



## Analysis of Factors Affecting the Development of Contractor's Safety Maturity Model in Construction Projects Using a Hybrid Multi-Criteria Decision Approach

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**ABSTRACT:** Despite safety regulations, the execution of construction projects has irreparable risks, including physical accidents and financial crashes for human resources and the project. These events adversely affect the balance of cost, time, and quality of projects. Therefore, a safety management system can play an effective role in improving the project management process. This research aims to identify and evaluate the most important levels and safety criteria in construction projects, evaluate and develop a safety management maturity model in workshops based on a case study, statistical analysis of the data obtained from the questionnaire, and the combined multi-criteria decision-making method. It is based on combining Analytical Hierarchy Process, Technique for Order Preference by Similarity to Ideal Solution, and Decision-Making Trial and Evaluation Laboratory methods. Based on the study results, twelve important safety criteria were identified and ranked according to the performed weighting. Then among the three study projects, one was selected as the project closest to the ideal solution. In the end, the most effective criteria were identified according to prioritization in the four main pillars of the project. Components of using the integrated system of project safety documentation and records by different stakeholders with scores of 15.39 and 17.9579, using optimal methodologies and processes based on UpToDate procedures with a score of 11.1443, and determining goals, procedures, strategies, and project safety requirements and communicating its documents with stakeholders with a score of 6.6906 were recognized as the most important components in the pillars of leadership and management of the project organization, key personnel and project staff, project partners and stakeholders, and policies and strategies, respectively.

### Review History:

Received: Nov. 15, 2020  
Revised: Sep. 01, 2021  
Accepted: Dec. 28, 2021  
Available Online: Jan. 19, 2022

### Keywords:

Construction Projects Management  
Safety maturity model  
method of Multi-Criteria Decision Making (MCDM)

### 1- Introduction

Accidents in the construction profession have caused great damage to workers, their families, employees, and members of the community [1, 2]. Accordingly, paying attention to human resources as the main asset of the organization and improving work processes to improve the productivity of this capital is one of the most important criteria for the competitiveness of organizations [3]. Also, the high social and economic impacts of accidents and injuries have led to many efforts to solve the unfavorable situation of occupational and safety health (OSH) in the construction industry [4-6]. According to the statistics of construction industry accidents, it can be found that the same amount that paying attention to important components such as cost, time, and quality, which are the three most important vertices of the project management triangle, make the project successful, paying attention to safety performance also contributes to the success of the project [7]. Therefore, with the implementation and establishment of a safety management system in any organization, many risks of the

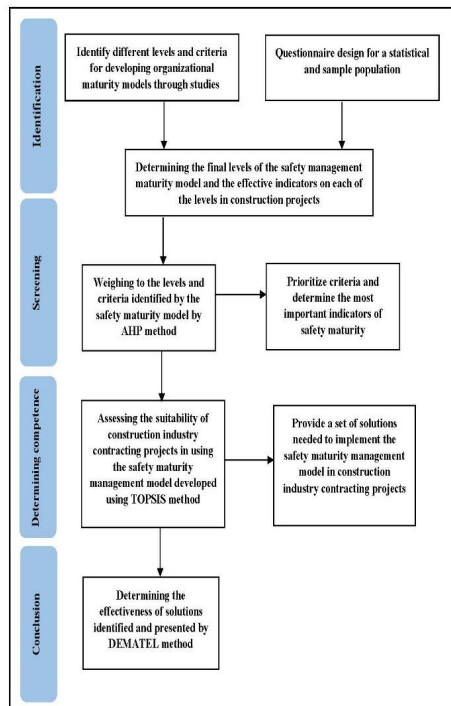
executive operations of that organization will be identified, and of course, suitable solutions can be provided to reduce the risks to a significant extent [8].

### 2- Methodology

This study attempts to examine and identify the most important criteria and parameters affecting the development of the safety management maturity model and evaluate the model in construction industry projects based on experts' opinions. To achieve this goal, in the first stage, using the library and documentary studies such as, project management standards, maturity models are examined, and various levels for the development of a maturity model such as, basic levels, standards, integration, and measures will be identified by monitoring and optimization. Then, the sub-criteria and parameters affecting each of these levels to achieve a model with safety management maturity in construction industry projects will be identified. These components will then be evaluated to develop a systematic model. This process uses

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**Fig. 1. Conceptual model of the general stages of research**

data screening through a Likert-based questionnaire that will be provided to the statistical population of the research. After determining the importance of these criteria by experts, the data are entered into SPSS software, and Friedman statistical test is used to determine the most important cases. In the next step, based on the most important criteria obtained from the results of the Friedman test, weighting and prioritization of identification parameters will be done using a combination of multi-criteria decision methods based on the combination of Analytic Hierarchy Process (AHP) and The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS).

First, the sub-criteria related to each level of the safety management maturity model will be prioritized using questionnaires based on pairwise comparisons and experts' opinions to extract the most effective criteria. Then, the parameters will be weighted using the scores obtained from the previous step. Then, using the TOPSIS method, some construction projects will be evaluated in terms of desirability in the developed maturity model. Finally, the effectiveness of the identified solutions is investigated using the Decision-Making Trial and Evaluation Laboratory (DEMATEL). For this purpose, the impact of the four basic pillars of the project on these solutions is measured, besides the impact of the solutions on each other in each pillar. It should be noted that in all stages of the research, for evaluations, the opinions of experts in the construction industry will be used with a case study in the construction projects of the country (Figure 1).

### 3- Results, Discussion and Conclusion

According to previous researches that mostly deal with

issues, such as identifying levels and criteria affecting the maturity of safety management and also renting different safety models with different methods, in this research, experts weighted and prioritized safety criteria, as well as the effectiveness of these criteria on the four important pillars of the immune system after collecting safety criteria from previous researches and then identifying the most important ones. The most important safety criteria are the full application of safety standards to develop a safety maturity model (W2), setting the goals, procedures, strategies, safety requirements of the project, and communicating its documentation with all stakeholders (W3), using project safety management tools and techniques (W5), establishment of project safety system and its principle-based implementation (X1), compatibility and coordination of tools, procedures and techniques of planning, control and implementation based on safety strategies (X5), using integrated project documentation system and safety records by different stakeholders (X7), monitoring, evaluating, and analyzing safety plans at different levels of the project (Y1), conducting regular periodic inspections to ensure compliance with safety regulations (Y8), developing and updating complete regulations to enhance safety culture (Z1), using optimal methodologies and processes based on UpToDate procedures (Z5), safety quality improvement through tools and techniques of planning, control, and execution on a regular basis (Z7), and implementing safety audits on a continuous basis to ensure compliance with regulations and guidelines (Z9). Finally, the effect of safety criteria in four pillars was discussed. Component Z5 is the most important criterion (in terms of interaction with other criteria) in the safety system. Components W5 and Z7 are the most effective and the most impressive criteria in the safety system from the leadership and management perspective. Component X7 is the most important criterion (in terms of interaction with other criteria) in the safety system. Also, components W5 and Z9 are the most effective and the most impressive criteria in terms of the role of partners and stakeholders. Component Z5 is the most important criterion (in terms of interaction with other criteria) in the safety system. Components W3 and Z9 are the most effective and the most impressive criteria in the safety system from the perspective of the role of key personnel and employees. Component W3 is the most important criterion (in terms of interaction with other criteria) in the safety system. According to the objectives set in this study, it seems that relevant bodies and organizations, such as contractors of construction projects, consulting engineers, various stakeholders in the construction projects, such as companies and organizations active in safety management systems in the country, are among the advantages.

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**HOW TO CITE THIS ARTICLE**

*M. Banar, R. Ansari, M. Mahdikhani, Analysis of Factors Affecting the Development of Contractor's Safety Maturity Model in Construction Projects Using a Hybrid Multi-Criteria Decision Approach, Amirkabir J. Civil Eng., 54(7) (2022) 559-562.*

**DOI:** 10.22060/ceej.2022.19264.7118



