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A Delphi Study to Identify Environmental Aspects Associated with Demolition Works

Fatemeh Nateghi, Arham Abdullah*

Department of Structures and Materials, Faculty of Civil Engineering, Universiti Teknologi Malaysia, Skudai, Johor, 81300 Malaysia.

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Abstract

Construction and demolition projects, adversely impact on environment. Environmental laws, put the responsibility of controlling environmental aspects associated with construction and demolition projects on the shoulder of contractors. Obviously, those that break the law will be heavily fined. While complying with environmental laws is a challenging task for demolition practitioners, Environmental Management System (EMS), a self-regulatory framework aims to improve environmental performance of organizations and their complying with regulations. Demolition contractors are no exception, however, the first step in implementing EMS in demolition companies is, identifying environmental aspects. While very few research works cover demolition environmental aspects, this research aims to identify them with the aid of Delphi study.

Keywords: Environmental aspect evaluation, aspect identification, Delphi study, environmental management system

1 Introduction to Environmental Concerns

Environmental concern is not a new concept. Probably the first clear definition of environmental concern was given at the United Nations conference. The conference was about human environment and held at Sweden in early 70 [1]. Twenty years later this issue was again highlighted at "Rio Conference" where worlds' leaders were asked to build a consensus on how to manage and save planet. The conference closing remarks highlighted two basic principles which have been agreed by 171 nations; sustainable development and the protection of environment. This global agreement gingered governments to take necessary, immediate and sufficient steps toward achieving sustainable development goal and protection of the environment by developing relevant environmental performance standard [2].

Government of Malaysia, professional bodies and private sectors, in conjunction with their global responsibilities and public concerns on environmental pollutions have also started to enhance awareness among companies and improve companies' knowledge about their environmental performance [3]. Construction industry although is not an exception in this movement, unfortunately, in Malaysia, controlling environmental impacts associated with construction process by practitioner is very new concept [4].In addition to that, setting environmental regulations and raising external pressure such as community's concerns encouraged companies to move towards adopting self-regulatory frameworks that introduces a strategic solution for companies' environmental aspects and impacts in early planning stage [5]. Environmental Management System (EMS) is a framework that like a road map shows how to comply with regulations and take public concerns into consideration
[6, 7, 8]. Construction industry although is not an exception in this movement, unfortunately, in Malaysia, controlling environmental impacts associated with construction process by practitioner is very new concept [8].

2 Environmental Management System and its Current Status

Compliance with regulations in particular environmental laws has always been a challenging task for construction companies. According to [9], regulation and competitive pressure(go green movement) are two main causes that force companies to deal with their environmental aspects. In this regard, EMS can be seen as a tool that brings positive changes into the organizational layers by defining new management strategies and practices that identify all opportunities to reduce environmental pollutions and continues improvement in environmental performance [10]. [11] introduce EMS as a framework for companies to define and organize their policies and also the first step for companies to move towards sustainable environment. Hence, the first environmental management system standard was introduced by British Standard in 1992 (BS7750). The European Union in 1993 prepared the first environmental management system which is called

Corresponding Author: Associated Professor Dr. Arham Abdullah. Department of Structures and Materials, Faculty of Civil Engineering, Universiti Teknologi Malaysia, Skudai, Johor, 81300 Malaysia. Email: Arham@utm.my.

'Eco-Management Audit Scheme' EMAS; and subsequently, International Organization for Standardization (ISO) introduced the ISO 14000 series which are a road map in order to compliance with regulations. Since then, countries have developed their localized version of EMS based on their local environmental regulations (eg. MS ISO 14001: 2015)

A study conducted by [12] revealed very few Malaysia construction companies have implemented EMS in their organizations when it is compared with other countries such as Japan and Hong Kong. In addition to that, from the environmental-based marketing point of view, construction in contrast with manufacturing does not struggle with trade barriers; also, environmental performance has been never considered as a selection criterion in tendering process. Therefore, practitioners in this industry neglect their environmental aspects. Besides that, from the regulatory view of point, having voluntary or self-regulatory attitude towards EMS in construction industry is considered another reason for such stalling.

The scope of this research is narrowed down to the planning phase of EMS (ISO 14001) in particular identifying significant environmental aspects in demolition works. This standard for the first time was introduced in 1996 and revised on November 2015. Majority of changes between two versions are about clarification of the clauses [13]. The implementation of ISO 14001, starts with identifying environmental aspects associated with the organization's activities. In other words, an inventory of aspects should be formed with respect to the relevant local regulations. This inventory must be later used to determine interrelationships among organizations activity and environment [2].

3 Demolition Environmental Aspects

[14] defines environmental aspects as "the most important element of any environmental management system". In the meantime, environmental aspect is the most confusing element of environmental management system. Dilemma of environmental aspect evaluation is one of the reasons that makes organizations reluctant to adopt EMS [15]. ISO 14001 defines environmental aspect as "an element of an organization's activities, products or services that can interact with the environment". This standard also explains significant environmental aspect is the one that has significant environmental impact. Organizations are responsible to establish, maintain and implement procedures to identify and determine "significant" aspects. The word "significant" is probably the beginning of dilemma. Impact and aspect are two sides of one entity. However, cause and effect relationship exists between them. Impact is caused by aspect [16]. The eco-management and audit scheme (EMAS) and also [17] categorize environmental aspects into nine main categories. This includes emission to air, release to water, waste generation, emission to land, natural and raw resources use, local issues, environmental accident and effect on biodiversity. [17 and 18] developed a comprehensive list of construction aspect (listed in Table 1). This research adopts their list of aspects duo to similarity between demolition and construction activities and with the aid of Delphi study verify and validate their aspects. It is expected to filtrate irrelevant aspects at the end of this study and major demolition environmental aspects are identified.

4 Research Methodology

Delphi has been selected as main research method of this study [19] believe Delphi should be conducted in three rounds. Analysis technique in their proposed Delphi is based on median and deviation around median (Equation 1). This is justified by the fact that no universally accepted level of standard deviation has been defined for Delphi and researchers selectively define it.

$$\text{Absolute Deviation (AD)} = (\text{Median } x_j - X_j) \quad \text{(EQ.1)}$$

The first round of study helps facilitator to understand how experts think about the questions. Median of judgments represents aggregated responses to a question. For every single question deviation between group median and responses to that question should be calculated. Average of all absolute deviations (AAD) should not be greater than one unit around median (Equation 2). This is a measure that proves achieving consensus in the round. According to [19] even if panel member reach to a good consensus in the first round, the study should be continued up to the third round.

$$AAD = \left| Average\ AD_i \right| \leq 0.5 \quad \text{(EQ.2)}$$

The results obtained in the first round should be given to the same panel members in the second round of study; experts are asked to justify the reason why for outlaying such responses if their earlier responses are two or more units from the median. By the way, experts can freely change their earlier responses by either getting closer to group medians or drifting apart from group medians. Similar to the first round, median of responses, deviation from responses and average of all absolute deviations should be calculated. Round three is the final round; in this round final opportunity is given to experts and they are asked to respond to the same questions after taking a look at justifications collected in the second round. If in this round responses shift towards those who made justifications, it means those who had two or more-unit deviation from median were correct. Similar to the first and second round of study average of all deviations around median must be calculated validate consistency of study and proof consensus forming.

5 Data Collection and Analysis

November 15th, 2013, the first round of Delphi study was started. Delphi questionnaire template which was developed in Microsoft Word was sent to 15 experts and they were asked to return the complete files within 30 days. The questionnaire form incudes 37 environmental aspects and the experts were asked to express their degree of agreement with all 37 factor if they think factors are relevant to demolition projects. Answering to the questions could be on the scale of 1 to 10 however for the sake of

simplicity, experts were asked only choose 1,3,5,7 and 9. Where 1 and 9 respectively denote not relevant at all and extremely relevant. 37 Environmental aspects along with their coding are shown here.

Table 1: Initial List of Aspects

NO.	Aspect Name
As1:	Generation of GHG (CO2, N2O,) and metal emission to air by machinery and power generator
As2:	VOC and CFC (Synthetic paint, damaged refrigerant, cleaning and liquefying agents in fuels, …)
As3:	Dumping of water resulting from dust control process to water
As4:	Dumping of sanitary water to water
As5:	Dumping due to cleaning process of machinery and tools to water
As6:	Generation of inert waste (debris, rubble, earth and concrete…)
As7:	Generation of ordinary waste (wood, plastic, metal, paper, cardboard, glass, …)
As8:	Generation of special waste (potentially dangerous such as: asbestos, lead…)
As9:	Generation of municipal waste by on-site demolition workers
As10:	Land occupancy (occupancy of public through fares by on site facilities, storage, …)
As11:	Dumping derived from the use and maintenance of demolition machinery to soil
As12:	Dumping of water resulting from the dust control to soil
As13:	Dumping of sanitary water resulting from on-site sanitary conveniences to soil
As14:	Water consumption during the demolition process
As15:	Electricity consumption
As16:	Fuel consumption
As17:	Material consumption
As18:	Dust and Particles generation
As19:	Dirtiness at the on-site entrances
As20:	Generation of noise and vibrations due to site activities
As21:	Odor generation
As22:	Landscape alteration such as existing visual and lighting alteration
As23:	Increase in external road traffic due to demolition site
As24:	Interference in external road traffic due to the demolition site.
As25:	Vegetation removal (inside and outside of site) and emission to flora habitat
As26:	Emission to fauna habitat
As27:	Create barrier to migration of animals & fish
As28:	Cause migration of animals & birds
As29:	Soil compaction and changing in absorption rate, drainage pattern and amount of surface water run off
As30:	Soil erosion and Removal of top soil
As31:	Water channelling and stream water cut off and changing river banks
As32:	Alter in national park, rivers, national forest land, …
As33:	Fires at areas for storing flammable and combustible substances
As34:	Fires due to breakage of underground liquid or gaseous hydrocarbon pipes
As35:	Breakage of receptacles with harmful substances or storage of dangerous product and wastage
As36:	Breakage of electric power cables, telephone lines, water pipes
As37:	Accidental spills and leaks of oils, furls, chemicals, herbicides…

In the first round, it was expected to collect 555 answers (15 experts * 37 questions= 555). However, one expert did not answer to several questions and ultimately 549 answers were received; although it had no negative impact on quality of data. Responses to each question in Microsoft Excel was sorted in ascending order. Median of their responses were obtained. This value represents how group of 15 experts think about importance of environmental aspects. For example, generation of GHG (CO_2, N_2O…) and metal emission to air by machinery and power generator that represented by AS1 is considered important (relevant to demolition) because the group median for this aspect is equal to seven. Grey columns in Table 2 shows those answers that captured in the first round of study. For instance, three experts believe AS1 is extremely important; seven believe this environmental aspect is just important and the rest of respondents had neutral opinion about this factor. Apparently, initial results show that six environmental aspects including AS21, AS25, AS27, AS30, AS31 and AS32 can be excluded from the list of demolition environmental aspects (marked with yellow). However, this is not the final conclusion and study must be continued.

To determine consensus in the first round for every single response absolute deviation around median was calculated (shown in appendix). For instance, (-2) indicates that group median is two units smaller than what this expert believes about the importance of AS1. In the first round average of all absolute deviations is equal to 0.32<0.5 which proves achieving consensus in the first round.

The second round of Delphi study immediately stared after analysing the first round's data. 10th Jan 2014, the second series of Delphi questions were sent to the same panel of experts. In the second round the median of their earlier responses were given to the panel members. They were asked to highlight the importance of given 37

environmental aspects once again. In addition to that, experts in the second round were asked to justify the reason for outlaying a judgment with more than 2-unit distances from median. Appendix 1 was also sent to experts along with questionnaire forms. It remarks which expert's judgment has more than two-unit distance from median. Green line represents group median values while orange and blue bars represent expert's responses. This figure shows that 13 judgments had 2 or more unit distances from group median. For example, in the first round of study group of experts believe that accidental spillage of oil is an important environmental aspect of demolition works since its median is equal to seven. However, expert one believes this environmental aspect is neither important nor unimportant. In the second round experts are expected to react in two ways; sticking to their earlier judgment and justifying the reason why for outlaying such judgments or changing their previous responses and getting closer to the group median.

Orange columns in Table 2 shows how experts responded to the second round's questions. Interestingly, in the second round of study, only one median value changed (AS30, median changed from 6 to 5). This value change however, did not change first round's initial assumption that says six environmental aspects should be removed from the list.

Average of all absolute deviations around median in the second round is equal to 0.24. This value indicates that in the second round experts reach to a better consensus as this value is smaller than 0.32 (measure of consensus in the first round).

Table 2: Delphi Study

NO.	Agreement Level															Med	Med	Med
	9			7			5			3			1					
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
As1	3	3	3	7	8	12	4	4	0	0	0	0	0	0	0	7	7	7
As2	4	4	4	5	5	6	4	6	5	1	0	0	0	0	0	7	7	7
As3	3	3	3	6	6	7	5	6	5	0	0	0	0	0	0	7	7	7
As4	3	3	3	5	6	6	6	6	6	0	0	0	0	0	0	7	7	7
As5	1	1	1	7	7	9	6	7	5	1	0	0	0	0	0	7	7	7
As6	2	2	2	8	9	12	4	4	1	1	0	0	0	0	0	7	7	7
As7	0	0	0	9	9	12	6	6	3	0	0	0	0	0	0	7	7	7
As8	5	5	5	7	7	9	3	3	1	0	0	0	0	0	0	7	7	7
As9	1	1	0	7	7	10	6	6	4	1	1	1	0	0	0	7	7	7
As10	3	3	3	7	7	7	4	5	5	1	0	0	0	0	0	7	7	7
As11	1	1	1	7	7	11	7	7	3	0	0	0	0	0	0	7	7	7
As12	2	2	2	9	9	11	4	4	2	0	0	0	0	0	0	7	7	7
As13	3	3	3	5	7	9	7	5	3	0	0	0	0	0	0	7	7	7
As14	4	4	3	6	6	7	4	4	4	1	1	1	0	0	0	7	7	7
As15	1	1	1	8	8	8	5	5	5	1	1	1	0	0	0	7	7	7
As16	2	2	2	9	9	13	4	4	0	0	0	0	0	0	0	7	7	7
As17	1	1	1	7	7	8	7	7	6	0	0	0	0	0	0	7	7	7
As18	3	3	3	8	9	12	4	3	0	0	0	0	0	0	0	7	7	7
As19	2	2	2	6	6	6	6	7	7	1	0	0	0	0	0	7	7	7
As20	3	3	3	5	6	10	7	6	2	0	0	0	0	0	0	7	7	7
As21	1	1	1	4	4	8	8	8	6	2	2	0	0	0	0	5	5	7
As22	4	4	4	5	5	6	5	6	5	1	0	0	0	0	0	7	7	7
As23	1	1	1	7	7	7	6	7	7	1	0	0	0	0	0	7	7	7
As24	1	1	1	12	12	12	2	2	2	0	0	0	0	0	0	7	7	7
As25	1	1	3	5	5	6	8	9	6	1	0	0	0	0	0	5	5	7
As26	2	2	1	6	7	10	6	6	4	0	0	0	0	0	0	7	7	7
As27	2	0	0	3	5	5	10	10	10	0	0	0	0	0	0	5	5	5
As28	2	2	2	6	6	5	6	6	7	1	1	1	0	0	0	7	7	5
As29	3	3	3	5	5	5	4	6	6	3	1	1	0	0	0	7	7	7
As30	2	2	2	5	5	6	5	7	6	2	1	1	0	0	0	6	5	7
As31	1	1	1	6	6	6	5	5	6	3	3	2	0	0	0	5	5	5
As32	1	0	0	3	4	4	6	6	6	5	5	5	0	0	0	5	5	5
As33	5	5	3	7	7	9	3	3	3	0	0	0	0	0	0	7	7	7
As34	3	3	3	6	6	8	6	6	4	0	0	0	0	0	0	7	7	7
As35	1	1	1	11	11	11	3	3	3	0	0	0	0	0	0	7	7	7
As36	1	0	0	8	10	11	6	5	4	0	0	0	0	0	0	7	7	7
As37	4	4	4	8	8	8	2	3	3	1	0	0	0	0	0	7	7	7
Consensus Measure (Median Absolute Deviations)																**0.32**	**0.24**	**0.17**

Considering AS1, in the second round, similar to the first round of study three experts believe this environmental aspect is extremely important. However, in contrast to the first round that seven experts believed this environmental aspect is important; in the second round one expert joined changed his earlier judgment and came closer to the first round's group median. In this round of study, eight experts believe that AS1 is only important and the rest of them (3 experts) voted neutrally.

Round three is the final round of study. In this round the pattern through which experts make their final decision is developed. In 15th March 2014, the final questions sent to the panel members. In contrast to the second round that 1st round's group medians were given to the experts, in the final round, 2nd round's group medians were sent to the experts together with all justifications that were made by experts. In the first two rounds, the analysis revealed that six environmental aspects should be excluded from the list. However, in the final round this number reduced to only found environmental aspects. All irrelevant environmental aspect to demolition projects were remarked with yellow color (whose median falls below seven). The measure of consensus in the final round is lower than the second round's measure and as this measures (0.17) is lower than 0.5, Delphi study can be stopped at this round.

6 Discussion and Finding

The first objective of this research was set to identify major demolition related environmental aspects. In response to this objective with the aid of extensive review of literature initial pool of ٣٧ environmental aspects developed. Three-round Delphi study conducted on these aspects to verify and identify major demolition relate ones. It was found "Create barrier to migration of animals & fish", "Cause migration of animals & birds", "Water channeling and stream water cut off and changing river banks" and "Alter in national park, rivers, national forest land, …" can be removed from the initial developed pool of aspects (whose median in the third round is equal or lower than 5).

While responsibility of identifying environmental aspects is given to those creating them, no demolition or construction guideline directly suggests comprehensive list of environmental aspects; and usually suggestions limit to controlling nuisance (dust, noise and vibration). This objective, however, identified 33 demolition relevant environmental aspects. Something far broader than controlling only dust, noise and vibration. In other words, this objective highlights the responsibility of demolition practitioner in protecting environment by introducing major aspects that have to be always considered during the execution of demolition projects.

7 Conclusion

The aim of this study was to identify major environmental aspects associated with demolition projects. Therefore, a comprehensive list of environmental aspects with the aid of reviewing literature has been developed. Delphi which is a consensus forming strategy was selected and with the aid of 15 demolition experts the initial list of aspects was verified and validated. In three rounds of Delphi study, finally major demolition environmental aspects were identified.

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