment tool to measure the implementation of green construction concept. The Green Construction Site Index is expected to be applied as a standardized reference by both the construction industries and the authority; so that, both parties may develop mutual understanding upon conserving the environment.

The Objectives of the study are:

- i. To classify factors that associated with the green construction concept
- ii. To develop a framework of the Green Construction Site Index (GCSI) and Project Organization Commitment Index (POCI)

- iii. To investigate the efficiency, productivity, awareness and organization commitment of an ongoing construction projects

#### **1.4 The Scope of Research**

This study was undertaken to provide a quantitative assessment tool in construction site and evaluate an on-going project from which two aspects are scored and transformed into index. The two aspects consisted of the performance of a construction project measured by its efficiency, productivity and awareness and the degree of commitment of the personnel within an organizational structure of a construction project. Furthermore, the index obtained by an ongoing project shall be used as an input to the managerial level to make a decision upon an existing state of a project.

Ten construction projects participated in this study – categorized into three types; Non Commercial, Non Residential Building; Commercial, Residential Building; and Commercial, Non Residential Building. The data were collected in three ways: on site observation, interview with key personnel and review of the project documents.

This study merely focused on the construction project site located in Indonesia by conducting the following limitation:

- i. All projects participated in this study were state own enterprise.
- ii. The types of the building project involved this study were Non Commercial, Non Residential Building; Commercial, Residential Building and Commercial, Non Residential Building.
- iii. The assessment of construction waste management were conducted during the ongoing construction phase only, not full life cycle of building construction project.

- iv. This study is focused on the on site construction waste management not include factories that the precast material elements were produced.

## 1.5 Research Outputs

The output of the study is as follow:

- i. The formulation of Green Construction Site Index as quantitative assessment tool to measure the implementation of green construction concept
- ii. The method used to do assessment using Green Construction Site Index Application.

The benefits of the research output;

*For contractors:*

- i. Financial benefits might be generated as the tool works simultaneously with the construction process, so whenever the construction process and product are identified doing improper execution, the management might take an immediate action to avoid more losses.
- ii. Social benefits will be rewarded to the construction industry when the outcome proves to be technically properly and environmentally acceptable by both the government and the community.
- iii. Environmental benefits will be produced when the tool is used as part of the controlling mechanism to evaluate every step of the construction process.
- iv. Organization benefits will be earned once the community appreciates with the sustainable green construction product offered by the construction industry.
- v. Quality benefits will be generated when the previous four benefits are achived

*For Authority:*

- i. A controlling mechanism tool that has an ability to do assessment, evaluation and directly provide recommendation to an ongoing project
- ii. Authorities are expected to formulate policies and regulation with thorough enforcement in order to encourage environmental awareness, promote better productivity and apply more responsible practices
- iii. The growth of more productive construction industry in Indonesian that put emphasis its practice on reducing waste generation and improving efficiency, reducing cost of opening new landfills and preserving natural resources.



### **6.2.2. For Authorities**

In line with the development of the construction industry in Indonesia, the government should supervise any construction project to achieve sustainable green construction concept. To do so, the need of a tool to control and recommend an ongoing project is imperative. As a new method that will be implemented in Indonesia, The Green Construction Site Index is an option to be considered.

## REFERENCES

- Alarcon, L.F. (1993) Modelling Waste and Performance in Construction. In Alarcon, Luis, (Ed.) *Lean Construction*, Netherlands 1997.
- Alwi, S., Hampson, K. and Mohamed, S., (2000). Waste in the Indonesian Construction Projects. *Proceeding of CIB W107 1st International Conference: Creating a sustainable construction industry in developing countries*. 11 to 13 November, Stellenbosch, South Africa
- Alwi, S., Hampson, K. and Mohamed, S. (2002). Non Value-Adding Activities. A Comparative Study of Indonesian and Australian Construction Projects. *Proceedings of the Tenth Annual Conference of the International Group for Lean Construction IGLC-10*, Gramado, Brazil.
- Alwi, S. (2003). Factors Influencing Construction Productivity in the Indonesian Context. *Proceedings of the Eastern Asia Society for Transportation Studies*, Vol.4, October.
- Arif M and Egbu C, Haleem A, Kulonda D, Khalfan M (2008). State of green construction in India: drivers and challenges. *Journal of Engineering, Design and Technology* Vol. 7 No. 2, pp. 223-234
- Badarodin (2004). *The Effects Of Socio-Economic Characteristics On Household Wastes In Johor Bahru District*. Universiti Teknologi Malaysia: Tesis Doktor Falsafah
- B. Kourmpanis, *et al.*, "Preliminary study for the management of construction and demolition waste," *Waste Management & Research*, vol. 26, pp. 267-275, 2008.
- Begum, R.A., Pereira, J.J., Siwar, C., Jaafar, A.H. (2007). Implementation of waste management and minimization in the construction industry of Malaysia. *Resources, Conservation, and Recycling* 51 190-202.
- Begum, R.A., Pereira, J.J., Siwar, C., Jaafar, A.H. (2009a). Attitude and behavioral factors in waste management in construction industry in Malaysia. *Resources, Conservation, and Recycling* 53 321-328.
- Begum, R.A., Pereira, J.J., Siwar, C., Jaafar, A.H. (2009b). Contractors' willingness to pay for improving cons waste management in Malaysia. *Construction Research Institute of Malaysia (CREAM) Journal* 4 (1),

- Begum, R.A., Siwar, C., Pereira, J.J., Jaafar, A.H. (2006). A benefit–cost analysis on the economic feasibility of construction waste minimization: the case of Malaysia. *Resources, Conservation and Recycling* 48 86–98.
- Bergsdal, H., Bohne, R.A. and Brattebø, H. (2007) ‘Projection of construction and demolition waste in Norway’, *Journal of Industrial Ecology*, Vol. 11, No. 3, pp.27–39.
- Bossink, B.A.G., and Brouwers, H.J.H. (1996). Construction waste: quantification and source evaluation. *Journal of Construction Engineering and Management*, March.
- Building and Construction Authority (1999). *The BCA buildable design appraisal system, 4th ed.* Building and Construction Authority (BCA), Singapore.
- Braganca, L., Mateus, R., Koukkari, H. (2010). Building Sustainability Assessment. *Sustainability* 2010, 2, 2010-2023; doi:10.3390/su207 Published: 5 July
- British Research Establishment (1998). *The Building Research Establishment Environmental Assessment Method*, British Research Establishment Limited.
- Brooks, et all (1994) “Germany’s construction and demolition debris recycling infrastructure : What lessons does it have for the U.S?” Sustainable construction (Proc. 1<sup>st</sup> Conf. Of CIB TG 16) C.J Kibert, ed 647-656
- Building and Construction Authority (1999). *The BCA buildable design appraisal system, 4<sup>th</sup> ed, Building and Construction Authority (BCA)*, Singapore
- Bontoux L., et al., 1996, The Recycling Industry in the European Union, Impediments and Prospects, European Commission - Joint Research Centre, Institute for Prospective Technological Studies, Sevilla Spain
- Center of Environmental Technology (1999), *The Hong Kong Building Environmental Assessment Method*, Center of Environmental Technology Limited.
- Chandrakanthi, M, Hettiaratchi, P, Prado, B, Ruwanpura, JY (2002). Optimisation of the waste management for construction projects using simulation. In: *Proceedings of the Winter Simulation Conference*. San Diego, California, pp. 1771-1777.
- CIDB(1995). *Buildable design appraisal system 3rd ed.* Construction Industry Development Board (CIDB), Malaysia.
- Cheung, Y. W. (1993). Approaches to ethnicity: Clearing roadblocks in the study of ethnicity and substance abuse. *International Journal of Addictions*, 28(12), pp. 1209-1226.
- Chockalingam, S. and Sornakumar, T. (2011). Tools for improving safety performance of Indian construction industry—AWH & SIT approach.

European Journal of Economics, Finance and Administrative Sciences, 35, 15-22

- Chong, W.K., Kumar, S., Haas, C.T., Beheiry, S.M.A., Coplen, L., and Oey, M. (2009). "Understanding and Interpreting Baseline Perceptions of Sustainability in Construction among Civil Engineers in the United States." *J. Mgmt. Engrg.*, 25(3), pp 143-154.
- Chun-Li P, Grosskopf KR, Kibert CJ. (1994). Construction waste management and recycling strategies in the United State. In: Kibert CJ, editor. *Proceedings of the First Conference of CIB TG 16 on Sustainable Construction. Tampa, FL: Centre For Construction And Environment.* pp. 689–96.
- Construction Industry Institute (2011). IR166-3 "*CII Best Practices Guide: Improving Project Performance*", Version 3.1
- Cochran, K., Townsend, T., Reinhart, D., Heck, H. (2007). Estimation of regional building-related C&D debris generation and composition: case study for Florida, US. *Journal of Waste Management* 27 pp. 921-931.
- Coventry, S., Shorter, B., Kingsley, M. (2001). *Demonstrating Waste Minimization Benefits in Construction*. London: Construction Industry Research & Information Association (CIRIA), UK.
- Craven, E. J., Okraglik, H. M., and Eilenberg, I.M. (1994), 'Construction waste and a new design methodology,' *Sustainable construction: Proc., 1st Conf. of CIB TG 16*, C.J. Kilbert, ed., pp. 89-98.
- Crichton, L.M. and Lucas, J.L.(1994). "Strategic Planning for the Management of Municipal Solid Waste." *Proceedings of IEM/ICE Conference on Solid/Industrial Waste Management System.* 19-21 September, 1994. Kuala Lumpur, Malaysia. 4C
- Dainty Andrew R.J and Richard J. Brooke (2004) *Towards improved construction waste minimisation: a need for improved supply chain integration?.* *Structural Survey Volume 22 · Number 1* pp. 20–29 q Emerald Group Publishing Limited · ISSN 0263-080X
- De Silva, N. (2008). Use of PC elements for waste minimization in the Sri Lankan construction industry. *Structural Survey* 26 pp. 188-198.
- Edwards W. (1977). Use of multiattribute utility measurement for social decision making. In: Bell DE, Keeney RL, RaiKa H, editors. *Conacting objectives in decisions.* New York: Wiley;. p. 247–76
- El-Haggar, S. (2007). *Sustainable industrial design and waste management; cradle-to-cradle for sustainable development.* Boston: Elsevier Academic

Environmental Protection Agency (EPA), U.S. <http://www.epa.gov>

Environmental Protection Department (EPD), Hong Kong.  
<http://www.info.gov.hk/epd>

Ervianto, W.I., Soemardi, B.W., Abduh, M., Suryamanto. (2011). Pengembangan Model *Assessment Green Construction* Pada Proses Konstruksi Untuk Proyek Konstruksi Di Indonesia. *Prosiding Konferensi Nasional Pascasarjana Teknik Sipil (KNPTS)*, 20 Desember.

Faniran, O.O., Caban, G. (1998). Minimizing waste at construction project sites. *Engineering, Construction, and Architectural Management* 5(2) 182-188.

Ferguson, J., Kermode, N., Nash, C.L., Sketch, W.A.J., Huxford, R.P. (1995). *Managing and minimizing construction waste: a practical guide*. Thomas Telford Publications, London.

Farrell, M. J. (1957). "The Measurement of Productive Efficiency." *Journal of the Royal Statistical Society. Series A (General)* 120(3): pp. 253-290.

Fatta, D., Papadopoulos, A., Avramikos, E., Sgourou, E., Moustakas, K., Kourmoussis, F., Mentzis, A., Loizidou, M., (2003). Generation and management of construction and demolition waste in Greece-an existing challenge. *Resources, Conservation and Recycling* 40, pp. 81–91

Firmawan, F. (2006). Analisis Berbagai Variabel Penyebab Terjadinya Penyimpangan Biaya Material Terhadap *Indicator Material Cost Overrun* Paling Berpengaruh. *Jurnal Pondasi Vol. 12 No. 2 Desember, hal.112-126*

Firmawan, F. (2012a). Framework for Green Construction Assessment: A Case Study of Government Institution Building Project in Jakarta, Indonesia. *Journal of Emerging Trends in Engineering and Applied Sciences (JETEAS)* 3 (4): pp. 576-580

Firmawan, F.(2012b). *Green Construction Policy* menuju Pembangunan Perumahan dan Kawasan Pemukiman Ramah Lingkungan. *Jurnal PWK Undip*.

Formoso, C. T., Isatto, E. L. and Hirota, E. H., (1999). Method for Waste Control in the Building Industry. *Proceedings of the Seventh Annual Conference of the International Group for Lean Construction IGLC-7*, University of California, Berkeley, CA, USA.

Formoso, C. T., Soibelman L., Cesare, C. D. and Isatto, E. L., (2002). Material Waste in Building Industry: Main Causes and Prevention. *Journal of Construction Engineering and Management*, Vol. 128, No. 4, pp. 316-324

Franklin Associates (1998) *Characterization of Building-related Construction and Demolition Debris in the United States*, The U.S. Environmental Protection Agency Municipal and Industrial Solid Waste Division Office of Solid Waste Report No. EPA530-R-98-010

- Gangoellis, M., Casals, A., Gasso, S., Forcada, N., Roca, X., Fuertes, A. (2009). A Methodology For Predicting The Severity Of Environmental Impacts Related To The Construction Process Of Residential Buildings. *Building and Environment* 44 pp. 558– 571.
- Gavilan, R.M., Bernold, L.E. (1994). Source evaluation of solid waste in building construction. *Journal of Construction Engineering & Management* 120(3), ASCE Publications.
- Glavinich, T. E. (2008) : *Contractor's Guide to Green Building Construction*, John Wiley.
- Graham, P. and Smithers, G. (1996), “Construction waste minimisation for Australian residential development”, *Asia Pacific Journal of Building & Construction Management*, Vol. 2 No. 1, pp. 14-19.
- Grönqvist, M., Male, S., Kelly, J. (2006). The Function Priority Matrix: *Meeting the Function of Function Analysis*. Value Solutions Ltd.
- Green Building Council Indonesia, (2010). *GREENSHIP*, Jakarta
- GREEN BUILDING INDEX SDN Bhd (2010) green building index. Malaysia: [www.greenbuildingindex.org](http://www.greenbuildingindex.org)
- Goeritno, B. (2011) : Draft Agenda 21 Konstruksi Berkelanjutan Indonesia', *dipresentasikan dalam Seminar Internasional Toward Sustainable Construction in Indonesia*, Jakarta, 14 Juni.
- Hendrickson, C.T., and Horvath, A. (2000), Resource Use and Environmental Emissions of U.S. Construction Sectors. *Journal of Construction Engineering and Management*, ASCE, 126(1), pp. 38-44
- <http://www.greenbuildingindex.org/how-GBI-works2.html#Classification>
- International Council for Research and Innovation in Building and Construction (CIB), (1998). Sustainable Development and the Future of Construction—A Comparison of Visions from Various Countries, vols. 13–16, *International Council for Research and Innovation in Building and Construction*, , pp. 156– 157.
- Ishiwata, J. (1997) IE for the shop floor: Productivity Through Process Analysis. *Thomson-Shore, Inc.*
- Huichao D, Jun, Li (2004) Key Technique and Main Innovation About Concrete Construction Technique In The Three Gorges Project. *29th Conference on Our World in Concrete & Structures: 25 - 26 August, Singapore*

- Jalali, S (2006). Quantification of Construction Waste Amount. *6<sup>th</sup> International Technical Conference of Waste, Viseu, Portugal, October.*
- Jane J. L. HAO, MJ Hills, CST Chan (2002) An Intergra Simulation Model For Improving Construction Waste Management In Hong Kong.
- Kahya N.C, Selda Al, Sari RM, Sagsoz A (2010) Two Traditional Construction Techniques: Goz Dolma and Muskali. *Research Journal of International Studies* - Issue 17 November.
- Kartam Nabil , Al-Mutairi Nayef, Al-Ghusain Ibrahim, Al-Humoud Jasem (2004) Environmental management of construction and demolition wastein Kuwait. *Waste Management* 24 pp. 1049–1059
- Kibert, C.J (2000). Deconstruction as an essential component of sustainable construction. In Broonstra, C, Rover, R & Pauwels, S (eds) *International Conference Sustainable Building 2000 Proceeding*, 22-25 October, Maastricht Netherland, Aenest Technical Publisher p.89
- Kim, J.H., Kim, J.M., Cha, H.S., Shin, D.W. (2006). Development of The Construction Waste Management Performance Evaluation Tool. *ISARC*.
- Koskela L. (2000). *An exploration towards a production theory and its application to construction*. Espoo, Finland: VTT Publication No. 408.
- Koskela, L. (1992) Application of the New Production Philosophy to Construction. *Technical Report No. 72*, CIFE, Stanford University.
- Kumaraswamy, M.M , Ugwu, O.O.nPalaneeswaran E. and Rahman M.M. (2004) Empowering collaborative decisions in complex construction project. *Engineering, Construction and Architectural Management Volume 11 · Number 2* pp. 133–142 q Emerald Group Publishing Limited · ISSN 0969-9988
- Lau et al (2008) Composition and Characteristics of Construction Waste Generated by Residential Housing Project. *Int. J. Environ. Res.*, 2(3): 261-268, Summer ISSN: 1735-6865
- Lau & Whyte A.(2007) A Construction Waste Study For Residential Projects In Miri, Sarawak. *Conference on Sustainable Building South East Asia*, 5-7 November, Malaysia.
- Lauritzen, E., & Hahn, N. (1992). *Building waste generation and recycling. International Solid Waste Association Year Book 1991-1992*. Cambridge, England.
- Lee, T.Y. (1998), The development of ISO 9000 certification and the future of quality management: a survey of certified firms in Hong Kong', *International Journal of Quality & Reliability Management*, Vol. 15 No. 2, pp. 162-77.

- Lembaga Pengembangan Jasa Konstruksi Nasional (2007) Penetapan Dan Pemberlakuan Panduan Permohonan Sertifikat Asesor Keterampilan Bidang Jasa Konstruksi (Book)
- Lehman and Reiser (2000). Maximizing Value & Minimizing Waste: Value Engineering & Lean Construction. *Lean Construction Institute*.
- Ling & leo (2000). Reusing timber formwork: importance of workmen's efficiency and attitude. *Building and environment* 35 (2) : pp 135 – 143
- Lu, W., Yuan, H., Li, J., Hao, J.J.L., Mi, X., Ding, Z. (2011). An empirical investigation of construction and demolition waste generation rates in Shenzhen city, South China. *Journal of Waste Management* 31 pp. 680 – 687
- Martinez Lage, I., Martinez Abella, F., Vazquez Herrero, C., Perez Ordonez, J.L. (2009). Estimation of the annual production and composition of C&D debris in Galicia, Spain. *Journal of Waste Management* 30 (4) pp. 636-645.
- Martinez Lage, I., Martinez Abella, F., Vazquez Herrero, C. and Perez Ordonez, J.L. (2010) 'Estimation of the annual production and composition of C&D debris in Galicia, Spain', *Journal of Waste Management*, Vol. 30, No. 4, pp.636–645
- Masudi, A.F., Che Hassan, C.R., Mahmood, N.Z., Mokhtar, S.N. and Sulaiman, N.M. (2011). Construction Waste Quantification and Benchmarking: A Study in Klang Valley, Malaysia. *Journal of Chemistry and Chemical Engineering*, Vol. 5, No.10, October, pp. 909-916.
- Massachusetts Department of Environmental Protection* (2007) Construction & Demolition Debris Industry Study, FINAL REPORT
- Mincks, W.R (1994) "The construction contractor's waste management plan: optimizing control and cost" sustainable construction construction (Proc. 1<sup>st</sup> Conf. Of CIB TG 16) C.J Kibert, ed Ctr. For Constr and Envir, Gainesville, Fla, 765-774
- McDonald B, Smithers M. (1998) *Implementing a waste management plan during the construction phase of a project: a case study. Construction Management and Economics*;16:71–89.
- Moyano PM, Agudo Antonio R and Santiago M.O (2001) Calculation Methodology to Quantify and Classify Construction Waste. *The Open Construction and Building Technology Journal*, 5, (Suppl 2-M3) 131-140
- Muhwezi I et al (2012) An investigation into Materials Wastes on Building Construction Projects in Kampala-Uganda. *Scholarly Journal of Engineering Research* Vol. 1(1), pp. 11-18, April
- Nitivattananon, V and Borongan,G (2007) Construction and Demolition Waste Management: Current Practices in Asia. *Proceedings of the International*



*Conference on Sustainable Solid Waste Management, 5 - 7 September, Chennai, India. pp.97-104*

- Nunnally, S.W. (2007). *Construction methods and management*. New Jersey: Pearson Prentice-Hall.
- Ofori, G., Ekanayake, L.L. (2000). Construction Material Waste Source Evaluation. *Proceedings: Strategies for a Sustainable Built Environment*, Pretoria, 23-25 August.
- Ofori, G., Ekanayake, L.L. (2004). Building Waste Assessment Score: Design-Based Tool. *Building and Environment* 39 pp. 851-861
- Ohno T. (1988). *Toyota production system*. Cambridge, MA: Productivity.
- Pheng, L.S. and Meng, C.Y. (1997) *Managing Productivity in Construction*. Ashgate Publishing Limited, England.
- Poon, C.S., Yu, A.T.W., Ng, L.H. (2001a). On-site sorting of C&D waste in Hong Kong. *Resources, Conservation and Recycling* 32 pp 157-172.
- Poon, C.S., Yu, T.W., Ng, L.H. (2001b). *A Guide for Managing And Minimizing Building And Demolition Waste*. Hong Kong: Hong Kong Polytechnic University Publishing, May.
- Poon, C.S., Yu, A.T.W., Wong, S.W., Cheung, E. (2004b). Management of construction waste in public housing projects in Hong Kong. *Construction Management and Economics* (22) pp. 675-689
- Poon, C.S., Jaillon, L., Chiang, Y.H. (2009a). Quantifying the waste reduction potential of using prefabrication in building construction in Hong Kong. *Journal of Waste Management* 29 pp. 309-320.
- Robert H. Falk and David B. Mckeever (2004) *Recovering Wood for used and Recycling A United States Perspective* University Studio Press Publishers Of Academic Books and Journal Thessaloniki.
- Rogoff, M., and Williams, J. F. (1994) : *Approaches to implementing solid waste recycling facilities*, Noyes, Park Ridge, N.
- Roudebush, W.H. (1998). An Environmental Value Engineering Application to Assess the Environmental Impact of Construction Waste. *North Carolina Recycling Association 8<sup>th</sup> Annual NCRA Conference and 3rd Annual Southeastern Green building Conference* March 2-4, Greensboro, NC.
- Siagian, I.S. (2005). *Bahan Bangunan Yang Ramah Lingkungan*. Universitas Sumatera Utara.

- Serpell A, Labra M. (2003) A study on construction waste in Chile. In: Ofori G, Ling FYY, editors. *Proceedings, Joint Symposium of CIB W55, W65 and W107 on Knowledge Construction*, vol. 2. 22–24 October. Singapore, pp. 102–11.
- Serpell, A.; Venturi, A. and Contreras, J. (1995) Characterization of Waste in Building Construction Projects”. In Alarcon, Luis (1997, Ed.) *Lean Construction*, A.A. Balkema, Netherlands.
- Skoyles, E.R. and Skoyles, J.R. (1987). *Waste Prevention on Site*, Mitchell Publishing, London.
- Solis-Guzman, J., Marrero, M., Montes-Delgado, M.V., Ramirez-de-Arellano, A. (2009). A Spanish model for quantification of construction waste. *Journal of Waste Management*.
- Salomonsson, G.D. & MacSporrán, C. (1994) 'Recycling of Materials in Building Construction' Conference Proceedings, 1st International Conference on Building & the Environment, Watford, UK
- Suprpto, H. and Wulandari, S. (2009). Studi Model Pengelolaan Limbah Konstruksi Dalam Pelaksanaan Pembangunan Proyek Konstruksi. *Proceeding PESAT (Psikologi, Ekonomi, Sastra, Arsitektur & Sipil)* Vol. 3 Oktober Universitas Gunadarma - Depok, 20-21 Oktober.
- Shakantu W, Muya M, Tookey J, Bowen P (2008) Flow modelling of construction site materials and waste logistics A case study from Cape Town, South Africa Engineering, *Construction and Architectural Management* Vol. 15 No. 5, 2008 pp. 423-439
- Shen, L.Y., Lu, W.S., Yao, H., Wu, D.H (2005). A computer-based scoring method for measuring the environmental performance of construction activities. *Automation in Construction* 14 pp. 297– 309.
- Shingo, S. (1989). *A Study of the Toyota Production System from an Industrial Engineering Point of View*. Productivity Press, USA.
- Siagian, I.S. (2005). *Bahan Bangunan Yang Ramah Lingkungan*. Universitas Sumatera Utara.
- Stokoe MJ, Kwong PY, Lau M-M.(1999) Waste reduction: a tool for sustainable waste management for Hong Kong. In: Barrage A, Edelmann Y, editors. *Proceedings of R'99 World Congress*, vol. 5. Geneva: EMPA. pp. 165–701.
- Symonds Group Ltd, ARGUS, COWI and PRC Bouwcentrum (1999) construction and demolition waste management practices, and their economic impact. In final report to DGXI, european commission p. 208
- Tammemagi H. (1999) *The waste crisis*. Oxford University Press;

- Tam VWY, Tam CM, Zeng SX, Chan KK (2006). Environmental performance measurement indicators in construction. *Building and Environment*;41 (2):164e73.
- Tam, V.W.Y. and Le, K.N. (2007). Assessing Environmental Performance in the Construction Industry. *Surveying and Built Environment Vol 18 (2)*, pp. 59-72.
- Tam, V.W.Y, Wang, J.Y., Kang, X.P. (2008a). An investigation of construction waste: an empirical study in Shenzhen. *Journal of Engineering Design and Technology 6(3)*.
- Tam, V.W.Y. (2008b). On the effectiveness in implementing a waste-management-plan method in construction. *Journal of Waste Management 28* pp. 1072-1080.
- Tang, H. H, Soon, H. Y. & Larsen, I. B. (2003), *Solid Waste Management in Kuching, Sarawak*, DANIDA / Sarawak Government UEMS Project, Natural Resources and Environment Board (NREB), Sarawak & Danish International Development Agency (DANIDA).
- US EPA (United States Environmental Protection Agency) (1998) Characterization of Building-Related Construction and Demolition Debris in the United States. Office of Solid Waste Management, Washington, DC, Report EPA 530-R-98-010.
- U.S. Green Building Council (2001) *Leadership in Energy and Environmental Design—Rating System Version 2.0*, U.S. Green Building Council.
- Vivian W.Y. Tam (2008) On the effectiveness in implementing a waste-management-plan method in construction. *Waste Management 28* pp. 1072–1080
- Wimalasena, et al (2010). Construction Research Congress 2010: Innovation for Reshaping Construction Practice, pp 1498-1507
- Wooley, S. Kimmins, P. Harrison, R. Harrison, (1997). *Green Building Handbook*, E&FN Spon.
- World Bank. (1999). What a waste: Solid waste management in Asia. *Urban and Local Government Working Paper Series number 1*. Washington, DC: World Bank.
- Yahya, K. and Boussabaine, A.H. (2006). Eco-costing of Construction Waste. *International Journal of Environmental Quality Management Vol. 17, No.1*, pp. 6 – 19.

Yahya, K. and Boussabaine, A.H. (2010). Quantifying Environmental Impacts and Eco-Costs From Brick Waste. *Architectural Engineering and Design Management Vol.6*, pp.189-206.