Construction Waste Management in Newly Industrialized Countries

Manowong, E.
Civil Engineering Department, Bremen University of Applied Sciences, Bremen, Germany
(email: emanowong@ext.hs-bremen.de)
Brockmann, C.
Civil Engineering Department, Bremen University of Applied Sciences, Bremen, Germany
(email: Christian.Brockmann@hs-bremen.de)

Abstract

Newly industrialized countries are in transition towards the stage of advanced industrialized countries. The dynamic of this process leads to a change of institutions. Institutions can be understood as social structures with a high degree of resilience and they rest on the three pillars of regulations, norms and culture (Scott, 2001). New Institutional Theory can provide a framework of analysis for the problem of construction waste. Millions of tons of waste from construction and demolition (C&D) activities are generated every year. Problems related to C&D waste are being faced in least developed, newly industrialized, and advanced industrialized countries but the problems are handled within different institutional frameworks. Literature and data on C&D waste management in advanced industrialized countries are abundant; however, this is not the case for newly industrialized countries such as Thailand. A field study on C&D waste management in Thailand based on site observations, questionnaire surveys, and interviews provides data for an institutional analysis while a review of the existing literature on other least developed and new industrialized countries allows broadening the analysis. While urbanization in newly industrialized countries accelerates with great speed, the institutions of C&D waste management are developing at a slower rate. They are lagging behind in comparison with the status in advanced industrialized countries. Findings and lessons learned are expected to contribute to raising awareness and willingness for a change of institutions among policymakers, developers, and key construction stakeholders at the national level in Thailand and internationally among those of developing and newly industrialized countries.

Keywords: newly industrialized countries, new institutional theory, construction, waste management, Thailand

1. Introduction

Institutional theory has expanded from a formative stage in the works of Marx, Weber, and Veblen to what is called today New Institutional Theory (Selznick, 1948; Powell and Dimaggio, 1991; Scott, 2001). It can be used for the analysis of society as well as economics. As C&D waste management is both, a societal and an economic problem, New Institutional Theory provides a promising framework. Therefore, the three institutional pillars of regulations, norms, and culture (Scott 2001) are categories of our analysis.

According to the per capita gross national income, countries can be differentiated into least developed (LDC, or low income countries), newly industrialized (NIC, or middle income countries), and advanced industrialized countries (AIC, or high income countries). The transition from LDC to NIC is especially marked by a move from an agrarian to an industrializing economy; the one from NIC to AIC is typified by a further industrialization and a widening of the service sector (World Bank, 2003). The changes are accompanied by an institutional development as the old institutions are no longer adapted to the environment.

Thailand is a NIC with high economic growth in the past and a rapid urbanization. There is a host of environmental problems connected to C&D waste management. A lack of landfills leads for example to dumping in public areas, causing environmental problems to the local communities. Research on and implementation of C&D waste management are rather new issues in Thailand. Thus, data were gathered on the status quo within the construction industry in different regions of Thailand. Then, the available literature on C&D waste management practices in other NICs was also studied. A comparative analysis allowed us to identify obstacles, potentials and opportunities for future improvement and implementation of sustainable C&D waste management for Thailand as well as other newly developed countries.

2. C&D waste management problems and practices

2.1 Global economic and environmental problems

The construction industry is globally among the main consumers of energy and resources. Excessive use of natural resources and a large amount of C&D waste are a result of a lack of awareness of resource-efficient construction practices (UNEP, 2002). The methods of Reduce, Reuse, and Recycle (3Rs) are widely applied for municipal waste management but less practiced in the construction industry. One of the reasons is that recycling building materials is not cost-effective (Wong and Yip, 2004). There is a lack of market demand for some types of construction waste such as concrete and broken bricks (Duran et al., 2006). Previous research on C&D waste has mainly focused on the types of wastes, management processes, and technologies. The institutional development (e.g. willingness to change attitudes and behaviour pertaining to waste generation, collection, and disposal) has been less researched. There is a need to investigate the construction project stakeholders' attitude and percep-

tion reflecting their actual needs, behaviour, and decision making regarding waste handling (Kulatunga et al., 2006).

2.2 Newly and advanced industrialized countries

Advanced institutions of C&D waste management have been implemented in AICs such as Australia, Denmark, Germany, the Netherlands, the UK, and the USA. In these countries, acceptance of recycled materials is driven by scarcity of landfill sites and natural resources (Addis, 2006). Issues of waste recycling are well covered by established policies, legislations, directives, and waste management strategies. Construction stakeholders have been widely involved in the process by government agencies such as the "Kreislaufwirtschaft" (Recycle) scheme in Germany, the Department for Business, Enterprise and Regulatory Reform (BERR) in the UK, and the US Green Building Council's Leadership in Energy and Environmental Design (Weisleder and Nasseri, 2006). Such initiatives aim to help the construction industry in delivering more sustainable construction methods and products with improved resource efficiency, overall effectiveness, and social responsibility (BERR, 2008). In Asia, AICs such as Japan, Hong Kong, and Singapore are well equipped with advanced C&D waste management practices. In such countries, there exist not only specific regulations and norms for C&D waste management but also extensive research on C&D waste management is available.

Asian NICs such as China, India, Indonesia, Malaysia, Sri Lanka, and Thailand, as well as NICs in Africa and South America, are still in need of institutional development for C&D waste management. Generally in Asia, national and regional policies, laws, and regulations governing 3R principles for C&D waste are rare and the 3R program is rather spearheaded by relevant international organizations (Nitivattananon and Borongan, 2007). Examples are the Asian Development Bank (ADB), the Canadian International Development Agency (CIDA), and the German Gesellschaft für Technische Zusammenarbeit (GTZ, Technical Cooperation Agency) who work in cooperation with different Asian governments.

2.3 The example of Thailand

Thailand has been experiencing high economic growth which has lead to rapid urbanization and an increased demand of real estate and infrastructure development. In consequence, large amounts of waste have been generated from construction activities. Similarly to other NICs with transition economies, Thailand has just begun to broadly study and promote C&D waste management (PCD, 2007). As such, there does not exist a widely published body of academic research on C&D waste management in Thailand. Recently, Kofoworola and Gheewala (2009) attempted to estimate the C&D waste generation in Thailand and emphasized benefits of C&D waste recycling in terms of job creation and energy savings.

3. Objectives, methods of study and analysis

This study aims to examine current C&D waste management practices in Thailand in order to produce an output that is useful for the country's regulatory and normative framework for C&D waste management in the future. As stakeholders' inputs are crucial, norms, attitudes and perceptions of Thai construction stakeholders were studied, and so were regulatory initiatives from the private sector and the government. Furthermore, the study also builds upon experiences from different NICs in order to broaden knowledge of C&D waste management approaches.

The field study was carried out in 2008. Construction projects of various sizes (small, medium, and large) in various regions of Thailand were selected for the study attempting to generally reflect the C&D waste situation within the country. There were nine projects from the Bangkok metropolitan and peripheral provinces, ten projects from the north, three projects from the north-east, and twelve projects from the south of the country. Data were collected via site observations, questionnaire surveys and interviews. General statistics were applied for data analysis. Then, practices in other NICs were studied by means of a literature review and qualitative analysis. The status quo is evaluated based on the following aspects:

1. Construction waste quantification and classification.
2. Regulatory institutions for C&D waste management
3. Normative institutions for C&D waste management
4. Construction waste recyclability and resource recovery

4. Results and findings

4.1 C&D waste quantification and classification in Thailand

There were in total 384 respondents directly or indirectly involved with construction projects and/or affected by such projects. They are project participants (e.g. project owner, managers, designers, site engineers, foremen, workers; 43.7%), government officials (24.3%), people from the local community (living or working near construction sites; 31.0%), and waste recycling companies (1.0%). The survey results reveal that the largest amount of waste was generated during the construction stage (67.6%) compared to other stages such as material transportation and preparation (14.2%), and design (9.7%). Figure 1 shows the amount of waste of different construction materials produced on-site as well as the preferred waste handling method. Materials such as concrete and bricks were largely dumped to landfill sites because they were considered as difficult to recycle or reuse. Only metal, wood, paper, and plastic were more often recycled than sent to land fills.

Especially on small scale projects, C&D waste is not segregated so that broken bricks and tiles, cement, plastering, cement bags, packaging and other rubbish are mixed together and then sent for land filling. Hence, improper handling on construction sites and material yards (cf. fig. 2) is considered as

one of the major causes that made large volumes of waste material not reusable or recyclable as they were mixed and as their quality was considerably reduced. The variation in composition of C&D waste in Thailand is high. As a result, such materials cannot be reused in construction. The construction firms segregate only immediately reusable and recyclable C&D debris such as steel and wooden frames. The rest of C&D waste such as concrete debris, bricks and cut-off piles are mixed with other types of waste and disposed as fill material.

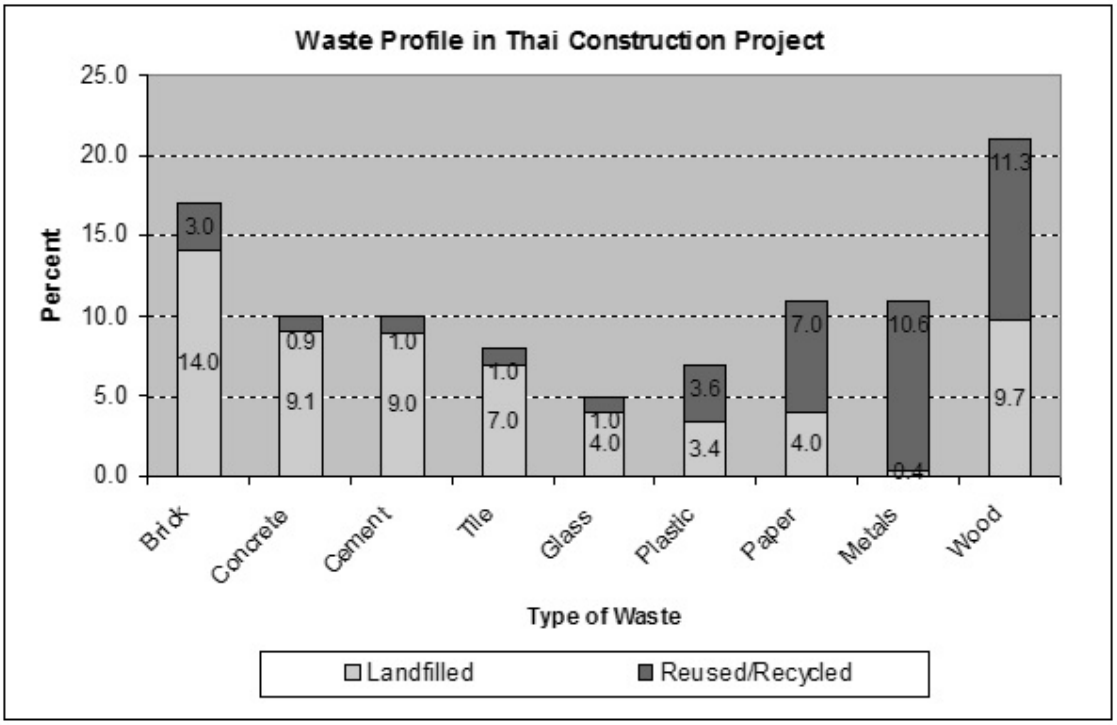

Figure 1: Construction site waste profile and management in Thailand

Figure 2: Mixed and improper store of C&D waste

4.2 C&D waste regulations

57% of the respondents knew of related C&D waste management regulations in their localities. Some of the construction contractors had already initiated their own waste management processes such as keeping C&D waste in separated storage areas and transporting C&D waste to landfills. However, a considerable percentage of the respondents (26.6%) were unaware of any regulations on C&D waste management, or they even indicated that there were no such regulations (16.4%). In fact, Thailand has no regulations specifically pertaining to the management of C&D waste. The available environmental protection laws are applied as fundamental guidelines for waste handling, transportation, and disposal. Besides, the unclear regulatory situation of C&D waste management has lead to uncertainty of local government officials with regard to their role. They are not sure who should be responsible for dealing with C&D waste.

4.3 C&D waste norms of Thai construction stakeholders

The respondents indicated that the best way to manage construction waste is to "Recycle" (44.2%), followed by "Landfill" (34%), "Reduce" (9.6%), "Reuse" (8.3%), and other options (3.9%) respectively (cf. fig.3). As a norm, recycling construction waste is a highly acceptable option. It was emphasized that selection of the C&D waste management alternatives depends on types of construction waste generated from construction activities. There is no significant statistical difference (Chi-Square Test; Sig. = 0.836) between gender. However, it was found that more women clearly prefer recycling to land filling while men's opinions on these two options did not much differ. This implies that, in Thailand, women may be more responsive to recycling regulations.

Figure 3: Respondents' preference on C&D waste management options

The construction stakeholders' norms were further investigated regarding obstacles to and limitation of construction waste management in Thailand. While the norms show a preference for recycling, the 3Rs are hardly practiced because it is difficult to change the people's behaviour and because the process is regarded as being costly. Project owners rank "profit" as the most important factor while rating "waste management" as the least important. Any additional investment leading to a reduction of profits is not favoured. In sum, implementing 3Rs is valued only as long as there is no financial trade-off involved. Recycled construction products are not popular for consumers in Thailand. However, other factors promote implementation of C&D waste management such as "health and safety", "social and environmental impacts", "quality of work", "time management", and "expenses" because they were overall ranked as important factors supporting more engagement in C&D waste management.

4.4 Construction waste recyclability and resource recovery

An additional study was carried out attempting to investigate potential energy savings in the studied projects through C&D waste management. This estimate is based on the approach proposed by Kofoworola and Gheewala (2009). By applying recent construction information provided by Thailand's National Statistical Office (TNSO, 2009), it was found that the amount of Thailand's construction waste generated in 2008, i.e. the period of this study, was estimated at 1.03 million tons. Assuming that construction waste previously sent for land filling would be recycled, total energy savings would have been about 57.4×10^5 GJ or 1,593 kWh per year. If all waste generated on-site would be recycled, the total amount of energy saving would increase to 127.9×10^5 GJ or 3,553 kWh per year. The total value of energy savings is approximately 5,300 millions Baht (106 millions Euros) per year.

4.5 Comparing C&D waste management practices in Thailand and other NICs countries

Results of C&D waste status and management practices in Thailand and other NICs from Asia are compiled and briefly compared (table 1) as well as from other countries (table 2). They are discussed in the next section.

5. Discussions and recommendations

In Thailand, some construction waste such as wood, plastic, paper and metal is used for recycling but a larger part such as concrete, cement, and bricks is sent to land fills because of lower cost and greater convenience. This is similarly found to be the case in other NICs. It is difficult to change such behaviour of construction operatives as long as it is not economically rewarded. This constitutes the most important obstacle for improving voluntary C&D waste management. As indicated by Kulatunga et al. (2006), attitudes and behaviour of construction operatives limits the extent of waste management. The additional cost of the process discourages recycling of C&D waste, as previously pointed out by Duran et al. (2006). All activities affecting economic interests face resistance. Hence, to encourage

recycling of C&D wastes, it is essential to promote economic incentives as a leading objective. Although salvaged materials are commonly reused, many consumers are little attracted to products made from recycled waste. Hence, the government agencies could take a lead in using more recycled products in the public construction projects.

Table 1: Comparison of C&D waste management status quo in NICs (Asia)

Country	***Classification Quantification (tons/year)***	***Regulations***	***Norms***	***R&D, Recyclability, Resource Recovery***
China	• *No classification* • *18 millions in 2008 (Jones, 2007 and RIC, 2009)*	• *No specific C&D law* • *Environmental laws for construction projects (Chen et al., 2007)* • *Strictly imposed on municipal projects (Jones, 2007)*	• *Low awareness and willingness of contractors (Chen et al., 2007)* • *Low public awareness (Chen et al., 2007)*	• *Growing R&D, extensive in Hong Kong* • *Many recycling facilities* • *Building houses from C&D waste (Fan, 2009)*
India	• *No classification* • *20 millions in 2003 (Joseph, 2007)*	• *No specific C&D law* • *Environmental laws for all large construction projects* • *Municipal rules require C&D waste to be separately stored and disposed (Joseph, 2007)*	• *Low awareness (Kumar, 2007)* • *Growing trend of willingness for reuse & recycle*	• *Growing R&D* • *Waste used as mixture of road construction material (Merchant, 2009)* • *Solid waste & energy recycling facility initiated (Joseph, 2007)*
Malaysia	• *No classification* • *2 millions (Periathamby et al., 2009 and Begum et al, 2006)*	• *No specific C&D law* • *Reuse & Recycle are promoted (Begum et al, 2006)* • *Encouraged economic return policy (Begum et al, 2006)*	• *Low awareness (Begum et al, 2006)*	• *Growing R&D supported by government* • *Currently focused on waste minimization through economic incentives (Begum et al, 2007)*
Sri Lanka (Lower Middle Income)	• *No classification* • *No data*	• *No specific C&D law(COWAM, 2004)* • *Environmental law and waste regulations available but devoid of penalty/incentive (COWAM, 2004)*	• *Moderate to high awareness* • *Low willingness, less priority given (Kulatunga et al., 2006)*	• *R&D assisted by foreign supports (COWAM, 2004)* • *Concrete waste not recycled (COWAM, 2004)* • *Reuse/Recycle industry newly emerged, with high demand*
Thailand	• *No classification* • *1 million (field study in 2008)*	• *No specific C&D law* • *Investigation on reuse & recycle of disaster debris was initiated (Nitivattananon and Borongan, 2007)*	• *Moderate to high awareness* • *Low willingness*	• *Beginning R&D*
Vietnam (Low Income)	• *No classification* • *1million (VEM, 2004)*	• *No specific C&D law* • *Little environmental liability of waste producers (VEM, 2004)*	• *Low awareness and willingness*	• *R&D focused only on hazardous waste*

Table 2: Comparison of C&D waste management status quo in NICs (world)

Country	*Classification Quantification (tons/year)*	*Regulations*	*Norms*	*R&D, Recyclability, Resource Recovery*
Botswana (Urio and Brent, 2006)	• *No classification* • *No data*	• *Government initiated waste management project in 1993 and waste management Act in 1998*	• *Low awareness and willingness*	• *Beginning R&D* • *Current attempt to introduce proactive legislation on waste reduction*
Egypt (Al-Ansary et al., 2004)	• *4.5 millions*	• *C&D waste based on Environmental Law*	• *Low awareness and willingness*	• *Beginning of R&D* • *There was an attempt to promote practices of 4Rs (Reduce, Reuse, Recycle, Recovery)*
South Africa (Bester et al., 2004)	• *No classification* • *No data*	• *No specific C&D law*	• *Low awareness and willingness*	• *Beginning R&D*
Romania (Biggs et al., 2008)	• *No classification* • *No data*	• *The European Commission's Waste Framework Directive (codified and in force since 2006)*	• *High awareness on waste issues among public and officials* • *Otherwise low awareness and willingness*	• *Professionalized recycled/salvage services available across all industries* • *Energy efficiency focused in real estate sector*
Turkey (Esin and Cosgum, 2007)	• *No classification* • *No data*	• *Regulation on the Control of Excavation, C&D waste issued on March 18, 2004* • *The rule is not yet implemented*	• *Low awareness and willingness*	• *Beginning R&D*
Brazil	• *68.5 millions (John et al., 2004)* • *C&D waste are classified into two classes: Red & Grey (John et al., 2004)*	• *CONAMA Resolutionno.307 announced in 2002, municipalities must implement C&D waste strategies (Nunes et al., 2007)* • *A Technical Group on C&D waste was formed and waste transfer stations established (John et al., 2004)*	• *Low awareness and willingness*	• *Research focuses on financial viability for C&D waste recycling investment (Nunes et al., 2007)* • *12 cities have operating scheme with recycling plants (John et al., 2004)* • *Recycled materials used in road construction (John et al., 2004)*

One common problem of C&D waste management in NICs is a lack of official records of C&D waste. Regarding the institutional initiatives, there are no regulations specifically dealing with C&D waste management in Thailand. Most regulations are related to environmental protection laws, and the situation is similar for majority of other NICs. At the same time, research and development on waste management or recycled products as construction materials are also key factors to reflect a country's intention to achieve the goal of sustainable construction. Some NICs are already more active on C&D waste research, supported by government and the construction industry. It is, however, not necessary to manage C&D waste with high technology and expensive recycling facilities. As practiced in India

(Merchant, 2009), it has been proved that use of recycled materials in basic infrastructure construction can be economical.

It is therefore recommended that NICs with limited financial resources should combine C&D waste management initiatives with the countries' basic requirements for economic development, while improving environmental protection and social welfare. To achieve such goals, specific challenges have to be overcome: (1) Positive change of the norms of construction stakeholders with regard to C&D waste management. (2) Establishing of waste classification systems with quantification of waste. (3) Waste reduction. (4) Integration of recycling and national energy savings programs. (5) Extended research on C&D waste recyclability and its implementation, with support from public and private sectors to provide broader alternatives for handling C&D waste. (6) Establishment and enforcement of specific regulations. Although they are not motivating factors to improve C&D waste management practices, they are essential starters and drivers to achieve the goal of sustainable construction in NICs.

6. Conclusion

C&D waste in NICs usually is a result of their rapid economic growth and urbanization. Many governments of NICs are lacking institutions for C&D waste management. Although waste reuse and recycling are practiced, this applies only to some kinds of waste such as steel, paper, wood, and plastic. Inert waste such as concrete and bricks are not recycled in most NICs, including Thailand. On the other hand, possible energy savings in Thailand could range from 57.4×10^5 GJ or 1,593 kWh to 127.9×10^5 GJ or 3,553 kWh per year. As real estate and infrastructure development in NICs continues to expand, C&D waste generation is likely to increase further. Sustainable construction in NICs can be achieved through effective utilization of resources in construction, material recovery, an improved system for C&D waste management, and energy savings. In the case of Thailand and other NICs, low-cost management strategies and tactics are possible and should be primarily considered. However, the first objective to be achieved is a change of the stakeholders' norms. To drive towards the goal of sustainable construction in NICs, strong regulatory initiatives such as specific laws and policies for C&D waste management are as important as the stakeholders' awareness and willingness to participate.

Acknowledgement

The authors are truly grateful for all supports from the Alexander von Humboldt Foundation and Bremen University of Applied Sciences. The first author receives a Georg Forster Postdoctoral Research Fellowships from the Alexander von Humboldt Foundation to carry out a postdoctoral research on construction waste management at Bremen University of Applied Sciences from November 2009 to October 2011.

References

Addis, B (2006) *Building with Reclaimed Components and Materials: Design Handbook for Reuse and Recycling*, London, Earthscans Publications.

Al-Ansary M, El-Haggar S and Taha M (2004) "Sustainable Guidelines for Managing Demolition Waste in Egypt", *International RILEM Conference on the Use of Recycled Materials in Building and Structures*, 9-11 November 2004, Barcelona, Spain.

Begum R, Siwar C, Pereira J, and Jaafar A (2006) "A Benefit–Cost Analysis on the Economic Feasibility of Construction Waste Minimization: the Case of Malaysia." *Resources, Conservation and Recycling*, **48**: 86-98.

Begum R, Siwar C, Pereira J, and Jaafar A (2007) "Factors and values of willingness to pay for improved construction Waste management: A perspective of Malaysian contractors." *Waste Management* **27**: 1902-1909.

Business, Enterprise and Regulatory Reform Department (BERR) (2008) *The Strategy for Sustainable Construction Consultation*, (available online http://www.berr.gov.uk/sectors/construction/sustainability/page13691.html [accessed on 24/05/2008])

Bester J, Kruger D and Hinks A (2004) "Construction and demolition waste management in South Africa", *Proceedings of the 2004 International Conference 'Sustainable Waste Management Recycling'*, 14-15 September 2004, London, UK.

Chen Z, Li H, and Wong C (2000) "Environmental management of urban construction Projects in china." *Journal of Construction Engineering and Management*, **126**(4): 320-324.

COWAM (2004) *Strategy for Sustainable Construction and Demolition Waste Management in Galle, Sri Lanka*, (available online http://www.cowam-project.org/cms/Content/download/Interim_Report_Vision_2018.pdf [accessed 1/10/2009])

Duran X, Lenihan H, and O'Regan B (2006) "A model for assessing the economic viability of construction and demolition waste recycling-the case of Ireland." *Resources, Conservation and Recycling* **46**: 302–320.

Esin T and Cosgun N (2007) "A study conducted to reduce construction waste generation in Turkey." *Building and Environment* **42**: 1667-1674.

Fan L (2009) *Using Construction Waste to Build Houses*, (available online http://www.cbfeature.com/chinese_company/news/using_construction_waste_to_build houses [accessed 1/1/2009])

Biggs J, Bieru A, Bocaneanu S, Frangeti S and Dragnea D (2008) *Opportunities for Green Construction and Energy Efficient products, material and technology in Romania and the Central Eastern*

European region (available online http://www.rogbc.org/romania-green-building-council/documents/Green_Building_Products_and_Services.pdf [accessed 24/11/2009])

Jones S (2007) *Highlights of Waste Control Laws and Regulations in China. Fact Sheet: A China Environmental Health Project*, (available online http://www.wilsoncenter.org/topics/docs/_waste-law.pdf [accessed 20/11/2009])

Joseph K (2007) "Lesson from Municipal Solid Waste Processing Initiatives in India", *International Symposium MBT 2007*, 22–24 May 2007, Hannover, Germany.

Kofoworola O and Gheewala S (2009) "Estimation of construction waste generation and management in Thailand." *Waste Management* **29**: 731-738.

Kulatunga U, Amaratunga D, Haigh R., and Rameezdeen R (2006) "Attitudes and perceptions of construction workforce on construction waste in Sri Lanka." *Management of Environmental Quality: An International Journal*. **17**(1): 57-72.

Merchant V (2009) *Use of Dirty Comingled Plastic Waste in Road Construction in India: Creating Value - Challenges & New Opportunities with Indigenous Technology*, (available online http://www2.plasticseurope.org/files/event_files/New%20opportunity%20with%20indigenous%20technology.pdf [accessed on 15/11/2009])

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 2007, Chennai, India.

Nunes K, Mahler C, Valle R, and Neves, C. (2007) "Evaluation of investments in recycling centres for construction and demolition wastes in Brazilian municipalities." *Waste Management* **27**: 1531-1540.

Periathamby A, Hamid F and Khidzir K (2007) "Evolution of solid waste management in Malaysia: impacts and implications of the solid waste bill, 2007." *Journal of Material Cycles and Waste Management* **11**(2): 96-103.

Pollution Control Department (PCD) (2007) *A Study of the Guideline for C&D Waste Management in Thailand*, Bangkok, Ministry of Natural Resources and Environment.

Powell W and DiMaggio P (1991) *The New Institutionalism in Organizational Analysis*, Chicago, University of Chicago Press.

Research In China (RIC) (2009) *The vertical portal for Chinese business intelligence, announces the release of a new report - China Solid Waste Disposal Industry Report 2009*, (available online http://www.researchinchina.com/Htmls/Report/2009/5784.html [accessed 24/11/2009])

Scott W (2001) *Institutions and Organizations*, Thousand Oaks, Sage.

Selznick P (1948) "Foundations of the Theory of Organizations" *American Sociological Review* **13**: 25-35.

Thailand's National Statistical Office (TNSO) (2009) *The 2008 construction area survey*, (available online http://web.nso.go.th/en/survey/construction/con_area09.htm [accessed 17/11/2009])

United Nations Environmental Programs (UNEP) (2002) *Urban Areas. Global Environment Outlook 3: Past, present and future perspectives*, London, Earthscans Publications.

Urio A and Brent A (2006) "Solid waste management strategy in Botswana: The reduction of construction waste." *Journal of the South African Institution of Civil Engineering* **48**(2): 18–22.

Vietnam Environment Monitor (VEM) (2004) (available online http://siteresources.worldbank.org/INTVIETNAM/Data%20and%20Reference/20533187/VEMeng.pdf [accessed 1/11/2009])

Weisleder S and Nasseri D (2006) *Construction and Demolition waste Management in Germany*, A study report, The EU-ASIA PRO ECO II B Post-Tsunami Programme.

Wong E and Yip R (2004) "Promoting sustainable construction waste management in Hong Kong." *Construction Management and Economics* **22**: 563–566.

World Bank (2003) Classification of Economies (available online http://siteresources.world-bank.org/INTRGEP2004/Resources/classification.pdf [accessed 20/12/2009])