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Decision-making on reverse logistics in the construction industry

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Abstract

With the growing competition, many construction organizations attempt to improve their productivity, quality, and efficiency. Construction waste management, by means of reverse logistics, becomes a key issue to improve the productivity, and raise the company's green image. In this study, four reverse logistics methods-direct reuse, remanufacturing, recycling, and landfill-are considered to manage construction and demolition (C&D) waste. Two factors (economic and site-specific) with their 15 sub-factors affecting the decisions to implement the reverse logistics are examined. The hierarchy model of reverse logistics decisions, developed through the analytic hierarchy process, reveal the importance of the economic factor over the site-specific factor. It is suggested that the transportation cost, the processing cost, the specific sorting technology, and the limited project time must be first considered before making decisions on reverse logistics plans. The construction company can utilize the developed hierarchy model to decide on the most appropriate reverse logistics plan to achieve the best benefits.

Keywords: analytic hierarchy process, construction industry, reverse logistics

1. Introduction

The construction industry is one of the industries that contributes large amount of wastes called construction and demolition (C&D) wastes (Chen and Wong, 2002). According to Fatta *et al.* (2003), C&D waste is generated on active building sites and includes a wide range of materials depending on the source of the wastes, for example excavation materials (e.g. earth, sand, gravel, rocks and clay), road building and maintenance materials (e.g. asphalt, sand, gravel and metals), demolition materials (e.g. earth, gravel, sand, blocks of concrete, bricks, gypsum, porcelain and lime-cast), and other worksite waste materials (e.g. wood, plastic, paper, glass, metal and pigments).

C&D waste is becoming a serious issue in many countries. In England, the construction industry produces around 53.5 million tons of C&D wastes annually, in which more than half are disposed of directly into landfills (Lawson *et al.*, 2001). Jang and Townsend (2001) added that the presence of gypsum from drywall in the construction industry gives a negative impact on the environment. In Netherlands, around 10% of every single purchased construction material leaves the site as solid waste (Ibrahim *et al.*, 2010). In Thailand, it is estimated that 1.1 million tons of construction waste were generated per year. The C&D waste, when segregated, can include high-value materials and resources for new construction. It is, however, found that not many wastes are reused and recycled due to the lack of reverse logistics knowledge.

This paper, therefore, aims at examining key factors influencing the reverse logistics decision utilizing the analytic hierarchy process (AHP) approach. Case studies of reverse logistics decision are also provided. It is expected that the study results assist the construction company in deciding its best reverse logistics implementation.

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2. Reverse Logistics

Reverse logistics is defined as how the area of business logistics plans, operates, and controls the flow of logistics information, corresponding to the returns of post-sale and post-consumption goods to the productive cycle through reverse distribution channels. Its process benefits in improving economic, ecological, legal, logistical, and corporate image (Bouzon *et al.*, 2012). The process starts when goods, which are in possession of the customers (business or private), are collected. Collections can be stored in different locations, such as, central warehouses or local stores. Once the goods are collected, they are transferred to facilities for sorting and testing (Srivastava, 2008). It is important to mention that the unwanted products are not collected, and do not enter the reverse logistics system (Mollenkopf *et al.*, 2007).

According to Srivastava (2008), four disposition options are listed: 1) recycle, 2) repair, 3) reuse, and 4) remanufacture. Peng *et al.* (1997), in contrast, recommended six types of reverse logistics: 1) reduce, 2) reuse, 3) recycle, 4) compost, 5) incinerate, and 6) landfill. El-Haggar (2007) separated reverse logistics into five types: 1) reduce, 2) reuse, 3) recycle, 4) recovery, and 5) disposal.

This study divides reverse logistics into four major types: 1) direct reuse, 2) remanufacturing, 3) recycle, and 4) landfill. These four types of reverse logistics represent the most common reverse logistics methods in Thailand (Oyeshola and Shabbir, 2009).

2.1 Landfill

Modern landfills are well-engineered facilities that are located, designed, operated, and monitored to ensure compliance with regulations. Solid waste landfills must be designed to protect the environment from contaminants, which may be presented in the solid waste stream (Hao *et al.*, 2008). Many countries around the world are, however, facing the problem of scarcity of landfills, for example Singapore and Hong Kong (Renbi and Mardina, 2002).

2.2 Direct reuse

According to Lee and Chan (2009), direct reuse is defined as products or components that are traded as is (without being modified), and can be used a second or multiple times (Bonderud, 2013). In the construction industry, the materials that can be direct reused are plastic containers, electric tools and equipment, furniture, wooden packaging, doors, frames, flooring, ducting, tiles, and bricks (Chapman *et al.*, 2009; Bonderud, 2013).

2.3 Remanufacturing

The definition of remanufacturing is an industrial process, in which worn-out products are restored to like-new condition through a series of industrial processes (Lund, 1983). Usable parts are cleaned, refurbished, and put into inventory. Then the new product is reassembled from the old, and where necessary, new parts to produce a fully equivalent, or sometimes superior, in performance and expected lifetime to the original new product. Remanufacturing is distinctly different from repair operations since products are disassembled completely, and all parts are returned to like-new condition (Lund, 1983). In the construction industry, the materials that can be remanufactured are the durable goods with interchangeable parts. An example is sash windows that can be cost-effectively reconditioned by repair and replacement of technical elements, and sometimes upgraded by the addition of, for example, double glazing (Chapman *et al.*, 2009).

2.4 Recycle

Recycling processes turn wastes into new products (Shakantu *et al.*, 2009). It has increasingly been adopted by communities as a method of managing municipal solid waste (US Environmental Protection Agency, 1998). It helps lower raw materials and energy requirements, and reduces air and water pollution (Shakantu et al., 2009). In the construction industry, the materials that can be recycled are cardboard and paper, concrete, and plastic (Tam and Tam, 2006).

3. Factors Affecting Reverse Logistics Decisions

There is a need to understand factors affecting the decision to implement specific reverse logistics methods. Based on the construction-related literature, two key factors affecting reverse logistics decisions are economic and site-specific factors.

3.1 Economic factor

Melon *et al.* (2009) and Wright *et al.* (2011) mentioned that if there is no economic value in reverse logistics, it will be much more difficult to induce companies to participate. The economic factor is associated with nine sub-factors, including:

1. Labor cost (LBC): Labor cost is incurred when companies perform each type of reverse logistics (Yuan and Shen, 2011).
2. Inventory cost (IVC): Inventory cost is required when storing C&D waste before transferring to the next construction site or destination (Waters, 2003).
3. Transportation cost (TPC): Distances from site to site affect the transportation cost and the project budget (Maqsood *et al.*, 2004).
4. Processing cost (PCC): New knowledge of operation processes lowers the processing cost (Terrance *et al.*, 1992).
5. Specific sorting machine (SSM): Specific sorting machine is required in order to effectively sort waste in limited time (Tam *et al.*, 2007).
6. Specific technology (STG): Some reverse logistic methods require specific technologies to perform; an example is the making of aggregated concrete (Collins, 1997).

7. Matured market (MMK): The size of the market for recycled waste affects the recycling decision (Poon *et al.*, 2001).

8. Landfill charge (LFC): There is a fee or charge when dumping C&D waste to landfill. A high landfill charge forces the company to implement other reverse logistics methods (Hao *et al.*, 2008).

9. Availability of landfill (ALF): The scarcity of landfills affects the reverse logistic decision (Renbi and Mardina, 2002).

3.2 Site-specific factor

A number of site specific variables, such as project time, site space, and legislative pressure, affect level and severity of waste production (Schultmann and Sunke, 2007; Liu *et al.*, 2011; Zou and Moon, 2014). Six sub-factors under the Site-specific factor are as the followings.

1. Site space (SSP): Limited site space on the construction site affects the amount of C&D waste stored at the site (Yuan and Shen, 2011).

2. Green image site (GIM): According to Schultmann and Sunke (2007), the green image gained by environmentally friendly business operations can help to win the favor of the public.

3. Replacement of virgin material (RVM): According to Zou and Moon (2014), reusing waste concrete for backfill materials or coarse aggregate for road construction helps reduce waste generation and traffic congestion.

4. Limited project time (LPT): Construction projects often have limited time, and that might affect the decision to implement the reverse logistics (Lawson *et al.*, 2001; Liu *et al.*, 2011).

5. Legislative pressure (LPR): Many construction companies now face pressure to act according to the principle of sustainability to foster resource preservation and emission avoidance (Schultmann and Sunke, 2007).

6. Knowledge of sorting (KLS): Training laborers in various sorting techniques enhances the sorting effectiveness and, perhaps, reduces labor requirement (Terrance *et al.*, 1992).

4. Analytic Hierarchy Process of Reverse Logistics Decisions in the Construction Industry

4.1 Hierarchy model of reverse logistics decisions

The economic and site-specific factors, along with their 15 sub-factors, are used to develop the hierarchy model of reverse logistics for the analytic hierarchy process (AHP) analysis. The AHP is a multiple criteria decision-making tool that has been used in many applications. It is one of the most widely used multiple criteria decision-making tools, and is applied in many areas. Srdjevic *et al.* (2012), for example, evaluated four possible methods i.e. chemical treatment, evaporation, separation by the use of the membranes, and biological treatment, applicable to the manufacture of colored metals in Serbia using seven criteria: 1) energy consumption, 2) price of the chemicals, 3) effectiveness, 4) simplicity of the process, 5) price of the facilities, 6) ecological impact, and 7) necessary educational level of the workers. Liu *et al.* (2011) proposed a hierarchical analytic network process that synthesizes hierarchical structures and networks, where hierarchies are used to represent outer dependency and networks serve to delineate inner dependence, and introduced a statistical method to obtain influence weights based on measurable data rather than subjective judgment.

This study utilizes the AHP method to assess the weights of each factor and sub-factor of reverse logistics decisions in the construction industry (see Figure 1). The hierarchy model consists of two factors, 15 sub-factors and four decision options (direct reuse, recycle, remanufacturing, and landfill).

Expert Choice software is used to gather information for the AHP analysis. According to Melon *et al.* (2008), six to 12 interviewees are considered appropriated for the interviews to gain depth of responses at reasonable cost. In this study, six interviewees involved are experts in the construction industry, and engage in reverse logistics decisions in their organizations. They are from different medium- and large-sized companies, with at least 50 million baht in capital, and minimum of 50 full-time employees (Chittithaworn *et al.*, 2011). The projects range from general civil engineering

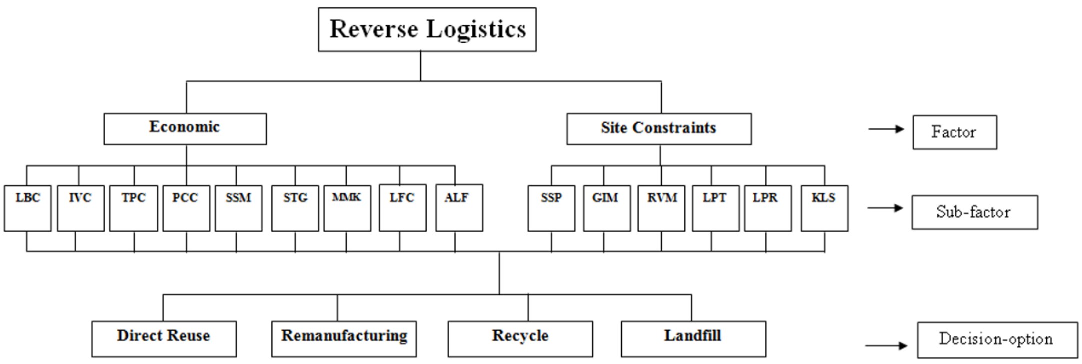

Figure 1. Hierarchy model of reverse logistics in the construction industry.

to large-scale infrastructure projects. Four of the interviewees are project managers, and two are the owners of the companies. All of them have been working in the construction industry for more than 10 years. They can make decision regarding reverse logistics implementation. Each of the interviewees was asked to rate his opinions on a number of pairs of factors or sub-factors, pair by pair, using the Saaty score (as explained in Table 1). For example, the interviewee was asked to consider the importance of the economic factor relative to the site-specific factor. If the Economic factor was assessed as having extreme relative importance, the score would be 9. Vice versa, the score of the site-specific factor relative to the economic factor would be 1/9.

A total of 52 comparison statements were asked for each interviewee (based on a pair of factors and 51 pairs of sub-factors), and the data were gathered. The AHP analysis was then performed, and the results were checked with the consistency ratio (CR) to accept or reject the results. According to Saaty (2008), the CR of less than or equal to 0.1 is commonly considered acceptable.

4.2 Weights of factors and sub-factors of reverse logistics decisions

Data gathered from the six interviewees were used to calculate the importance weights of each factor and sub-factor of reverse logistics decisions in the construction industry. To gain the overall opinions of the reverse logistics decisions, the geometric mean was employed to finalize the weight of each factor and sub-factor; the results were as shown in Figure 2. The economic factor was confirmed with higher weight (0.57) than the site-specific factor. Four out of six experts considered the economic factor as having more importance in making reverse logistics decisions than the site-specific factor. So, when consider implementing the reverse logistics in the construction industry, the transportation cost (TPC), the processing cost (PCC), and the specific sorting technology (STG) must first be considered, as they represent the highest weights among the Economic sub-factors (weights of 0.19, 0.15, and 0.13, respectively, see Figure 2). The pressure on the limited project time (LTP, with

Table 1. Saaty score (Saaty, 2008).

Comparison Scale Intensity	Definition	Explanation
1	Equal importance	Two factors contribute equally to the objective
3	Moderate importance of one over another	Experience and judgment favor one factor over another
5	Essential or strong importance	Experience and judgment strongly Favor one factor over another
7	Very strong importance	A factor is strongly favored and its dominance demonstrated in practice
9	Extreme importance	Evidence of favoring one factor over another is of the highest possible order of affirmation
2, 4, 6, 8		Intermediate values when compromise is needed

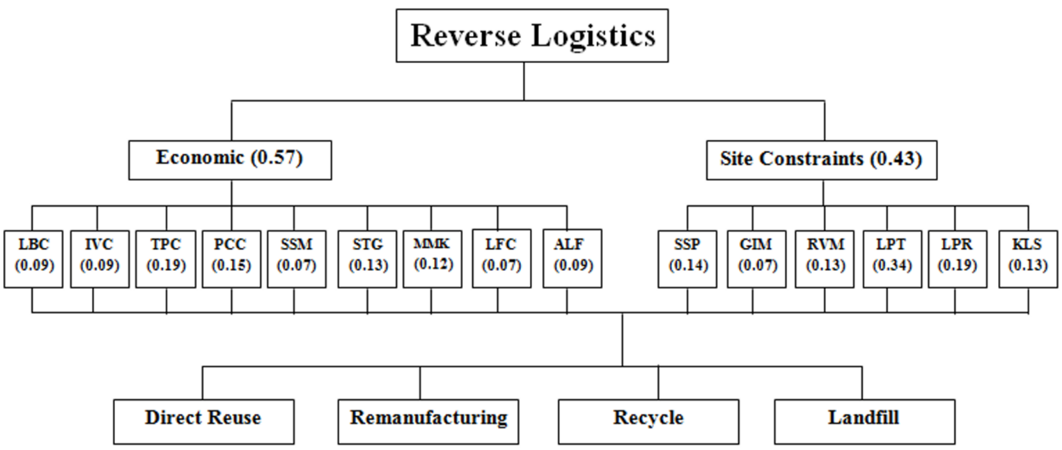

Figure 2. Final weights of factors and sub-factors of reverse logistics decisions in the construction industry.

the important weight of 0.34) also affected the decision to perform the reverse logistics.

4.3 Decision-making using the hierarchy model of reverse logistics

The hierarchy model of reverse logistics factors has been applied to develop decisions on the reverse logistics implementation. In this study, two construction companies, specializing in the building construction and operating in Bangkok, were involved in the assessment of the appropriate reverse logistics method (direct reuse, remanufacturing, recycle, and landfill) for each organization. The two companies are large-scale companies, with more than 200 full-time employees, and 200 million baht in capital. The two companies currently implement a number of C&D waste reuse and recycling activities, such as the direct reuse of window frames from one site to another, and the use of concrete wastes for leveling purposes.

Each company set up a team of three to five members, including senior engineer, project manager, and manager, to provide data for the assessment. The team members were selected based on their past involvement in the reverse logistics decision makings. Each team was brief with the steps of conducting the AHP assessment by the author (see Figure 3). The teams could also email or call the author if they need more clarification on the assessment processes. Please note that the assessment steps are common for all organizations. Though, they can be adjusted with different project cultures and situations.

Details of each step are as following: Score of each sub-factor, when considering a pair of decision options, was filled by the team using the Saaty score system (see Table 1). One single score is filled for each pair-comparison based on the consensus of all team members. For example when considering the 'labor cost' sub-factor (see Table 2), if the team moderately preferred the 'direct reuse' method than the 'remanufacturing' method, then the team filled the score of 3.

For each sub-factor, the scores, achieved from all pair-comparisons, in each column (represented each decision option) were summed. For example, the sum of the direct reuse column = 1 (i.e. comparison score between 'direct reuse' and 'direct reuse' methods) + 0.33 (i.e. comparison score between 'remanufacturing' and 'direct reuse' methods) + 0.33 (i.e. comparison score between 'recycle' and 'direct reuse' methods) + 0.20 (i.e. comparison score between 'landfill' and 'direct reuse' methods) = 1.86 (see Table 2).

Figure 3. Seven steps of decision making on reverse logistics implementation.

For each sub-factor, each score in each column was then adjusted by dividing its score with its summed score (in Step 2) to make the adjusted sum of 1. For example, adjusted score of comparing the remanufacturing method with the direct reuse method= 0.33/1.86 = 0.177 (see Table 3). The adjusted sum of the direct reuse column was then 0.538 +0.177+0.177+0.108 = 1.00.

After that, the adjusted scores in each row (each decision option) were summed, and divided by the number of decision options (four in this case) to achieve the total adjusted score (see Table 3). Please note that the sum of total adjusted scores in each column must equal 1.

Once the total adjusted scores of the 15 sub-factors (nine sub-factors in Economic factor and six sub-factors in Site-specific factor) were calculated, the total weight score of

Table 2. Example of the scores of the "labor cost" sub-factor when comparing the four reverse logistics method.

The "Labor Cost" Sub-Factor	Direct Reuse	Remanufacturing	Recycle	Landfill
Direct reuse	1	3*	3	5
Remanufacturing	1/3 = 0.33	1	1	3
Recycle	1/3 = 0.33	1	1	5
Landfill	1/5 = 0.20	1/3 = 0.33	1/5 = 0.20	1
Sum	1.86	5.33	5.20	14

Note: *When considering the 'labor cost' sub-factor, if the team moderately preferred the 'direct reuse' method than the 'remanufacturing' method, then the team filled the score of 3.

Table 3. Example of the adjusted scores of the "labor cost" sub-factor.

The "Labor Cost" Sub-Factor	Adjusted Score				Total Adjusted Score
	Direct Reuse	Remanufacturing	Recycle	Landfill	
Direct Reuse	1/1.86 = 0.538	3/5.33 = 0.563	3/5.20 = 0.577	5/14 = 0.357	(0.538+0.563+0.577+0.357)/4 = 0.509
Remanufacturing	0.33/1.86 = 0.177	1/5.33 = 0.188	1/5.20 = 0.192	3/14 = 0.214	(0.177+0.188+0.192+0.214)/4 = 0.193
Recycle	0.33/1.86 = 0.177	1/5.33 = 0.188	1/5.20 = 0.192	5/14 = 0.357	(0.177+0.188+0.192+0.357)/4 = 0.229
Landfill	0.20/1.86 = 0.108	0.33/5.33 = 0.062	0.20/5.20 = 0.038	1/14 = 0.071	(0.108+0.062+0.038+0.071)/4 = 0.070
Sum	1	1	1	1	1

Note: The denominators used in this table come from the summed scores in Table 2.

each decision option of each sub-factor was calculated by multiplying each total adjusted score with its sub-factor weight (calculated from the AHP). For example, the total weight of the direct reuse method when considering the "labor cost" sub-factor equaled to the total adjusted score of 0.508 multiplied by the weight of the "labor cost" sub-factor (0.09, see Figure 2). It was then 0.508 × 0.09 = 0.046.

Once the total weight scores of each decision option of the 15 sub-factors were calculated, the net weight score of each decision option of each sub-factor was achieved by multiplying each total weight score with its associated factor's weight achieved from the AHP. For example, the net weight score of the direct reuse method when considering the "labor cost" sub-factor equaled the total weight score of 0.046 multiplied by the weight of Economic factor (0.57, see Figure 2). It was then 0.046 x 0.57 = 0.026. The net weight score of the remanufacturing method when considering the "labor cost" sub-factor, alternatively, equaled the total weight score of 0.017 multiplied by the weight of Economic factor, which 0.017 x 0.57 = 0.010.

Once the net weight scores of each decision option of the 15 sub-factors were calculated, the final weight score of each decision option was achieved by summing the net weight scores of the 15 sub-factors in that decision option. To illustrate, the final net weight score of the direct reuse option was achieved by summing the net weight score of the "labor cost" sub-factor with the net weight score of the "inventory cost" sub-factor with the "transportation cost" sub-factor, and so on.

The decision option with the highest final net weight score was considered the best reverse logistics decision to implement in the organization.

Table 4 shows the final net weight scores of the two companies. The first company considered the direct reuse method as the most appropriate method of reverse logistics. This is consistent with the company's strategy, as the direct reuse of construction materials does not require high costs of waste sorting and waste processing. The team also mentioned that with limited project time, the direct reuse method seemed to be the best reverse logistics method of the company.

The second company had similar opinions as the first company that the direct reuse is the most appropriate method to implement. However, if the materials cannot be direct reused, the company preferred to dump them into landfill without considering recycling or remanufacturing them. This had do with low landfill charge compared with the transportation and processing costs (as shown in Figure 2 with high important weights of the "transportation cost" and the "processing cost" sub-factors). Moreover, with the intense project time, the recycling or remanufacturing methods might be considered inappropriate.

5. Conclusions

This study considered four types of reverse logistics methods, namely the direct reuse, the remanufacturing, the recycling, and the landfill methods, in the construction industry. The Economics and Site-specific factors were used, together with their 15 sub-factors, to develop the hierarchy model of reverse logistics decisions using the AHP program. The results revealed the importance of the Economic factor over the Site-specific factor, especially in the "transportation cost", "processing cost", and "specific sorting technology" sub-factors. Apart from that, the intense project time might affect the decision to reuse or recycle the C&D wastes.

The construction company can utilize the developed hierarchy model to assess the most appropriate reverse logistics method to implement. In this study, two case studies selected the direct reuse method, as it gave the highest final

Table 4. Final net weight scores of the two companies.

Final Net Weight Score	Direct Reuse	Remanufacturing	Recycle	Landfill
Company # 1	0.59	0.17	0.20	0.04
Company # 2	0.45	0.05	0.16	0.34

net weight score among the four methods. This might be because of the cost and time savings of this method to implement. The company can plan for their reverse logistics program based on the assessment results.

Data used for the analysis in this study derived from experts who their companies are located in Bangkok. More interviews, nevertheless, might be conducted from experts in different geographical areas to increase the accuracy of the data.

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References

Bonderud, K. 2013. Solid Waste Recycling and Waste Reduction Programs. Informational Paper 70, Wisconsin Legislative Fiscal Bureau. Available from: http://legis.wisconsin.gov/lfb/publications/Informational-Papers/Documents/2013/ 70_Solid%20Waste%20Recycling%20and%20Waste%20Reduction%20Programs.pdf. [October 2, 2012].

Bouzon, M., Spricigo, R., Rodriguez, C.M.T. and De Queiroz, A.A. 2012. Reverse Logistics: Stakeholders' Influence, Barriers and Opportunities in a Case Study in Southern Brazil. Available from: http://expertise.hec.ca/rirl/wp-content/uploads/2011/05/Logistiqueinvers% C3%A9e-Reverse-Log.pdf. [April 20, 2013].

Chapman, A., Bartlett, C., McGill, I., Parker, D. and Walsh, B. 2009. Remanufacturing in the UK. A Snapshot of the Remanufacturing Industry in the UK in 2009. Centre for Remanufacturing and Reuse Used under Creative Commons License. Available from: http://creativecommons.org/licenses/by-nc-sa/2.0/uk/. [April 22, 2014].

Chen, Z., Li, H. and Wong, C.T.C. 2002. An application of bar-code system for reducing construction wastes. Automation in Construction. 11(5), 21-33.

Chittithaworn, C., Islam, M.A., Keawchana, T. and Yusuf, D.H.M. 2011. Factors affecting business success of small and medium enterprise (SMEs) in Thailand. Asian Social Science. 7(5), 180-190.

Collins, R. 1997. Recycled concrete. Quarry Management. 24(12), 31-36.

El-Haggar, S.M. 2007. Sustainable Industrial Design and Waste Management: Cradle-to-Cradle for Sustainable Development, Elsevier Academic Press, Maryland Heights, U.S.A.

Fatta, D., Papadopoulos, A., Avramikos, E., Sgourou, E., Moustakas, K. and Kourmoussis, F. 2003. Generation and management of construction and demolition waste in Greece – an existing challenge. Resources, Conservation, and Recycling. 40(1), 81-91.

Hao, J.L., Hills, M.J. and Tam, V.W.Y. 2008. The effectiveness of Hong Kong's construction waste disposal charging scheme. Waste Management and Research. 26(6), 3-8.

Ibrahim, A.R.B., Roy, M.H., Ahmed, Z.U. and Imtiaz, G. 2010. Analyzing the dynamics of the global construction industry: past, present and future. Benchmarking: An International Journal. 17(2), 232-252.

Jang, Y. and Townsend, T. 2001. Sulfate leaching from recovered construction and demolition debris. Advances in Environment Research. 5, 203-17.

Lawson, N., Douglas, I., Garvin, S., McGrath, C., Manning, D. and Vetterlein, J. 2001. Recycling construction and demolition wastes-a UK perspective. Environmental Management and Health. 12(2), 146-157.

Lee, C.K.M. and Chan, T.M. 2009. Development of RFID-based reverse logistics system. Expert Systems with Applications. 36(5), 9299-9307.

Liu, Z., Osmani, M., Demian, P. and Baldwin, A.N. 2011. The Potential Use of BIM to Aid Construction Waste Minimalisation. Centre Scientifique et Technique du Bâtiment (CSTB), Loughborough University Institutional Repository, Leicestershire, UK.

Lund, R.T. 1984. Remanufacturing: the Experience of the United States and Implications for Developing Countries, World Bank, U.S.A.

Maqsood, I., Huang, G.H. and Zeng, G.M. 2004. An inexact two-stage mixed integer linear programming model for waste management under uncertainty. Civil Engineering and Environmental Systems. 21(3), 187-206, DOI: 10.1080/10286600410001730698.

Melo, M. T., Nickel, S. and Saldanha-da-Gama, F. 2009. Facility location and supply chain management – a review. European Journal of Operational Research. 196(2), 401-412.

Melon, M.G., Beltran, P.A. and Cruz, M.C.A. 2008. An AHP-based evaluation procedure for innovative educational projects: a face-to-face vs. computer-mediated case study. Omega. 36, 754-765.

Mollenkopf, D., Russo, I. and Frankel, R. 2007. The returns management process in supply chain strategy. International Journal of Physical Distribution and Logistics Management. 37(7), 568-592.

Oyeshola, K. and Shabbir, H. 2009. Estimation of construction waste generation and management in Thailand. Waste Management. 29(2), 731-738.

Peng, C.L., Scorpio, D.E. and Kibert, C.J. 1997. Strategies for successful construction and demolition waste recycling operations. Construction Management and Economics. 15(1), 49-58.

Poon, C.S., Yu, A.T.W. and Ng, L.H. 2001. On-site sorting of construction and demolition waste in Hong Kong. Resources, Conservation and Recycling. 32, 157-172.

Renbi, B. and Mardina, S. 2002. The practice and challenges of solid waste management in Singapore. Waste Management. 22(5), 557-567.

Saaty, T.L. 2008. Decision making with the analytic hierarchy process. International Journal of Services Sciences. 1(1), 83-98.

Schultmann, F. and Sunke, N. 2007. Organization of reverse logistics tasks in the construction industry. In Sustainable Construction, Materials, and Practices, Braganca *et al.*, editors. Portugal SB07, IOS Press, Amsterdam, The Netherlands.

Shakantu, M.W., Muya, M., Tookey, J.E. and Bowen, P.A. 2009. Conceptualising reverse logistics in a construction context: re-defining their contours. Journal of Contemporary Management. 6, 81-96.

Srdjevic, Z., Samardzic, M. and Srdjevic, B. 2012. Robustness of AHP in selecting wastewater treatment method for the coloured metal industry: Serbian case study. Civil Engineering and Environmental Systems. 29(2), 147-161, DOI: 10.1080/10286608.2012.672412.

Srivastava, S.K. 2008. Network design for reverse logistics. Omega. 36, 535-548.

Tam, V.W.Y., Shen L.Y., Fung, I.W.H. and Wang, J.Y. 2007. Controlling construction waste by implementing governmental ordinances in Hong Kong. Construction Innovation: Information, Process, Management. 7(2), 149-166.

Tam, V.W.Y. and Tam, C.M. 2006. A review on the viable technology for construction waste recycling. Resources, Conservation, and Recycling. 47, 209-221.

Terrance, L., Pohlen, M. and Theodore, F. 1992. Reverse logistics in plastics recycling. International Journal of Physical Distribution and Logistics Management. 22 (7), 35-47.

US Environmental Protection Agency. 1998. Characterization of building-related construction and demolition debris in the United States. Report No. EPA530-R-98-010, Municipal and Industrial Solid Waste Division, Office of Solid Waste, U.S.A.

Waters, D. 2003. Inventory Control and Management, John Wiley and Sons, West Sussex, England.

Wright, R., Richey, R.G., Tokman, M. and Palmer, J.C. 2011. Recycling and reverse logistics. Journal of Applied Business and Economics. 12(5), 9-20.

Yuan, H. and Shen, L. 2011. Trend of the research on construction and demolition waste management. Waste Management and Research. 31, 670-679.

Zou, X. and Moon, S. 2014. Hierarchical evaluation of on-site environmental performance to enhance a green construction operation. Civil Engineering and Environmental Systems. 31(1), 5-23, DOI: 10.1080/10286608.2012.749871.