Identificatio n Of Key Factors Affecting Waste Management In Life Cycle Of The Construction Project By Using Delphi Technique

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ABSTRACT

The problem of generated waste as a result of the implementation of construction projects, has been aggravated recently because of construction activity experienced by the world, especially Iraq, which is going through a period of reconstruction, where construction waste represents (20-40%) of the total generated waste and has a negative effect on the environment and economic side of the project. In addition, the rate of consumpted amounts of natural resources are estimated to be about 40% in the construction industry, so it became necessary to reduce waste and to be manage well. This study aims to identify the key factors affecting waste management through the various phases of the project, and this is accomplished by using the Delphi technique. After conducting three questionnaire rounds of the Delphi to a group of experts, the results of this study identified forty four key factors affecting waste management distributed on the phases of the project, where found that the factor of frequent errors in the designs has the highest effect on the design phase, and the factor of the use of construction techniques that do not generate waste has highest effect on the construction phase. The purpose is to provide data base for decision-makers to control waste management well to avoid all affecting factors, with the possibility of building waste management system based on factors effective for each phase.
Key words: phases of construction project; key affective factors; waste management; Delphi technique.

تحديد العوامل الرئيسة المؤثرة على ادارة المخلفات في دورة حياة المشروع الانشائي بأستخدام تقنية دلفي

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الخلاصة

مشكلة المخلفات المتولدة نتيجة تنفيذ المشاريع الانشائية تفاقمت في الاونة الاخيرة بسبب الحركة العمرانية التي يمر بها العالم وخصوصا العراق الذي يمر بمرحلة اعادة اعمار تشكل المخلفات الانشائية (20-40)% من المخلفات الكلية المتولدة، اضافة الى تاثيراتها السلبية على البيئة وعلى الجانب الاقتصادي للمشروع، علاوة على استهلاك كميات كبيرة من الموارد الطبيعية تقدر بحوالي 40 % في الصناعة الانشائية، لذلك اصبح من الضروري تقليل كميات المخلفات المتولدة وادارتها بصورة جيدة. تهدف هذه الدراسة الى تحديد العوامل الرئيسية المؤثرة على ادارة المخلفات خلال مراحل المشروع المختلفة، ويتم تحقيق ذلك عن طريق استخدام تقنية دلفي. تم اجراء ثلاث جولات استبيانية من دلفي لمجموعة من الخبراء كانت نتائج هذه الدراسة هي تحديد اربعة واربعون عاملاً رئيسياً مؤثراً على ادارة المخلفات موزعة على مراحل المشروع الانشائي، حيث وجد ان عامل الاخطاء المتكررة في التصميم هي الاكثر تاثيراً في مرحلة التصميم، وعامل استخدام التقنيات التنفيذية التي لاتولد مخلفات هو الاكثر تأثيراً في مرحلة التنفيذ. ان الفائدة من ذلك هي توفير قاعدة بيانات لاصحاب القرار لادارة المخلفات بصورة جيدة متلافي بذلك جميع العوامل المؤثرة، مع امكانية بناء نظام لادارة المخلفات يستند على العوامل المؤثرة في كل مرحلة.

كلمات البحث: مراحل المشروع الانشائي؛ العوامل الرئيسية المؤثرة؛ ادارة المخلفات؛ تقنية دلفي.

1. INTRUCTION

In the construction industry,especially during the construction, renovation and demolition projects achieving 'zero waste' will be a great strategy for a world in an the environmental crisis, but, this is a highly challenging target in construction. However, by involving and committing all stakeholders to minimize waste from source and developing a good waste management strategies by both the reuse and recycle of materials, minimization of construction waste can be achieved at various phases of a construction project life cycle; and opportunities and responsibilities lie with all supply chain stakeholders, clients, designers, contractors and suppliers. The ratio of construction and demolition waste (C&DW) represents (20 – 40) % of the nation's total waste stream to landfills, **Altuncua & Kasapseçkina, 2011**, and the rate of consumpted amounts of natural resources were estimated to be about 40% in the construction industry, **Winkler, 2010**. Despite some European countries have high rates for reuse and recycling up to 80%, this rate is still very low in many European countries, therefore, a plan should developed to make waste re- use, recycling and other material recovery rate increase to a minimum of 70% by weight in Europe by 2020, it is important publish initiatives that contribute to an effective waste management approach reaching high rates of construction and demolition waste recovery, **Gangolells et al., 2014**. While in Iraq there is no system for managing waste in construction projects, in addition the relevant previous studies are focused on estimate the volume of C&DW that will be generated on a site and their impacts only. **Fig.1** shows a construction and demolition waste management framework. **Boyle, 2004,** reported that the principles of sustainability greatly contribute to preserving the natural resources and the environment by reduction of the C&DW quantities and increasing recycling/reusing of materials. In addition, decrease the environmental impact of construction materials, the term sustainability refers to development strategies that take into account the requirements of the present and future generations together and provide a balance of interests that serve all in the economic, social and environmental fields, so sustainable development is defined as meeting the needs of present generations without compromising the ability of future generations to meet their needs and requirements and that the idea of environmental sustainability is based on the principle of leaving the land in good condition for future generations, **A1, 2011**. The three dimensions of sustainability to achieve these requirements, **Blair, 2008,** are as follows**:**

1- Social equity: which includes safety at work, standards on consumer protection, and accessibility requirements for people with disabilities.
2- Integrity environmental: which includes standards on sustainability in relation to activities such as water and soil quality, the quality of water services and air, building construction, treatment of waste. Also standards on energy efficiency and renewable sources and support of the environmentally friendly practices are also included.
3- Economic growth: which provide tools for consolidating innovation, business transactions and eliminating barriers to trade, and contributing to interoperability and the dissemination of new technologies. In addtion, to the "toolbox" of standards is used for conformity assessment, to increase confidence in products and services.

2. DELPHI TECHINEQUE

The Delphi name came from the island of Delphi, which was the hallowed site of the most respected oracle in ancient Greece, **Powell, 2002.** A Delphi procedure was selected as the most appropriate method for attaining consensus in a national panel of the subject matter experts (SMEs), **Farmer, 1998.** There are many definitions of the Delphi method. **Yousuf, 2007 and Mayburry, and Swanger, 2010,** defined Delphi technique as "a group process involving an

interaction between the researcher and a group of identifying experts on a specific topic or topics, usually through a series of questionnaires". The development of the Delphi technique started in the 1940s with work of Olaf Helmer, and his associate, Norman Dalky, at the RAND Corporation, **Yousuf, 2007**. The development of Delphi was in five stages: secrecy and obscurity; novelty; popularity; scrutiny; and continuity, **Rowe, and Wright, 1999**. Finally, Delphi method has been applied in different fields such as higher education, marketing, information technology, library and information science, engineering and medicine, and it became a great assistance tool in reaching important results for a number of difficult issues, **Antoniades, 2014**.

2.1 Designing a Delphi Method

As in all applied research, attention must be paid to the detailed planning and then to effective execution of this study. This section focuses on four elements for planning of Delphi technique, they are as follows:

1- Problem Definition: A problem definition is an important initial step to ensure that both the nature and scope of the problem or issue to be investigated, to define expected outcomes of the study, as well as the appropriateness of the Delphi method to address the specific problem, **Welding, 2013**.

2- Selection of Experts: Careful selection of the panel of experts is the keystone to a successful Delphi study. The key aspects of panel selection include the experts' qualifications and the size of the participant's commitment, **Gohdes, and Crews, 2004**.

3- Panal Size: The careful selection of the panel is a key factor in the Delphi method because it enables a researcher confidently to use a small panel. There is no sample size advocated for Delphi studies. The literature on this subject suggests that the panel size be between (15-30) with heterogeneous population and (5-15) for a homogeneous population, **Adler, and Ziglio, 1996**. But, **Okoli, and Pawlowski, 2004,** gave the appropriate size of the group was between (10-18) experts.

4- Conducting the Delphi Rounds: Developing the questionnaire for rounds also called questions or iterations etc.) is based upon the clear identification of the study goals, and a critical literature review, among other preliminary research activities and enables the researcher to generate question items and response scales tapping the major questions and issue areas to be measured, and a Delphi study usually involves three or four rounds, **Welding, 2013**. The communication between panel members and researcher is usually conducted by mail, but the growing access to email and the web opens new channels for group communication that speeds up the timeline from many months to conduct all rounds in a few weeks, **Loo, 2002**.

3. IDENTIFICATION OF KEY FACTORS AFFECTING WASTE MANAGEMENT IN CONSTRUCTION PROJECTS

From the previous studies it was found there were many classifications of the construction project life cycles. Most, if not all, projects go through a life cycle that varied with the size and complexity of the project. A project consists of five phases as follows: (Brief Phase, Design Phase, Procuring Phase, Construction Phase, and Commissioning Phase), while the following studies: **Lu and Yuan, 2011; Llatas, 2013 and Lester et al., 2014,** reported the additional phase in the life cycle of the construction project, it is called Demolition or Decommissioning phase, this phase bagin when ending the life of the project. So a construction project life cycle that adopted by the researcher is consists of six phases as follows: (Brief Phase, Design Phase, Procuring Phase, Construction Phase, Commissioning Phase, and Demolition phase). The

researcher in this study had used the Delphi method for identifying the key factors affecting waste management in construction projects in Iraq, in each phase of project phases there are three processes:

1- Selection of the expert team.
2- Conducting Delphi rounds.
3- The conclusion.

3.1 Selection of the Expert Team

A group of experts was selected to provide opinions on the key factors affecting on waste management based on the following criteria:

1. They have extensive working experience in the construction industry in Iraq.
2. They are involved in the management of construction projects in Iraq.

Twenty invitation were sent to individuals to participate. The invitation explained the purpose of the study; the experts were informed that there would be a number of rounds of questionnaire, and the method of the distribution of the questionnaire would be either by receiving it directly or by an E-mail. Sixteen participant responded and agreed to participate, four of them come from the private sector and twelve from the public sector, all the participating have experience of not less than twenty years in the construction industry, all experts' information has been listed in **Table 1**, the names of experts and their organizations are not revealed for anonymity. The academic degrees, field of specialization, and work sector for the experts, are given in **Figs. 2, 3, and 4** respectively.

3.2 Conducting Delphi Rounds

3.2.1 Delphi first round: identifies the effective factors

In the first round of Delphi, the researcher prepared a list of effective factors depending on the relevnant litretures and studies, this list is distributed on seven groups (according to the six phases of construction project, as well as other factors), then experts were asked to identify a specified number of the major factors from this list that they considered affecting waste management in the construction projects of Iraq. Also this list had additional request to the experts to advise if there are any other factors affecting waste management not listed. The researcher managed in this round to meet with ten of experts in one place at one time and began with them a round of brainstorming to identify the factors and for the remaining six experts the researcher conducted interviews with them for the purpose of answering the questionnaire of the first round of the Delphi technique.

3.2.1.1 Result and analysis of the first round

The factors identified and suggested by the experts in the first round were carefully analyzed and a list of factors was formed after excluding the factors which have similar meanings. This list include seventy four factors in all phases of a construction project, they were prepared to be used in the second round of Delphi method.

3.2.2 Delphi second round: refining the selection factors

In the second round questionnaire, the experts were asked to indicate the relevant importance of these seventy four factors that had been identified in the first round of the Delphi method, using a five-level Likert scale, as follows (very low important, low important, medium important, highly important, very highly important).

3.2.2.1 **Results and analysis of the second round**

Table 2, shows the indication of relative importance of all effective factor in the second round. This round used the (SPSS) program to conduct the statistical analysis, like Mean (M) and standard deviation (S.D) according to Eq. (1) & Eq. (2) respectivally. The factors that got arithmetic mean less than number (3), were removed in third round of the Delphi method, like,**Mayburry and Swagner, 2010**, where (1= very low important, 2= low important, 3= medium important, 4= highly important, 5= very highly important). Forty four factors that resulted from the second round, were prepared for use it in the third round.

$$M=[(\sum_{i=1}^{K} x_i f_i)/n] \quad (1)$$

$$S.D=[(\sum_{i=1}^{k}(x_i - M)^2 f_i \ / \ (\sum_{i=1}^{k} f_i)]\hat{} \ ½ \quad (2)$$

Where:

M: mean.
S.D: standard deviation.
x_i : weight value for particular.
f_i : number of frequencies.
n : total number of answers.

3.2.3 Delphi third round: degree of consistency

In the third round of Delphi method, experts were asked to re-evaluate the relative importance of each factor that resulted from the second round by using the same five-level Likert scale. The aim of third round is to measure the consistency of experts' opinions between the second round and the third round. If the required consistency is not achieved the researcher will go to the fourth round for re-evaluation.

3.2.3.1 Result and analysis of the third round

Table 3 shows the indication of relative importance of each factor in third round. In this round also the (SPSS) program was used to conduct the statistical analysis. The results of the analysis show that all the factors got arithmetic mean of more than number (3). This means that all the effective factors that have been obtained from the third round are located between (medium to very high) importance and this result is similar to the result of the second round where there is no difference between the two rounds so there is no need to go to the fourth round. The researcher also conducted the validity and reliability test, for the experts' answers in this round, by extracting the alpha coefficient - Cronbach by using (SPSS) program, all the values of alpha were positive, because they reached the minimum value of (0.888), this indicates the answers of experts in this round, have a high stability and sincerity, while the value of Cronbach alpha should not be less than (0.70)**, A2, 2013.**

4. CONCLUSIONS

The result of Delphi technique is forty four key factors affecting waste management in all phases of a construction project and were sorted by importance, starting from the highest for each phase, as shown in **Table 4**, found that the factor of weakness in knowledge about the project life cycle and quantity of the generated waste has highest effect in the brief phase, and the factor of frequent errors in the designs has the highest effect on the design phase, and the factor of imposing contractual clauses for the main contractor and sub-contractors in dealing with the

waste and the method used for their disposal in the procuring phase has highest effect, and the factor of the use of construction techniques that do not generate waste has highest effect on the construction phase, and the factor of instructions on how to use and maintain should available for all occupants of the project has highest effect on commissioning phase, while the factor of use the high-tech equipment in the demolition process has highest effect on the demolition phase. By all the key effective factors may manage waste by taking the necessary procedure to address these factors, so the researcher recommended the following some measures for that purpose: The need to form a special technical committee to manage the construction waste in large companies, the need for support from the state to process of construction waste management by allocating the needed funds to manage waste, work training courses to qualify engineers on waste management, in addition to held scientific conferences by the government on waste management, government encouragement of investors to invest in the field of waste recycling, and the need to use high-tech equipment in the implementation process. In addition, these factors may be relied on constructing the proposed system for managing waste in construction projects.

REFERENCES

- Adler, M., Ziglio, E., 1996, *Gazing into the Oracle: The Delphi Method and its Application to Social Policy and Public Health*, London, England: Jessica Kingsley.

- Altuncua, D., Kasapseçkina, M. A., 2011, *Management and Recycling of Constructional Solid waste in Turkey*, Procedia Engineering, vol. 21, PP. 1072 – 1077.

- Antoniades, P., 2014, *SOA Maturity Model: A Delphi-Derived Proposal for Inter-Enterprise Setups*, Cham : Springer International Publishing.

- Blair, B., 2008, The *Role of Standards in Sustainablity*, Standards Australia, October.

- Boyle, C., 2004, *The Sustainable Buildings in New Zealand*, IPENZ Presidential Task Committee, March.

- Farmer, E. A., 1998, A *Delphi Study of Research Priorities in Tech-Prep*, Journal of Vocational and Technical Education, vol. 15, NO. 1, PP. 42-49.

- Gangolells, M., Casals, M., Forcada, N., Macarulla, M., 2014, *Analysis of the Implementation of Effective Waste Management Practices in Construction Projects and Sites*, Resources, Conservation and Recycling, vol. 93, PP. 99–111.

- Gohdes, W. L., Crews, T. B., 2004, *The Delphi Technique: A Rwsearch Strategy For Career and Technical Education*, Journal of Technology Education, vol. 41, NO. 2, PP. 105 – 122.

- Lester, E. A., CEng, FICE, FIMech.E, FIStruct.E, FAPM, 2014, *Project Management, Planning and Control*, (Sixth Edition).

- LLATAS, C., 2013, *Methods for Estimating Construction and Demolition (C&D) Waste*, University of Seville, Spain.

- Loo, R., 2002, *the Delphi Method: A Powerful Tool for Strategic Management,* An international journal police, strategies & management, vol. 25, NO. 4, PP. 762 -769.

- Lu, W., Yuan, H., 2011, *A Framework for Understanding Waste Management Studies in Construction*, Waste Management, vol. 31, PP.1252–1260.

- Mayburry, T., Swanger, N. A., 2010, *Identification of Industry Needs for BaccalaureateHospitality Graduates: A Delphi Study*, International CHRIE Conference-Refereed Track. Paper 4., July 31.

- Okoli, C., Pawlowski, S. D., 2004, *The Delphi Method as a Research Tool: An Example, Design Considerations and Applications*, Information & Management, vol. 42, Issue 1, PP. 15–29.

- Powell, T., 2002, *Quick Tips, Collecting Group Data*: Delphi technique, University of Wisconsin, Madison.

- Rowe, G., Wright, G., 1999, *The Delphi Technique as a Forecasting Tool: Issues and Analysis*, International Journal of Forecasting, vol. 15, PP. 353–375.

- Welding, A. K., 2013, *Project Evaluation: Lessons Learned Vs. Delphi Method*, Thesis of 6 ECTS credits submitted to the School of Science and Engineering at Reykjavík University in partial fulfillment of the requirements for the degree of Master of Project Management in MPM.

- Winkler, G., 2010, *Recycling Construction & Demolition Waste*, **,** A LEED-Based Toolkit.

- Yousef, M. I., 2007, *Using Experts' s Opinions Through Delphi Technique*, Practical Assessment, Research & Evaluation, vol. 12, NO. 4.

- (A1, 2011)
الصفار، أ.، 2011، *الاستدامة والصناعة الانشائية*، موقع الاستدامة الالكتروني.

- (A2, 2014)
حسن، ع. ق.، 2014، *تخمين و اعادة تدوير النفايات الانشائية في محافظة البصرة*، مجلة البصرة للعلوم الهندسية، الجلد 14، العدد الاول.

ABBREVIATIONS

AM: he Arithmetic Mean.
C&D W: Construction and demolition waste.
N: The sample size.
S.D: The Standard Deviation.
SMEs: Subject matter experts.
SPSS: Statistical Package for Social Science.
α: Cronbach's Alpha factor.

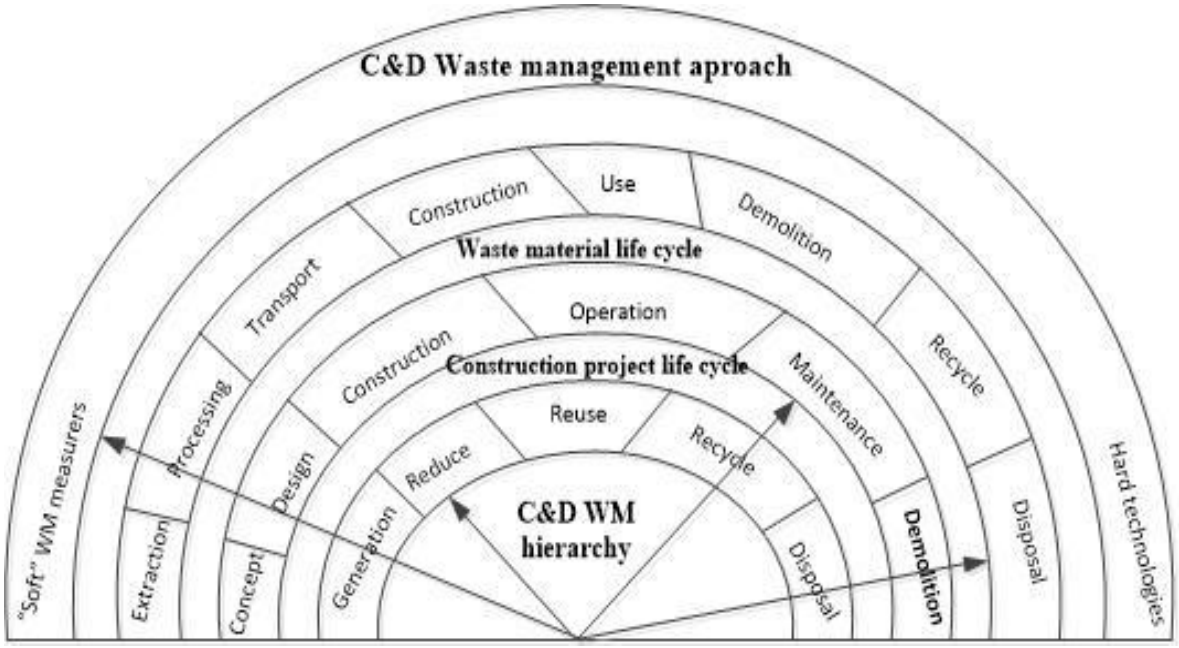

Figure 1. A Construction and demolition waste management framework,**Lu & Yuan, 2011**.

Table 1. List of qualifications for participants experts in delphi method.

NO.	Academic Degree	Eng. Field	Experience Year	Sector	Position	Organization
1	Ph.D.	Civil	29	Public	Construction Consultant	Ministry of Construction and Housing
2	Ph.D.	Civil	28	Public	Academic	University of X
3	Ph.D.	Environmental	25	Public	Academic	University of Y
4	Ph.D.	Architecture	21	Private	Construction Sup.	Company
5	Ph.D.	Architecture	21	Public	Department Manager	Ministry of Construction and Housing
6	M.Sc.	Civil	26	Public	Resident Engineer	Ministry of Construction and Housing
7	M.Sc.	Civil	21	Public	Construction Supervision	Ministry of Construction and Housing
8	M.Sc.	Architecture	20	Public	Site engineer	Ministry of Construction and Housing
9	B.Sc.	Mechanical	37	Public	Department Manager	Ministry of Construction and Housing
10	B.Sc.	Civil	35	Private	Construction Consultant	Company
11	B.Sc.	Civil	32	Private	Construction Cons.	Company
12	B.Sc.	Mechanical	30	Public	Project Manager	Ministry of Construction and Housing
13	B.Sc.	Civil	30	Public	Project Manager	Ministry of transportation
14	B.Sc.	Civil	25	Public	Construction Supervision	Ministry of Construction and Housing

15	B.Sc.	Architecture	21	Public	Department Manager	Ministry of Construction and Housing
16	B.Sc.	Electrical	20	Private	Site engineer	Company

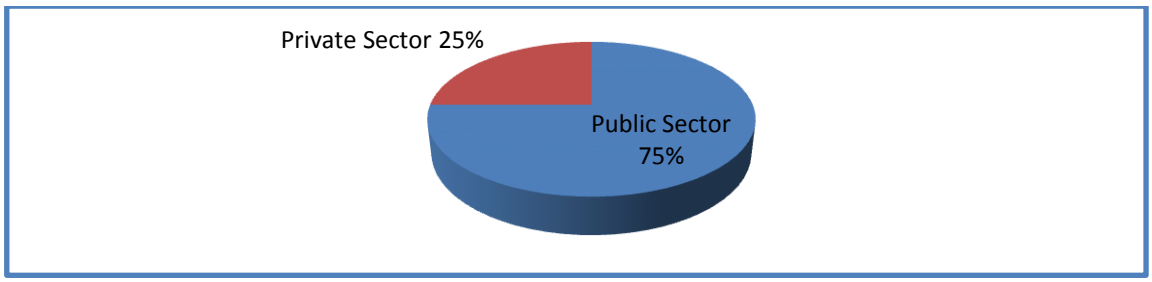

Figure 2. Experts from work sector.

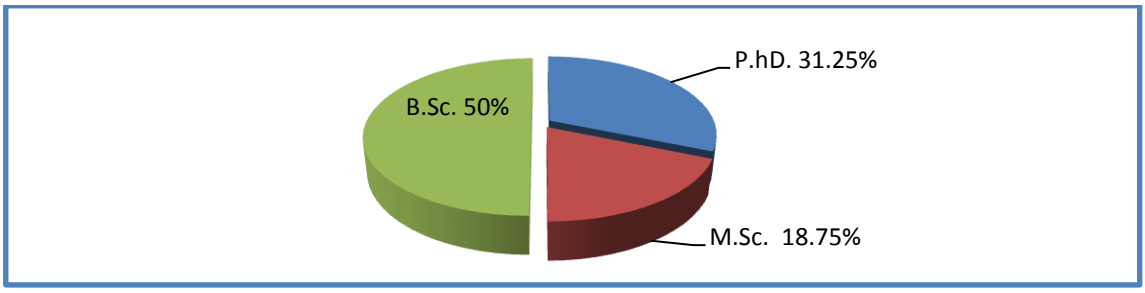

Figure 3. Experts academics degree.

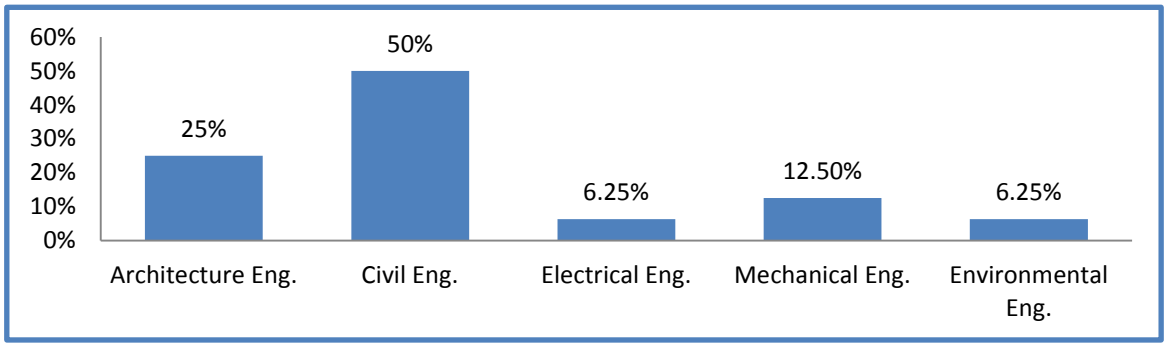

Figure 4. Field of specialization for experts.

Table 2. Delphi second round results: the mean and the standard deviation.

No.	The Factors	N	M	S.D
The Briefing Phase:				
1.	Awareness of the employer and the contractor of the project.	16	2.75	0.44721
2.	Keeping up the new ideas in the design in order to reduce the waste (the idea of sustainable design).	16	3.8125	0.75

3.	Lack of cooperation with the competent authorities.	16	3.0625	0.85391
4.	Lack of cooperation with the projects by the designers where the experience and information are limited to the consultant designer.	16	2.6250	0.88506
5.	Negligence in a way of the project management by using the technical means of modern science in the shipping and the contracting with suppliers.	16	3.5	0.89443
6.	The culture of preserving the environment.	16	4	0.89443
7.	The financial allocation for the project.	16	4.4375	0.62915
8.	Weakness in perception at the beginning of the project in the subject of waste.	16	3.4375	0.81394
9.	Weakness in the knowledge in the project life cycle and quantity of the generated waste.	16	3.9375	0.7719
The Designing Phase:				
1.	Accuracy in the preparation of BOQ.	16	3.8125	0.83417
2.	Changes in the design because of lack of clarity of the requirements of the employer.	16	4	0.5164
3.	Design using lengths and dimensions of the spaces that do not cause waste during execution of the project.	16	3.9375	0.68007
4.	Frequent errors in the designs.	16	3.8125	0.75
5.	The design and construction using standard materials.	16	3.5625	0.81394
6.	Use of prefabricated materials in implementation.	16	2.5	0.5164
7.	Use of sustainable materials that can be recycled or re-used after demolition.	16	2.375	0.7188
8.	Go to the idea of sustainable design in designs.	16	2.25	0.85635
9.	Application of environmental management systems in the designs.	16	2.1875	0.75
The Rocuring Phase:				
1.	Accuracy in the preparation of the contract documents.	16	3.5625	0.89209
2.	Application of waste management system.	16	4.25	0.68313
3.	Comprehensive and detailed schedule of all the activities, as well as a detailed schedule of construction materials to be purchased at the site before starting implementation.	16	3.625	0.88506
4.	Make sure of the executing company's ability to deal with waste.	16	4	0.6346
5.	Imposing contractual clauses for the main contractor and sub-contractors in dealing with the waste and the method used for their disposal.	16	4.4375	0.62915

6.	Waste management process coordination with municipal departments.	16	3.9375	0.57373
7.	Estimate the required costs to treat waste, in the contract document.	16	2.5	0.8165
8.	Incentives and priority in the bidding for the contractor who has a plan for reducing waste and increasing recycling	16	2.25	0.7746
9.	Simplify legal procedures for the provision of equipment for waste treatment.	16	2.1875	0.75
10.	Methods of recycling waste and how use it on the site.	16	2.0625	0.85391
The Construction Phase:				
1.	Activation of advanced technologies for the treatment and recycling of waste.	16	4.125	0.7188
2.	Allowing the use of recycled materials in the implementation.	16	2.875	0.80623
3.	Awareness and education in waste management system.	16	3.75	0.7746
4.	Bad the planning for the quantities required materials in the implementation, as well as sequence work activities.	16	4.1875	0.75
5.	Good storage and improving the traditional construction processes.	16	4.0625	0.57373
6.	Put separate containers according to the type of waste in the project.	16	2.75	0.68313
7.	The supervision system of the construction waste on-site	16	4.3125	0.60208
8.	The change in materials, specifications and type during execution the project.	16	3.75	0.60208
9.	The training to reduce the waste.	16	3.875	0.88506
10.	The use of construction techniques that do not generate waste.	16	4.25	0.85635
11.	Weak monitoring and control in the implementation of the project.	16	4	0.63246
12.	Workers' productivity and its technical skills.	16	4.125	0.80623
13.	Efficiency of the sub-contractors and cooperation among themselves in the management of waste.	16	2.75	0.57735
14.	Set a place for sorting waste and do it in the early stage of implementation.	16	2.875	0.61914
15.	Good storage and improving the traditional construction process.	16	2.875	0.34157
16.	Determine the controls on dealing with the originators of waste.	16	2.375	0.88506
17.	Communication and coordination system between the parties involved in the project.	16	2.9375	0.68007
18.	Technical training courses for project managers, technicians and workers.	16	2.9375	0.7719

19.	The needs of local markets for construction materials.	16	2.875	0.5
20.	Record retention for waste management (quantities, types, Etc).	16	2.625	0.61914
21.	Techniques on use of the handling materials.	16	2.9375	0.44253
The Commissioning Phase:				
1.	Develop a spare plan maintenance.	16	3.9375	0.68007
2.	Failure Repair the direct water and sewer pipes.	16	2.375	0.7188
3.	Lack of Periodical maintenance program.	16	4	0.7303
4.	Occupants culture of the building.	16	2.5	0.7303
5.	Penalize the projects that cause waste in the materials used And also punish for the person's negligence.	16	3.875	0.34157
6.	Proper storage of the remaining materials and the spare materials.	16	3.875	0.80623
7.	up the instructions on how to use and maintain should available for all occupants of the project.	16	4.1875	0.83417
8.	Referral the management of building during the Commissioning phase to professional people.	16	3.875	0.7188
9.	The accuracy and good work during maintenance operations.	16	4	0.8165
The Demolition Phase:				
1.	Allow the use of recycled materials.	16	2.375	0.80623
2.	Appointment of a place to sort the waste, and do this sorting in the early stage of implementation.	16	4	0.63246
3.	Awareness of the employer of issue to take advantage of the building after the end of the age.	16	3.8125	0.65511
4.	Determine the requirements of the local markets for construction materials.	16	2.625	0.88506
5.	Feasibility study on materials resulting from the demolition.	16	4.0625	0.68007
6.	Identify the recyclable materials.	16	4.125	0.80623
7.	Management of database for construction waste	16	2.8125	0.75
8.	The use of high-tech equipment in the demolition process.	15	4	0.63246
9.	Tight work site area.	16	2.5625	0.96393
The other factors:				
1.	Enact the laws for supporting waste management.	16	4.5625	0.51235
2.	Encourage citizens to use recycled materials.	16	2.5	0.5164

3.	Encouraged by the specialized agencies in this area.	16	2.5625	0.72744
4.	Increase the fees on mixed waste and reduce fees on classified waste.	16	2.6875	0.7932
5.	Number the landfill sites, and thier distance from the project site.	16	3.875	0.88506
6.	Put the severe sanctions by the government for violators of the laws relating to construction waste management.	16	4.3125	0.47871
7.	The tax exemption (Do not impose the tax) on the waste treatment equipment.	16	4.25	0.68313

Table 3. Delphi third round results; mean, standard deviation and cronbach's alpha factor (α).

No.	The Factors	N	M	S.D	α
The Briefing Phase:					
1.	Keeping up the new ideas in the design in order to reduce the waste (the idea of sustainable design).	16	4.1875	0.54391	0.957
2.	Lack of cooperation with the competent authorities.	16	3.4375	0.62915	0.953
3.	Negligence in a way of the project management by using the technical means of modern science in the shipping and the contracting with suppliers.	16	3.75	0.68313	0.953
4.	The culture of preserving the environment.	16	4.3125	0.70415	0.951
5.	The financial allocation for the project.	16	4.1875	0.75	0.948
6.	Weakness in perception at the beginning of the project to the subject of waste.	16	3.8125	0.75	0.951
7.	Weakness in the knowledge in the project life cycle and quantity of the generated waste.	16	4.3125	0.60208	0.949
The Designing Phase:					
1.	Accuracy in the preparation of BOQ.	16	4.25	0.68313	0.925
2.	Changes in the design because of lack of clarity of the requirements of the employer.	16	4.1875	0.40311	0.949
3.	Design using lengths and dimensions of the spaces that do not cause waste during execution of the project.	16	4.1875	0.54391	0.908
4.	Frequent errors in the designs.	16	4.25	0.57735	0.908
5.	The design and construction using standard materials.	16	4.0625	0.68007	0.912
The Procuring Phase:					
1.	Accuracy in the preparation of the contract documents.	16	3.875	0.7188	0.935
2.	Application of waste management system.	16	4.3125	0.60208	0.918
3.	Comprehensive and detailed schedule of all the activities, as well as a detailed schedule of construction materials to be purchased at the site before starting implementation.	16	4.25	0.44721	0.930
4.	Make sure of the executing company's ability to	16	4.1875	0.54391	0.923

	deal with waste.				
5.	Imposing contractual clauses for the main contractor and sub-contractors in dealing with the waste and the method used for their disposal.	16	4.5	0.5164	0.933
6.	Waste management process coordination with municipal departments.	16	4.375	0.5	0.922
The Construction Phase:					
1.	Activation of advanced technologies for the treatment and recycling of waste.	16	4.1875	0.65511	0.969
2.	Awareness of and education in waste management system.	16	3.875	0.7188	0.971
3.	Bad the planning for the quantities required materials in the implementation, as well as sequence work activities.	16	4.3125	0.70415	0.970
4.	Good storage and improving the traditional construction process.	16	4.125	0.61914	0.970
5.	The supervision system of the construction waste on-site	16	4.375	0.5	0.973
6.	The change in materials, specifications and type during execution of the project.	16	3.875	0.80623	0.970
7.	The training to reduce the waste.	16	4.0625	0.85391	0.970
8.	The use of construction techniques that do not generate waste.	16	4.4375	0.62915	0.972
9.	Weak monitoring and control in the implementation of the project.	16	4.1875	0.54391	0.972
10.	Workers' productivity and their technical skills.	16	4.1875	0.75	0.969
The Commissioning Phase:					
1.	Develop a spare plan maintenance.	16	4.0625	0.57373	0.957
2.	Lack of Periodical maintenance program.	16	4.0625	0.68007	0.951
3.	Penalize the projects that cause waste in the materials used and also punish for the person's negligence.	16	4.0625	0.44253	0.971
4.	Proper storage of the remaining materials and the spare materials.	16	4.125	0.7188	0.952
5.	Up the instructions on how to use and maintain should available for all occupants of the project.	16	4.3125	0.70415	0.957
6.	Referral the management of building during the Commissioning phase to professional people.	16	4.1245	0.61914	0.953
7.	The accuracy and good work during maintenance operations.	16	4.1875	0.75	0.955
The demolition Phase:					
1.	Appointment of a place to sort the waste, and do this sorting in the early stage of implementation.	16	4.125	0.5	0.901
2.	Awareness of the employer of issue to take advantage of the building after the end of the age.	16	3.9375	0.57373	0.915
3.	Feasibility study on materials resulting from the demolition.	16	4.25	0.57735	0.888

4.	Identify the recyclable materials.	16	4.25	0.68313	0.905
5.	The use of high-tech equipment in the demolition process.	15	4.25	0.44721	0.915
The other factors:					
1.	Enact the laws for supporting waste management.	16	4.5	0.5164	0.930
2.	Number the landfill sites, and thier distance from the project site.	16	4.0625	0.85391	0.926
3.	impose the severe sanctions by the government for violators of the laws relating to construction waste management.	16	4.375	0.5	0.909
4.	The tax exemption (Do not impose the tax) on the waste treatment equipment.	16	4.3125	0.60208	0.903

Table 4. The key factors affecting on waste management during all construction project phases (starting from higher effect to the least for each phase).

No.	The Factors
The Briefing Phase:	
1.	Weakness in the knowledge in the project life cycle and quantity of the generated waste.
2.	The culture of preserving the environment.
3.	Keeping up the new ideas in the design in order to reduce the waste (the idea of sustainable design).
4.	The financial allocation for the project.
5.	Weakness in perception at the beginning on the project to the subject of waste.
6.	Negligence in a way of the project management by using the technical means of modern science in the shipping and the contracting with suppliers.
7.	Lack of cooperation with the competent authorities.
The Designing Phase:	
1.	Frequent errors in the designs.
2.	Accuracy in the preparation of BOQ.
3.	Changes in the design because of lack of clarity of the requirements of the employer.
4.	Design using lengths and dimensions of the spaces that do not cause waste during execution of the project.
5.	The design and construction using standard materials.
The Procuring Phase:	
1.	imposing contractual clauses for the main contractor and sub-contractors in dealing with the waste and the method used for their disposal.
2.	Waste management process coordination with municipal departments.
3.	Application of waste management system.
4.	Comprehensive and detailed schedule of all the activities, as well as a detailed schedule of construction materials to be purchased for the site before starting implementation.
5.	Make sure of the executing company's ability to deal with waste.
6.	Accuracy in the preparation of the contract documents.
The Construction Phase:	
1.	The use of construction techniques that do not generate waste.

2.	The supervision system on the construction waste on-site
3.	Bad the planning for the quantities of required materials in the implementation, as well as sequence of work activities.
4.	Weak monitoring and control in the implementation of the project.
5.	Activation of advanced technologies for the treatment and recycling of waste.
6.	Workers' productivity and their technical skills.
7.	Good storage and improving the traditional construction process.
8.	The training to reduce the waste.
9.	Awareness of and education on waste management system.
10.	The change in materials, specifications and type during execution of the project.
The Commissioning Phase:	
1.	Up instructions on how to use and maintain should available for all occupants of the project.
2.	The accuracy and good work during maintenance operations.
3.	Proper storage of the remaining materials and the spare materials.
4.	Referral the management of building during the Commissioning phase for professional people.
5.	Penalizing the projects that cause waste in the materials used And also punish for the person's negligence.
6.	Develop a spare maintenance plan.
7.	Lack of Periodical maintenance program.
The Demolition Phase:	
1.	The use of high-tech equipment in the demolition process.
2.	Feasibility study of materials resulting from the demolition.
3.	Identify the recyclable materials.
4.	Appointment of a place to sort the waste, and do this sorting in the early stage of implementation.
5.	Awareness of the employer of issue to take advantage of the building after the end of the age.
The other factors:	
1.	Enact the laws for supporting waste management.
2.	Impose the severe sanctions by the government on violators of the laws relating to construction waste management.
3.	The tax exemption (Do not impose the tax) on the waste treatment equipment.
4.	Number the landfill sites, and their distance from the project site.