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# Modeling Effective Indicators of Construction Projects Using Fuzzy TOPSIS Method

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**Abstract:**
Recently growing rate of construction projects caused to expanse of construction industries. Unfortunately recent increasing demand on construction projects caused projects which do not match appropriately with construction industry's approaches and this caused delays in a part and sometimes whole of the projects. This will take into consideration when we understand that a large amount of national expenditures includes construction projects costs. These delays cause damages into infrastructure. Recently using fuzzy methods and multiple attribute decision making have become usual for help of managing and efficiency construction in worldwide .these methods are based on fundamental indicators by putting them in phase category and grading them decision making is done. Thus this paper surveys and explains four common approaches in construction projects and finally by using fundamental indicators in project delays these approaches will be graded by Fuzzy TOPSIS methods and Multiple Attribute Decision Making (MADM).

**Key words:** construction project, delays, multiple attribute decision making (MADM), TOPSIS.

## ۱. *Introduction*

One of the problems in any project implementation is the “delay” which is defined as the difference between the time a project is expected to be finished and the time the project takes to be actually finished .In the other word the variance between the predicted time a project takes to be finished and the actual time within which the project is finished is called “project

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delay". Each project consists of a series of activities which delay in starting a task could happen, resulting from the late finishing of the previous tasks. It could also result from the task activity itself or both of them. Delay in each project is the result of the combination delays in each task. As mentioned earlier delay in projects can result from the variety of factors many of which can be controlled by appropriate management. Many studies have been conducted to control project delays at the management level. However, the major problems of project delays seem not to be concerned with the nature of the projects. The experiences show that if a task lags on ٢٥% more than its predicted time, making up for this delay and finishing the project within the estimated time is minimized.

Concerning the role delays play in projects, there are many projects that starts well but despite the timing and resources allocation, they are left unfinished and the continuation of this trend will cause delayed finishing of the project. Or although these projects are finished the expected quality and the purposes are not satisfactorily accomplished. As these projects impose high costs, the delay of any sort in finishing them is considered as not benefiting from and ineffectiveness of great amount of investment in long term. Undoubtedly, this will lead to many economic damages to the infrastructures and having no planning to prevent these problems will harm the society. Therefore developing an appropriate and efficient model for preventing the delays in projects as an essential solution is inevitable.

The purpose of this study is to examine the available approaches in construction projects and to offer a classification of management systems in construction projects for dealing with delays, ranking these systems on the basis of obtained courses according to the indices using methods such as Multiple Attribute Decision Making (MADM) and Fuzzy TOPSIS Technique.

## ٢.*Studying available approaches in construction projects:*

### ٢-١ *Traditional Method:*

As traditional methods involve non-integrated design stages as well as project implementation the time a project takes to be finished increases. Consequently the costs increase, rendering plans uneconomical. It also results in delay in projects inauguration and sometimes delays in the operation of other projects. In this method the experiences and executive skills are excluded in the design, resulting in non-executive plans and programs. Generally the employer faces high risk.

### ٢-٢ *Project-centered Management Method:*

Project-centered Management provides planning for the implementation of project. However, limited adaptation with conditions as well as periodical meetings of executive team members, the team will be disassembled following the project implementation. Consequently, the experiences and the knowledge obtained will not be passed on. In a Project-centered Organization, the major tasks are performed in terms of temporary organizational units, established to meet the customer's needs. The business unit will be disassembled following the achievement of project's goal and project team members are recruited in a new project.

### ٢-٣ *Strategic Approach:*

Today, organizations face unpredicted new technologies, new products and new markets. Relying on a dynamic and future-oriented mentality, strategic management provides a

solution for many problems and issues faced by today's organizations. The fundamentals of strategic management depend on the extent to which managers perceive their competitors, environmental conditions, and their customers.

Strategic management enables an organization to take the initiative and consequently its activities are conducted in a way that the future is controlled. Given a variety of projects in an organization, there is a need to choose and prioritize these projects on the basis of organizational strategic goals and the importance of them. An appropriate project is selected according to the organization's needs and planned strategies in a particular time. The process of strategic management is delineated in the following ٥ steps:
١- Environmental Analysis. ٢- Establishing Organization Orientation. ٣- Goal-setting. ٤- Strategies Development. ٥- Preparation and Implementation of strategies as strategies control.

*٣. Multiple Indices and Multiple Attribute Decision Making (MADM):*

The agents are the main criteria against which decisions are made in multiple attribute decision making approach which is sued by this study. The purposes have been clearly stated and indices are developed on the basis of questions and forms as well as by surveying experts and specialist about the most important purposes and indices of urban management. MADM aims to select an option from among the available options. MADM approach to information processing is divided into many sections on the basis of information presented. Compensatory model is one of these sections.

Compensatory Model: In this model, there is interaction among the indices. That is, change in one available is compensated by counter changes in other indices. This model uses methods as TOPSIS (Technique for Order Preference by Similarity to Ideal Solution), ELECTR (Elimination Et Choice Translation Reality), Linear Allocation, AHP (Analytical Hierarchy Process).

*٤.Fuzzy Technique:*

The knowledge obtained from qualitative research is vague. Consequently, the data can be expressed numerically. Being so, an accurate number rather than verbal evaluation is used to give evaluation.

*٥. Fuzzy TOPSIS Technique and Design Modeling:*

This technique assumes that an ideal index is consistently incremental (decreasing). In other word, the indices are either positive or negative. The positive index represents interest index and negative index represents loss index. Consequently, the best value available for an index represents the ideal indicator and the worst value represents the negative ideal. (Table ١) shows the results obtained by determining the negative and positive importance of indices.

| | | | | | | |
|---|---|---|---|---|---|---|
| importance of indices | + | - | + | + | + | + |
| indices | Integrated Management | Cost | Quality | Time Management | Human Resources | Equipments |

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Table١. Determination the negative and positive importance of indices

TOPSIS method evaluates decision matrix, consisting of n options and ٢ indices. The modeling was performed, using ٣ options, namely Traditional, Project-centered, and Strategic as well as ٦ indices as follows: Integrated Management, Cost, Quality, Time Management, Human Resources and Equipments.

٦. *Modeling followed these steps:*

*Step ١: Developing Decision-making Matrix and Matrix Normalization:*
In order to develop decision-making matrix, the extent to which each index is important in the indices studied was examined, using experts' options and consultations. The data were analyzed and evaluated, yielding normalized results on the basis of (Eq. ١) given in the (table ٢) where $r_{ij}$ represents normalized index and $X_{ij}$ represents the level of importance each index has.

$$r_{ij} = \frac{X_{ij}}{\sqrt{\sum_{i=1}^{m} X_{ij}^2}} \qquad (١)$$

| Indexes / Options | Integrated Management | Cost | Quality | Time Management | Human Resources | Equipments |
|---|---|---|---|---|---|---|
| (A)Traditional | ٠.١١٦٢ | ٠.٠٦١٤ | ٠.٠٦٩٩ | ٠.٠٨٠٧ | ٠.٠٨٠٧ | ٠.٠٨٠٧ |
| (B)Project-centered | ٠.٢٣٢٣ | ٠.٦٨٦١ | ٠.٢٤٢٢ | ٠.٦٧٤٠ | ٠.٦٧٤٠ | ٠.٢٤٥٣ |
| (C) Strategic | ٠.٦٥١٤ | ٠.٢٥٢٤ | ٠.٦٨٨٠ | ٠.٢٤٥٣ | ٠.٢٤٥٣ | ٠.٦٧٤٠ |
| SUM | ١ | ١ | ١ | ١ | ١ | ١ |

Table ٢ . The decision making matrix is normalized. As shown, the sum of importance coefficients for four indices equals ١ and this proves that the importance of the indices is relative.

*Step ٢: Weighting Normalized Decision Matrix:*
In this step, each index is assigned a weight on the basis of its importance in comparison with other indices, drawing on the experts' judgment. The normalized and weighted decision matrix V is derived by multiplying column (j) of matrix R at the relevant weight (Wj). Table ٣ shows the results.

| Indexes / Approaches | Integrated Management | Cost | Quality | Time Management | Human Resources | Equipments |
|---|---|---|---|---|---|---|
| (A) Traditional | ٠.٠٨٧٢ | ٠.٠٥٨٤ | ٠.٠٥٥٩ | ٠.٠٧٢٦ | ٠.٠٦٨٦ | ٠.٠٦٨٦ |
| (B)Project- | ٠.١٧٤٢ | ٠.٦٥١٨ | ٠.١٩٣٧ | ٠.٦٠٦٦ | ٠.٥٧٢٩ | ٠.٢٠٨٥ |

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| | | | | | | |
|---|---|---|---|---|---|---|
| centered | | | | | | |
| (C) Strategic | ٠.٤٨٨٦ | ٠.٢٣٩٨ | ٠.٥٥٠٤ | ٠.٢٢٠٨ | ٠.٢٠٨٥ | ٠.٥٧٢٩ |

Table ٣ . The normalized weighted matrix V

*Step ٣: Determining Positive Ideal Solution and Negative Ideal Solution:*
٢ virtual options (positive ideal, negative ideal) are defined as follows: $A^+$ is the best option (positive ideal) and $A^-$ is the least effective option (negative ideal). (Table ٤) shows the results.

$$A^+ = \left(\{(\max v_{ij} / j \epsilon J)_i (\min v_{ij} / j \in J')\}/i = 1,2,\dots,m\right) \quad (٢)$$

$$A^- = \left(\{(\min v_{ij} / j \epsilon J)_i (\max v_{ij} / j \in J')\}/i = 1,2,\dots,m\right) \quad (٣)$$

$$\text{Related to profit index} \leftrightarrow J = \{j = 1,2,\dots,n\}$$
$$\text{Related to cost index} \leftrightarrow J' = \{j = 1,2,\dots,n\}$$

| Indexes / Ideal | Integrated Management | Cost | Quality | Time Management | Human Resources | Equipments |
|---|---|---|---|---|---|---|
| A+ | ٠.٤٨٨٦ | ٠.٠٥٨٤ | ٠.٥٥٠٤ | ٠.٦٠٦٦ | ٠.٥٧٢٩ | ٠.٥٧٢٩ |
| A- | ٠.٠٨٧٢ | ٠.٦٥١٨ | ٠.٠٥٥٩ | ٠.٠٧٢٦ | ٠.٠٦٨٦ | ٠.٠٦٨٦ |

Table ٤ . Determination of positive ideal and negative ideal solutions

*Step ٤: Measuring the Distance Amount:*
The distance between every N-dimensional option can be measured by Euclid's Method. The distance between option (i) and the positive ideal can be obtained from (Eq. ٤):

$$S_{i+} = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^+)^2} \quad \longrightarrow i=١, ٢,..., m \quad (٤)$$

In the same way, the distance between option (i) and the negative ideal can be obtained from (Eq. ٥):

$$S_{i-} = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2} \longrightarrow i=١, ٢,..., m \quad (٥)$$

The equation amounts earned in this step are shown in (table ٥).

| Distance / Options | $Si^+$ | $Si^-$ |
|---|---|---|
| A | ١.٠٩٥٢ | ٠.٥٩٣٥ |
| B | ٠.٨٤٣٢ | ٠.٧٦٥٢ |
| C | ٠.٥٦٠٨ | ٠.٩٣٣٤ |

Table ٥ . The Distance from the positive ideal and negative ideal

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*Step ٥: Calculating the relative distance between* $A_i$ *and* $\underline{A^+}$*:*
(Eq. ٦) is used to calculate the distance and the results are shown in (table ٦).

$$C_{i*} = \frac{S_{i-}}{S_{i+} + S_{i-}} \qquad (٦)$$

| Options | Relative Distance |
|---|---|
| A | ٠.٣٥١٤ |
| B | ٠.٤٧٥٨ |
| C | ٠.٦٢٤٧ |

Table ٥ . Calculation of Relative Distance for options

*Step ٦: Ranking groups:*
The available options can be ranked on the basis of decreasing order of $C_{i*}$ . As (table ٧) shows, strategic approach is ranked first, project-centered approach is ranked second and the traditional approach is ranked third.

| Rank in Decreasing Delay | Options | Final Score |
|---|---|---|
| First | C | ٠.٦٢٤٧ |
| Second | B | ٠.٤٧٥٨ |
| Third | A | ٠.٣٥١٤ |

Table ٧. Ranking available options on the basis of decreasing order

*٧.Conclusion:*
Given the results and the valuation outcomes, it was concluded that the strategic management enjoys the highest score among other approaches. Therefore, it stands the first rank. Its work mentioning that this approach reduces the costs and time of project implementation, using environmental factors. It also reduces the project delays by integrated management. Using the equipment which reduces the time and increases the quality and human resources, this approach is considered best option for implementing highly important projects.

Reducing the costs is the main basis of project-centered approach. This reduces the time a project takes to be finished through the decreased costs as well as by optimally using the human resources. This approach is tailored to the projects which are rather important.

As the main indices of construction projects management in traditional approach are assigned the lowest score, this approach is considered as an unacceptable method which is not used in most developed countries, due to the loss of considerable resources, facilities and

time. This approach should be applied by the developing countries to implement the least important projects.

It is concluded that the stricter supervision over projects prioritizations are required to reduce the delays in projects. So that the different approaches are assigned to different projects on the basis of the extent to which these projects are important. This allows the prevention of resources and assets loss in infrastructures. The timely appropriate implementation of construction activity entails the effective implementation of these activities by the efficient management in a principled way. This requires the best use of capabilities of all those construction activities so to pave the way for a more developed country.

*References:*

author: Nejabat Management Project Association Bayati A., Nasseri H., Afkhami v.”the Statue of Project Management Science Handbook”, Tehran: Petrochemical Industries National Co. ٢٠٠٥.

Byun H.S. & Lee K.H.,(٢٠٠٤)” A decision support system for the selection of a rapid prototyping process using the modified TOPSIS method”, Springer-Verlag London Limited ٢٠٠٤.

Iranmanesh H. & Piltan M. & Mohammadlu H. (٢٠٠٩),”Comparison between the Delay Analyzing Methods for Construction Projects and Recruiting the Timing Windows Method for a real project”, Paper collection of the ١st Thermal Power Stations Industry held in Technical Faculties of Tehran University, May ١٦ - ١٧, ٢٠٠٩.

Kacprzyk, J.,(١٩٨٦) "Group decision making with a fuzzy linguistic majority", Fuzzy Sets, (١٩٨٦).

M.J. Asgharpour, (٢٠٠٩), “Multiple Attribute Decision Making System”, ٧th Edition, Tehran, Tehran University Publications.

Moghassem, A. R.,(٢٠١٠),” Application of TOPSIS Approach on Parameters Selection Problem for Rotor Spinning Machine’’Fibers and Polymers, Vol.١١, No.٤, ٦٦٩-٦٧٥, ٢٠١٠.

Momeni, A. & Kheirkhah, A.S.(٢٠٠٦)“A model for Project Delays Prevention by Dynamic Decision Making Approach”, the ٢nd international conference on Project Manamegent, March ٠٦, ٢٠٠٦, pages ١–٢.

Pourshans M.P. (٢٠٠٣): “Documentaion Principles & Methods”, Iran Industrial Education & Research Center Publications, Iran, Pages ٣٧ – ٣٨.

WANG Li-jie, SHAO Xiang-li.,(٢٠١٠)’’ Study on the safety production evaluation of the coal mine based on entropy-TOPSIS”, JOURNAL OF COAL SCIENCE & ENGINEERING (CHINA), Vol.١٦ No.٣ Sep. ٢٠١٠.