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An Applying the Delphi Technique for Eliciting Criteria in Equipment and Materials Used in Highway Construction Projects

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ABSTRACT

This article aims to establish and evaluate standards for critical equipment and materials in highway projects in Iraq. Delphi technique has been used to analyze, explore, and discover the main criteria and sub-criteria that affect equipment and materials in highway construction projects in Iraq. To determine the correct response to the criteria presented in this study, a program (IBM, SPSS/V25) was used to assess the main criteria and sub-criteria using the mean score (MS) and standard deviation (SD) technique, as well as to check reliability using Cronbach's alpha factor (α). The experts' qualifications and the extent to which the person is ready to commit are both important factors in panel selection. The design of a questionnaire, which is also identified as questions or repetitions, is based on a clear identification of study objectives, a literature review, and other primary research activities. By applying the Delphi technique steps and procedures, this research reveals fifteen (15) successful criteria in equipment and materials in highway construction projects in Iraq.

Keywords: Delphi Technique, Cronbach's Alpha, Experts, Equipment and Materials.

تطبيق تقنية دلفي لإيجاد المعايير المهمة للمعدات و المواد المستخدمة في مشاريع بناء الطرق السريعة في العراق

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الخلاصة

الهدف من هذه المقالة هو وضع وتقييم المعايير للمعدات و المواد الحيوية في مشاريع الطرق السريعة في العراق. تم استخدام تقنية دلفي لتحليل واستكشاف واكتشاف المعايير الرئيسية والمعايير الفرعية التي تؤثر على المعدات و المواد في مشاريع إنشاء الطرق السريعة في العراق. لتحديد الاستجابة الصحيحة للمعايير المقدمة في هذه الدراسة ، تم استخدام برنامج (SPSS / V25 ، IBM) لتقييم المعايير الرئيسية والمعايير الفرعية باستخدام متوسط الدرجة (MS) وتقنية الانحراف المعياري (SD) ، وكذلك للتحقق

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من الموثوقية باستخدام عامل ألفا كرونباخ (α). تعد مؤهلات الخبراء ومدى استعداد الخبير للالتزام من العوامل المهمة في اختيار الفريق ، ويستند تصميم الاستبيان ، والذي يتم تحديده أيضًا على أنه أسئلة أو تكرارات على تحديد واضح لأهداف الدراسة ، بالإضافة إلى مراجعة الأدبيات وأنشطة البحث الأولية الأخرى. من خلال تطبيق خطوات وإجراءات تقنية دلفي ، كشفت نتائج هذا البحث عن خمسة عشر (15) معيارًا ناجحًا في المعدات والمواد في مشاريع إنشاء الطرق السريعة في العراق. **الكلمات الرئيسية:** تقنية دلفي، كرونباخ ألفا، الخبراء، المعدات والمواد

1. INTRODUCTION

The Delphi method, commonly known as Estimate-Talk-Estimate, is a strategy for predicting and talking about (ETE). It is a methodical communication approach or process that was first developed as a methodical communication approach or process participatory predicting method depending on a panel specialists' group (Dalkey, 2009). Guesstimate is another name for Delphi. It is a different approach that can be used in detailed interviews (Bernice, 1999). Delphi is frequently implemented in corporate prediction because it has a number of benefits associated with other Economics and organized prediction approaches (Sackman, 1973). Delphi is predicated on the concept that predictions produced by an organized group are more reliable than those made by unregulated groups (Tuoff, 1975). In two or more rounds, the experts respond to surveys. Each round is followed by a supervisor, or change candidate who delivers an anonymized overview of the experts' previous round forecasts, and the explanations they gave for their conclusions (Green and Graefe, 2007). As a result, experts are urged to revise their previous responses in consideration of the opinions of other panelists (Rowe and Wright, 2001). The range of alternative answers is expected to reduce as a consequence, and the group will converge on the "correct" option (Milbrey, 1990). After some predetermined criteria for ending (e.g., the overall number of sessions, the accomplishment of opinion, consistency of findings), the process is terminated, and the outcomes are determined by the mean or median scores of the final rounds (Jemais and Rai, 2000). Special consideration should be given to the design of the Delphi approach for theses, and the definition and selection of experts to avoid scientific defects that undermine the validity and reliability of the results (Niecs, C. et al., 2019). The name Delphi comes from the Delphi Islands, formerly the capital of Greece and a sacred site in ancient Greece. According to legend, Apollo was the master of Delphi; he was recognized throughout Greece for his ability to predict the future, and those who sought advice from the oracle sent gifts, making Delphi one of Greece's wealthiest and most powerful cities. (Mauksch et al., 2020).

2. HISTORICAL DEVELOPMENT OF DELPHI TECHNIQUE

Olaf Helmer, a professor of futurist researchers at the University of Southern California, invented the Delphi technique, and his associate, Norman Dalkey, at the RAND Corporation in the 1940s (Olaf and Dalkey, 1999). Then, in the early 1950s, RAND developed the Delphi method for the Air Force as a military forecasting tool. Its objective is military planning by requesting reliable responses from a panel of experts on a specific subject, and it was kept secret for about ten years (Heiko, 2012). Delphi is also used to determine the scale of a Soviet nuclear attack, which is required to destroy the US military industry (Basu and Schroeder, 1977). Finally, the Delphi approach has been used in a variety of disciplines, including university education, business,



telecommunications, library science, and construction are some of the fields in which it can work, and has proven to be a valuable tool in achieving crucial outcomes for a variety of challenging issues (**Hilbert and Julia, 2009**). Experts were invited to weigh in on potential adversary strikes' likelihood, frequency, and severity. Other professionals may be able to provide anonymous feedback. This approach continued to find a solution (**Kissiet et al., 2017**). In 2021, a multi-disciplinary group concentrated on new Delphi directions and advances, containing Delphi formats that are updated frequently. The authors present a methodological toolset to create Delphi questionnaires that incorporate, among other things, sentiment classification in psychoanalytic theory (**Mahamid, 2018**).

3. MAIN CHARACTERISTICS OF THE DELPHI TECHNIQUE

The Delphi approach has the following basic characteristics: (**Omran and Hooi, 2018**)

3.1 Anonymity:

Surveys or other methods of expression are used. That protects the identity of specific members of the panel.

3.2 Controlled feedback from the interaction:

A balanced response makes it possible for interactivity with a significant decrease in panelist conflict.

3.3 Statistical group response:

An arithmetic means of individual opinions is used to describe collective opinion members' ultimate opinions, with each member's point of view reflected in the group's final answer.

4. DESIGNING the DELPHI TECHNIQUE

This study's careful planning and, subsequently good execution must be prioritized. This part is dedicated to the following four factors for designing and Delphi approaches for organizing (**Bakr, 2019**):

4.1 Problem definition.

Problem definition is a key first stage in ensuring that the scope of the situation or issue that needs to be looked into, as well as the Delphi method's suitability for addressing the specific problem (**Town et al., 2016**).

4.2 Selection of experts.

A Delphi study's success hinges on the panel of experts is carefully chosen. The experts' qualifications and the extent to which the person is ready to commit are both important factors in panel selection (**Ghahramanzadeh, 2013**).

4.3 Panel size.

The Delphi technique relies heavily on the appropriate panel selection since it allows a researcher to employ a tiny panel reliably. For Delphi research, there is no recommended sample size. According to the literature, the Size of the panel should be between (15-30) for a heterogeneous population and (5-15) for a homogenous population. (**Baloi and Price, 2003**).



4.4 Conducting the Delphi technique rounds.

The creation of a questionnaire, which is also identified as questions or repetitions, is based on a clear identification of study objectives, as well as a literature review and other primary research activities, allowing the researcher to begin creating question items and response measures that capitalize on the key questions to be assessed. Three or four rounds are commonly involved in a Delphi study (Zou and Wang, 2007), (Dikmen and Han, 2007).

5. IDENTIFIED CRITERIA FOR EQUIPMENT AND MATERIALS USED IN HIGHWAY CONSTRUCTION PROJECTS

Because different criteria apply to different and diverse places nearby, different academics employed different criteria for equipment and materials in highway construction projects. A number of the most important significant criteria and sub-criteria from earlier research are employed in this study. **Table 1.** shows the important main criteria and sub-criteria from the previous study.

Table 1. Important main criteria and sub-criteria from the previous study.

Main Criteria	Sub- criteria	Reference
Project Risks	Value of project	(Dikmen and Han, 2007) (Tah and Carr, 2009)
	Poor planning/ scheduling of project	
	Type and nature of the project	
	Financial (government or private)	
	Complexity of project	
Equipment and Tools	Un poor equipment maintenance	(Roger, 1993) (Wang et al., 2004) (Ghosh, 2004) (Enshassi et al., 2013)
	Unused modern equipment	
	Construction equipment collision	
	Improper use of equipment	
	Insufficient traffic control	
	Poorly designed equipment	
Materials	Weak of protection in material carrying	(Issa et al., 2015) (Samson and Wiecek, 2009) (Raafat, 2021) (Suherman, 2010)
	Weak of protection in material storage	
	Working with toxic/ hazardous materials	
	Lack of knowledge about construction materials	
	Inadequate safety in handling materials	
Driver (Operator)	Visibility obscured by sun glare	(GP House, 2013) (Augustine and Edwin, 2021) (Uher and Loosemore, 2004)
	Visibility obscured by dust	
	Driver asleep or drowsy	
	Alcohol or drug involvement	
	Medical condition and advanced age	
	lack of knowledge or training	



6. APPLYING DELPHI TECHNIQUE FOR THE CRITERIA in the EQUIPMENT and MATERIALS used in HIGHWAY CONSTRUCTION PROJECTS.

The Delphi technique was employed to determine the important parameters affecting the equipment and materials utilized in Iraqi construction projects. Three stages were used in the study:

6.1 Selection of the expert team.

Based on the following criteria, a team of experts has been assembled to provide input on important issues that have a strong and direct impact on the equipment and materials used in highway construction in Iraq:

6.1.1 They have a lot of expertise working on highway construction projects.

6.1.2 They are key members of the project management process in highway projects.

6.1.3 Willingness to participate in the process.

Twenty questionnaires were sent by inviting the concerned individuals to participate in the questionnaire. A simplified explanation was given of the study's goal. Experts were informed that there would be several rounds to obtain accuracy and reliability in the results. The results were distributed through interviews as well as by e-mail. The forms of Delphi's technique rounds are (Sixteen) participants responded and agreed to participate, four of them come from the private sector and twelve from the public sector. All the participants have experience of not less than twenty years in the construction industry in highway projects.

6.2 Conducting Delphi technique rounds.

6.2.1 Delphi technique 1st round:

The first round of identifying criteria for highway building equipment and materials has begun. The researcher compiled a list of effective criteria depending on the final result in the 1st round of Delphi from **Table 1**. This list is distributed into four groups for main criteria and sub-criteria, as shown above in **Table.1**. After that, the participant was asked to indicate a particular number of main elements they think came from this list that affects equipment and materials in highway building projects and advise whether any other aspects were not identified. In this tour, the researcher arranged to meet (ten) experts in one place simultaneously and started a round of brainstorming with them to discover the elements, while the remaining (six) experts were interviewed to respond to Delphi.

The feedback and remark review procedure was carried out by comparing the comments with those of other experts from the same sort of company and past research and studies. In the first phase, the researcher analyzed and collated each expert's opinion and remarks on the list of criteria. The first round's results are four groups of equipment and materials criteria for highway construction projects. Major and minor sub-criteria are included in each group. The Delphi technique's second round was carried out using these group listings.



6.2.2 Delphi Technique second round:

In the 2nd round of the Delphi approach, selected criteria will be examined by (16) sixteen experts who will clarify their ability to participate in the 2nd and 3rd rounds. In contrast, the remainder of the experts will refuse to participate due to time constraints and responsibilities. The experts were asked about the degree of influence of each of the criteria that were defined and finalized in round one using a five-level Likert scale in this round ("1" has no impact, "2" has a low impact, "3" has a medium impact, "4" has a significant impact, and "5" has a high impact).

6.2.2.1 Results and analysis of second round for Delphi technique

Criteria with arithmetic mean less than (3) were eliminated (**Jardine, 2015**). The mean and standard deviation and Cronbach's alpha factor (α) that was calculated by using (SPSS/V25) for each criterion. This round (SPSS/V25) was used to monitor statistical study for the relative importance of whole criteria in a different organizational structure. First, the arithmetic means and variance and Cronbach's alpha factor (α) for criteria within the fourth category were calculated. Second, the criteria with a mean less than (3) were eliminated, and the remaining criteria will be employed in the Delphi technique's next round. The results of the second round are shown in **Table 2**. Then, it was prepared to be used in the third round.

Table 2. Applying the Delphi technique in the second round.

Main Criteria	Sub- criteria	No. of Experts	Mean	SD	Cronbach alpha (α)
Project Risks	Value of project	16	3.811	0.750	0.899
	Poor Planning/ scheduling of project	16	2.750	0.450	0.855
	Type and nature of the project	16	3.063	0.854	0.966
	Financial (Government or private)	16	2.623	0.886	0.785
	Complexity of project	16	3.000	0.500	0.701
Equipment and Tools	Un Poor equipment maintenance	16	3.500	0.894	0.909
	Unused of modern equipment	16	4.000	0.894	0.855
	Construction Equipment Collision	16	3.063	0.854	0.966
	Improper use of equipment	16	2.375	0.719	0.800
	Insufficient traffic control	16	2.625	0.885	0.900
	Poorly designed equipment	16	3.500	0.894	0.909

Materials	Lack of protection in material carrying	16	2.800	0.447	0.832
	Lack of protection in material storage	16	2.400	1.5166	0.834
	Working with toxic/ hazardous materials	16	1.800	0.447	0.965



	Lack of knowledge about construction materials	16	3.800	0.447	0.917
	Inadequate safety in handling materials	16	3.800	0.447	0.917
Driver (Operator)	Visibility obscured by sun glare	16	1.800	0.447	0.965
	Visibility obscured by dust	16	3.813	0.750	0.888
	Driver asleep or drowsy	16	2.750	0.450	0.758
	Alcohol or drug involvement	16	3.063	0.854	0.890
	Medical condition and advanced age	16	2.400	1.517	0.834
	lack of knowledge or training	16	3.500	0.894	0.909

6.2.3 Delphi third round: (degree of consistency)

Experts re-evaluated the significant criteria that emerged from the Delphi technique's 2nd round; the same five Point Likert rating was used. The main objective of this step is to ensure that expert opinions are consistent from the second round to the third round. There would be no need for additional rounds if the appropriate level of consistency was achieved in this round.

6.2.3.1 Results and analysis of 3rd round for Delphi technique

In this round, the researcher also employed the (SPSSV/25) program to conduct statistical analysis following the re-evaluation criteria within four primary groups. The results revealed that the arithmetic mean of the degree of influence for each re-evaluated criteria was (3) or higher, indicating that all criteria had a medium to very great influence. Furthermore, the findings of This round were consistent with the previous ones. therefore, there will be no need for a third round. Furthermore, Cronbach's alpha was used to test the internal consistency of the expert's assessment for this round's survey(α) test. The results of (SPSS/V25) software showed that all the values of Cronbach's alpha (α) test were positive and more than (0.70). This shows that expert judgment was consistent and steady (Mohammed and Hasan, 2012). The results of Cronbach's alpha (α) test and the mean and standard deviation are shown in **Table 3**.

Table 3. Applying the Delphi technique in the third round.

Main Criteria	Sub- criteria	No. of Experts	Mean	SD	Cronbach alpha (α)
Project Risks	Value of project	16	4.062	0.854	0.926
	Poor Planning/ scheduling of project	16	4.375	0.500	0.909
	Type and nature of the project	16	4.312	0.602	0.903
Equipment and Tools	Un Poor equipment maintenance	16	3.500	0.894	0.909
	Unused of modern equipment	16	4.000	0.894	0.855
	Construction Equipment Collision	16	4.250	0.447	0.915
	Improper use of equipment	16	4.500	0.516	0.930



Materials	Working with toxic/ hazardous materials	16	4.170	0.573	0.957
	Lack of knowledge about construction materials	16	4.083	0.680	0.951
	Inadequate safety in handling materials	16	4.063	0.442	0.971
Driver (Operator)	Lack of protection in material carrying	16	4.400	0.547	0.927
	Visibility obscured by dust	16	3.812	0.750	0.888
	Alcohol or drug involvement	16	4.375	0.500	0.973
	Medical condition and advanced age	16	3.875	0.806	0.970
	lack of knowledge or training	16	3.500	0.894	0.909

7. RESULTES AND DISCUSSIONS

The raw list of parameters impacting equipment and materials in highway building in Iraq, which was developed based on past research and studies, was shortlisted and modified in the 1st round of the Delphi technique. The 2nd and 3rd rounds of the Delphi approach were completed using the exhaustive list of criteria created in the first round. Furthermore, the 2nd and 3rd rounds were completed, with the results of the third-round indicating that no further testing was required based on the stability and reliability test results. The results of the Delphi 3rd round identified fifteen (15) criteria that influence equipment and materials used in highway construction in Iraq, divided into four (4) primary groupings.

8. CONCLUSIONS

This study presents a set of primary and sub-criteria for equipment and materials used in highway construction projects in Iraq, based on previous research and field experience. This research aims to establish essential criteria and utilize the Delphi technique to evaluate those criteria from a group of experts. Experts were recruited to assess the criteria and confirm the validity of the criteria items and their fit for the research objectives. The criteria discovered using the Delphi technique will be appropriate for equipment and materials in Iraqi highway construction projects. In this paper, the (SPSS) was used to determine the three rounds of the Delphi technique and find the mean and stander deviation and Cronbach alpha for each criteria. Finally, in the project risk group, the researcher discovered that the criteria of project value and project size have the greatest impact. In the second category, the most significant impact is improper equipment use and construction equipment collision elements. Working with toxic/ hazardous materials has the greatest value in the third category, as this aspect is very significant and useful in identifying materials in highway projects. Lack of knowledge or training in group four has the highest value, and this aspect is critical since drivers must receive training to prevent making mistakes on the job.



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