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ONE EXAMPLE OF CIVIL ENGINEERING RESEARCH CONDUCTED WITH THE DELPHI METHOD

In this work one example of civil engineering research conducted with the Delphi method is shown. The Delphi method is one of the most popular scientific methods for research of problems with lack of known data. For this research, researcher must form the team of experts and analyze their answers on questions asked during the research with controlled feedback. In this article researcher wanted to prove hypothesis for making risk assessment model for planning and design processes of wastewater treatment plants. This research was conducted with Classical Delphi method is shown step by step.

Keywords: Delphi method, civil engineering, research, risk assessment model.

1. INTRODUCTION

The Delphi method or Delphi technique is specific type of research used in various scientific disciplines. Development of this method started in early 50s of the last century in Research and Development Corporation (RAND) in Santa Monica. It can be defined as a method that enables the process of group communication so that the process is effective and allows a group of individuals, as a whole, to agree on a solution to a complex problem, i.e. to reach a consensus [1].

For finding a solution of some unexplored problem the Delphi method implies sending questionnaires, which are structured or partially structured, to the examinee who are most often defined as experts or panel of experts. Replies are collected and in the following circles either the original or changed questionnaire is sent to the participants. Participants need to confirm or customize previous responses after the data from the last round has been processed. This procedure repeats until a consensus is reached, i.e., confirmation of the starting hypothesis. Often, panelists can explain their answers or give a certain confirmation. The research itself is anonymous, which is suitable for participants because they respond without pressure [2].

This research method is used in different areas of scientific research. In September 2008, a

review of the Scopus database was conducted, and out of the 15.000 articles published by 4.000 publishers, 105 articles were based on the Delphi method [3].

The Delphi method is highly suitable for research precisely because the participants are anonymous and feel that they can freely provide their opinion. When designing any research, the most important thing is to carefully select individuals for the team of participating experts. Depending on the method of research, one can clearly define a specific group of individuals who stand out in a certain field or choose participants who can help discover new ideas related to a certain field. This approach involves understanding a concept that is part of a much larger theory that the researcher plans to develop during the research [4]. In this research is shown implementation of the Delphi method in specific civil engineering research. The Delphi method is used for making risk assessment model for planning and design processes of wastewater treatment plants [5].

There are published research about implementation of the Delphi method in civil engineering research. In [6] is said that there are 7 studies up to 2008. implementing of the Delphi method in civil engineering research. Also, they concluded that structure of this method is suitable in different areas of research.

According to the research [7], the construction project management and planning were processed in 29 out of 88 papers based on the Delphi method, where this method was used to obtain and evaluate the risk data. It is also important to note that between 3 and 93 experts participated in the research based on the Delphi method, in the field of construction, and the number of rounds of research varied between 3 and 6. In [8], there is a description of the research engaging 14 experts: professors, engineers, contractors and experts in the field of international development.

If a researcher wants to use the Delphi method for research, there are some things to consider: type of the Delphi research, sample size, defining criteria for experts, anonymity and controlled feedback.

There are three types of the Delphi method [9]:

1. The Classical Delphi: This type of study is characterized by features: anonymity, iteration, controlled feedback, statistical group response and stability in responses among those with

expertise on a specific issue. Participants in this type of Delphi have expertise and give opinions to arrive at stability in responses on specific issues.

The Policy Delphi: The aim in this research is not to reach stability in responses among those with expertise but to generate policy alternatives by using a structured public dialogue. Here the Delphi is an instrument for policy development and promoting participation by obtaining as many divergent opinions as possible. It is characterised by 'selective anonymity', iteration, controlled feedback, polarised group response and structured conflict. Selective nonymity may mean that participants answer questions individually but may also come together in a group meeting.

The Decision Delphi: This type of Delphi is used for decision making on social developments. Reality is created by a group of decision-makers rather than from the ad-hoc decision of only a small number of persons. Crucial to this type is that decision-makers involved in the problem participate in the Delphi. They are selected according to their position in the hierarchy of decision-makers and the aim is to structure thinking so that consensus can be achieved. The characteristic is 'quasi-anonymity' (where people with expertise are mentioned by name and known to everybody from the beginning but questionnaire responses are anonymous).

Sample size for the Delphi method could be from 3 to 50, or more examinee [7]. The most of the research (71 percent) had less then 20 experts. The recommended number of participants in scientific research is 10 to 50. It is likely that the results will be suitable for analysis and that sufficient data will be obtained if the number of experts is up to 50.

In [10,11,12,13, 14] are defined different types of criteria to choose who can be an expert. After analyzing, there is a conclusion that every research is unique and criteria also. It means that researcher need to realize which results want and in accordance with that make criteria for experts.

The most obvious advantage [9] of guaranteed anonymity in responding to individual questions is that it is likely to encourage opinions that are free of influences from others and is therefore more likely to be 'true'. It has been suggested that anonymity encourages experts to make statements based on their personal knowledge and experience, rather than a more 'cautious institutional position' [15]. By adopting an

iterative approach to data collection through questionnaires and feedback however, the 'collective human intelligence capability' found in groups of people with expertise can be harnessed [1].

The research presented in this article was performed as a theoretical experiment. This article is focused on making of this theoretical experiment step by step. In research there were 35 experts consisted of engineers of various professions, chemists and spatial planners from the Republic of Serbia and Bosnia and Herzegovina.

The Delphi method was conducted in three rounds (zero, first and second round), the zero one of which represented the selection of experts based on their education and expertise influencing the research, whereas the remaining two involved risk analysis and assessment by the selected first round expert team [5].

2. STRUCTURE OF THE DELPHI RESEARCH

This research started with hypothesis that it is possible to obtain a risk assessment model for the construction process using the Delphi method.

The researcher chose this scientific method after analysis of suitable methods. Making of risk assessment model was the main goal of this research and Delphi method was adequate because of lack of data about civil engineering risks in design of wastewater treatment plants. After research of literature, there is a conclusion that Delphi method is suitable for civil engineering research. In this research there was a need to include experts from different areas connected with wastewater treatment and that was also a reason for using the Delphi method for research. Therefore, it was necessary to perform identification, analysis, and evaluation, i.e., the assessment and evaluation of the risk significance of WWTP construction [5].

As it is said for using of Delphi method, the researcher had to consider type of the Delphi research, sample size, defining criteria for experts, anonymity and controlled feedback.

For this example of civil engineering research conducted with the Delphi method, the Classical Delphi was used. Team of experts is selected, because in this type of Delphi, participants have expertise and give opinions to

arrive at stability in responses on specific issues. For them, it is important that they are multidisciplinary, available and experts in the field of research [15].

To participate in the research, potential experts were selected based on experience in the planning and design processes of wastewater treatment plants. The number of experts with experience in this field is small because the topic itself is not sufficiently represented in Serbia. Therefore, the researcher decided to include experts from the state of Bosnia and Herzegovina in the research. On the territory of this state, planning and design laws are like laws in Serbia, and experts themselves have experience in both Serbia, and Bosnia and Herzegovina.

Sample size for this research was 35 experts, and this is number of experts which fits the suggested number of participants in the method. Thirty-five experts with experience in planning, designing, or constructing a wastewater treatment plant were selected to participate in the research. The team of 35 experts consisted of engineers of various professions, chemists and spatial planners from the Republic of Serbia and Bosnia and Herzegovina.

Researcher made specific criteria for expert's identification relying on literature instructions. Criteria is shown in Table 1.

Table 1. Criteria for experts

Number	Criteria	Explanation
1	Original scientific work	The expert has published scientific work in the field of risk management or wastewater treatment
2	Conference experience	The expert has participated in conferences or scientific meetings in the field of risk management or wastewater treatment
3	Experience in urban planning	The expert was involved in the development of two or more spatial or urban plans, defining the location of wastewater treatment plants

4	Experience in topic of research	The expert participated in the development of two or more previous studies or feasibility studies for the construction of wastewater treatment plants
5	Work experience	The expert has five or more years of experience in planning or designing or running wastewater treatment plants
6	Scientific experience	The expert works at the University
7	Professional associations	The expert is member of some professional associations
8	License	The expert is licensed engineer

The requirement to define the research participant as an "expert", was to meet 3 out of 8 criteria. Only two participants didn't meet this requirement.

The author himself, as a research facilitator of the method, fully respected the anonymity of the experts and their conclusions. Examinee felt free to express their opinion on certain risks and why they evaluated risks in that way. This approach has great benefit to the research.

The research was conducted through several phases in the Delphi method by forming a questionnaire given to the experts, specific analysis and systematization of the obtained data and forming a model for preliminary risk assessment (with quantified risks) [5].

Controlled feedback was the most important part because, after each round, there was need to analyze data proceeded from the experts. The Delphi method was conducted in three rounds (zero, first and second round), the zero one of which represented the selection of experts based on their education and expertise influencing the research, whereas the remaining two involved risk analysis and assessment by the selected first round expert team. After three rounds and statistical analysis the risk assessment model was made. This proved hypothesis from the beginning of the research.

3. CONCLUSION

In this research is shown one example of civil engineering research conducted with the Delphi method. This scientific method is very used in different areas of research, but in civil engineering research isn't implemented as in other areas of research. After literature review there was conclusion that this method can be used for civil engineering research. This research started with hypothesis that it is possible to obtain a risk assessment model for the construction process using the Delphi method. By selecting experts based on defined criteria and implementing an anonymity with controlled feedback, the researcher obtained the desired result – risk assessment model planning and design processes of wastewater treatment plants. This model was the proof for possibility of using this method in civil engineering research.

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