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Choosing an Appropriate Factorial System through the Modern and Outmoded System by Two Approaches ANP & AHP-FUZZY

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Abstract

Today, by introducing the factorial modern systems to the construction industry of the country, it is not easy to make a decision in order to use these modern systems together with the outmoded and conventional systems. Regarding the unique traits in each of these systems, and the special conditions of each project, it is possible that each of these systems to have a priority over the factorial systems prevailing in the country. Thus, it was made an effort to choose the most appropriate factorial system through the modern and outmoded systems in the country using the multi criteria making decision methods, ANP and AHP-FUZZY, and regarding some of the important criteria in choosing the type of the factorial system such as dead load, saving energy, performance facility, etc. finally, light steel frame (LSF) system has been chosen as the most appropriate selection through the ones under study.

Keywords: Structural systems, Industrialization, Management and structure engineering, ANP, AHP-FUZZY

1. Introduction

In order to the need of a country for the abundant constructions, it seems to be necessary to use the scientific methods and modern materials in the country. Choosing the factorial system is the first step in factorial designing system in the mass projects. Choosing the factorial systems is a complicated process due to lack of the abundant certainties. Multi criteria making decision methods have been considered for ranking process by the researchers and experts as one of the noted method. Through the multi criteria making decision methods, AHP hierarchy analysis process more than others has been considered in solving the ranking issues, so that so far, during the 15 years more than 1000 scientific references have recalled Mr. Saati study, he founder of the AHP method [1]. Application of AHP has been used, largely in recent years, as a beneficial tool in multi criteria making decision in a suitable locating for constructing some cases such as distribution centers [2] and limestone mines [3]. AHP hierarchy analysis process was used by Nidik and Hill [4], the first time; in 1992 this method was used in following years for this purpose, too. Typically, Handfield et al (2002) used the AHP method to choose the supplier [5]. Bota and Huck used this method for this purpose in this year [6]. Also, in 1992; Shenkerman does not accept the reversible ranking in AHP method in his known paper [7]. One year later, Luis J. Vargis in response to Shenkerman presented a paper favoring AHP, answered shenkerman's criticisms [8]. Furthermore, so far different papers and publications have been composed to improve the AHP process.

Since the standard AHP method for bigemen comparing of the selections, needs the explicit theories of experts and using the accurate numbers, it seems that recent applications of standard AHP method has the difficulty of not considering the lack of certainty and error in the theories of the experts.

Therefore, in AHP method, it is necessary to reflect the lack of certainty derived from the humanist it judgments in input data in a certain way [9]. To overcome this weakness point, it was suggested to use the fuzzy logic to consider the lack of certainty. In this direction, Fuzzy hierarchical analysis developed to solve the problems concerning the AHP hierarchical making decision. CHANG et al identified the suitable places to bury the municipal garbage by the GIS tool and FUZZY multivariate making decision [10]. Also, PAN analyzed the FUZZY-AHP approach to choose the best way of constructing through the existing three ways [11]. Zhao and Chen presented a model on the basis of the fuzzy analysis to identify the possible damages imposed on the bridge structure including the useful information for acquainting of the bridge designers with the various factors destroying the bridge structure and understanding the effect of each of these factors on destroying the bridge [12]. Wang and Elhang presented a FUZZY corporate making decision model for bridge project evaluating the bridge project factors model using the lingual terms. Also, in this paper, the model was reviewed by the ANP method so that this method was introduced by saati to complete the AHP method [13].

2. Methodology:

2.1. Network analysis method ANP

According to saati definition, ANP is a total, general and more complete model of AHP allowing analyzing the various problems having the mutual relations among the different factors [14]. He developed a method entitled by super matrix to estimate the weight of these series of problems [15]. The super

matrix moderates the effect of the connected factors weights considering one matrix participating all selections and factors. One of the advantages is that ANP arranges not only the elements of one group but also clusters of the elements on the view of the right of priority [16].

The ANP network analysis process is the only mathematical theory allowing reviewing the various types of actions and connections systematically. The reason of succeeding this method is on the way of extracting the judgments, using the measurement operations to measure the relative scales. The priorities are convincing numeral base directing the primitive mathematical operations meaningfully [17]. Therefore, ANP power is based on using the relative scales to control all actions, exact prediction and an appropriate making decision.

The step by step stages in ANP method include:

- The 1st step: At first we identify the selections and indices and regulate a questionnaire based on it.
- The 2nd step: we conduct the bigemen comparisons among the indices, then so do each index among the selections and do the comparisons for each selection among the indices.
- The 3rd step: we make normal the bigemen comparisons.
- The 4th step: we obtain the mathematical mean in each normal matrix line in bigemen comparisons.
- The 5th step: In this step we form the matrix of the relative weights entitled by primitive super matrix or non-weight super matrix.
- The 6th step: This super matrix, on the base of matkof' s chain method cubes a number so that its lines tend to fixed numbers. In this matrix, the best selection is the maximal ultimate weight.

2.2. Fuzzy hierarchical analysis method:

The following is the step of carrying out this method [18]:

- The 1st step: defining the problem and determining its aim.
- The 2nd step: creating the hierarchical structure from top to the medial levels and to the lowest level of the problem being the collection of the alternatives.
- The 3rd step: Forming the double comparison matrixes in the size of $n \times n$ for each of the top level elements by helping the relative measurement scales that we see in table 1. In this step, the weights are implemented in the manner of fuzzy.
- The 4th step: To improve the series of matrixes in the 3rd step to $n \times (n-1)$, the judgment is need to be obtained from each of the double comparisons mutually and automatically.
- The 5th step: In this step , the hierarchical combination is used to give a weight to the special vectors , For this purpose, the giving weight operations is conducted by the help of the criterion weights entering the successive level of the hierarchy.
- The 6th step: In this step , non-fuzzy making is done by Yager formula:

$$A = a_c + 1/3(a_u - a_l)$$

- The 7th step: All double comparison in order to determine the harmony by the special elements λ_{max} . The harmony index is calculated by:

$CI = \frac{\lambda_{max} - n}{n - 1}$, where n is the size of the matrix. The judgment harmony can be examined by obtaining the incompatibility ratio CR from CI by allocating the existing random harmony numbers in Table 1 RI (CR is obtained by dividing CI by RI). If CR is less than 0.1, the judgment matrix will be incompatible. The judgments should be reviewed and improved to obtain a compatible matrix.

Table 1: Random numbers RI

N	1	2	3	4	5	6	7	8	9	10
IRI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

- The 8th step: the 3rd to the 6th step can be performed for all levels of hierarchy.

3. Identify and introduce the criteria

3.1. Criteria

Apparently, it is better to use a group of experts instead of an expert because each expert may have a different approach compared to the others. The whole may be partly more than the part. Although there is some evidence showing the personal association among the experts in this study to use Delphi method to identify the effective and important criteria in choosing factorial system. The Delphi method allows a group of experts to be aware of each other's approaches with no personal relations. This method helps to prevent from being oblique the ideas deriving from the person's extra confidence and their personalities effect not from their technical skills. After performing the Delphi method, it was recognized that the criteria of the performance facility. Dead load, saving the energy, useful life span and the architectural limitation and stability are the most factors in choosing the type of the factorial system by the view of the experts.

3.2. Selections

Through the existing constructional factorial systems, five systems were chosen due to their prevailing in the country including three modern and industrial and two conventional systems. These systems are:

- 1) Insulating concrete forms (ICF): Super pane is the evolved type of the ICF systems. The outmoded systems ICF includes walls that is constructed by setting the hollow blocks, Estairen, and putting vertical and horizontal round bar limited in it and pouring concrete in the hollow spaces into the blocks. The base of this system is to use the carrier reinforced concrete structure in the ceiling and the wall of the building and the light armed polystairen partitions for the non-carrier dividers. The walls are poured concrete into the reinforced panels of

polyestairen and the frames of the ceilings are constructed by the reinforced polyestairen in a hollow state and similar to the concrete espirol ceilings. In other word's, the building is layered by two polyestairen layers having the maximal output from the aspect of insulation. The ICF system has extensive uncertainty degree. Therefore it is expected to show an acceptable seismic action [19].

- 2) Light steel frame (LSF): Light steel frame system (LSF) is a developed factorial system applicable in all kinds of one or multi-storey constructions in residential, administrative buildings, hotels, schools, restaurants, etc. Through the traits the 10% increasing the useful space of the building because of decreasing the thickness of the walls compared to the conventional buildings, useful life span over 50 years, facility in installing the electrical and mechanical installations, facility in changing the building plan, decreasing the building mass, decreasing the cost of materials and human forces and decreasing the time of the 5-storey buildings in the country with observing the special preparations.
- 3) Tunnel frame system: The concrete construction system by the way of tunnel frame has been used by the mass builders in the world since 40 years ago; so far it has been reviewed by the factor builders. This system is one f thee best industrial construction methods and was considered primarily by the countries encountering the earthquake, Tunnel frame system lie the other industrial construction method, I justifiable in four criteria: Time decrease, cost decrease, promotion the quality and the security of the staff.
- 4) Concrete structure system: This is one of the known a current existing in the country.
- 5) Steel structure system: This system like the concrete structure system is one of the known and current existing in the country.

The hierarchical factor the selections and the considered criteria have been shown in this research.

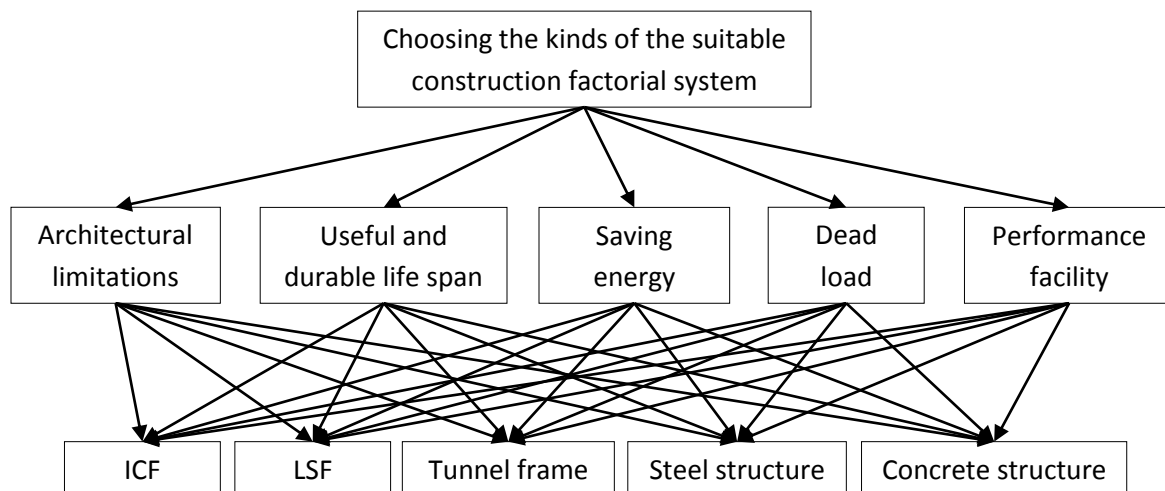


Figure 1-Hierarchical factor of the standards and selections

As it is evident in figure 1, it is in the first level, establishing the aim of the problem choosing the kind of the constructional factor system. In the studied report.

4. Result and discussions

The validity degree of the decisions made in these two methods qualitative and quantitatively is dependent on this questionnaire. This questionnaire is regulated and completed by the help of individuals and organizations involved in the making decision process. Then, based on the completed questionnaires, the tables of bigemen matrix are regulated. In this research, the questionnaires were arranged for gathering the needed evidence for choosing the superior system and expert's opinions were gathered, too. Meanwhile, the opinions of 20 experienced contractors and professors of university were used. The durability of these questionnaires was examined by the SPSS software. The reliability of the questionnaire has been 0.84. It is evident that this degree is more than 0.7.

4.1. The results of the ANP method

In the matrix of the bigemen comparisons, the scale of each element indicates the importance degree of the line selection compared to the column selection. In this paper, The Super Decision software was used to review the model by ANP method. In This software, after forming the model structure, the bigemen comparisons will be focused, so that one of the samples of the bigemen comparison of the selections regarding the different selections was shown below, concerning the durability and useful life span selection.

Alternative	1	2	3	4	5	6	7	8	9	10
1. ICF	>=9.5	9	8	7	6	5	4	3	2	1
2. ICF	>=9.5	9	8	7	6	5	4	3	2	2
3. ICF	>=9.5	9	8	7	6	5	4	3	2	2
4. ICF	>=9.5	9	8	7	6	5	4	3	2	2
5. 2.LSF	>=9.5	9	8	7	6	5	4	3	2	2
6. 2.LSF	>=9.5	9	8	7	6	5	4	3	2	2
7. 2.LSF	>=9.5	9	8	7	6	5	4	3	2	2
8. 3.Tunnel frame	>=9.5	9	8	7	6	5	4	3	2	2
9. 3.Tunnel frame	>=9.5	9	8	7	6	5	4	3	2	2
10. 4.Steel structure	>=9.5	9	8	7	6	5	4	3	2	2

Figure 2-Compare alternatives with respect to useful and durable life span in super decisions software

After receiving the bigemen comparison of the selections regarding the each selection, the bigemen comparison will be done regarding the different selection, so that the figure below will show a sample of the bigemen comparison of the selection regarding the LSF selection.

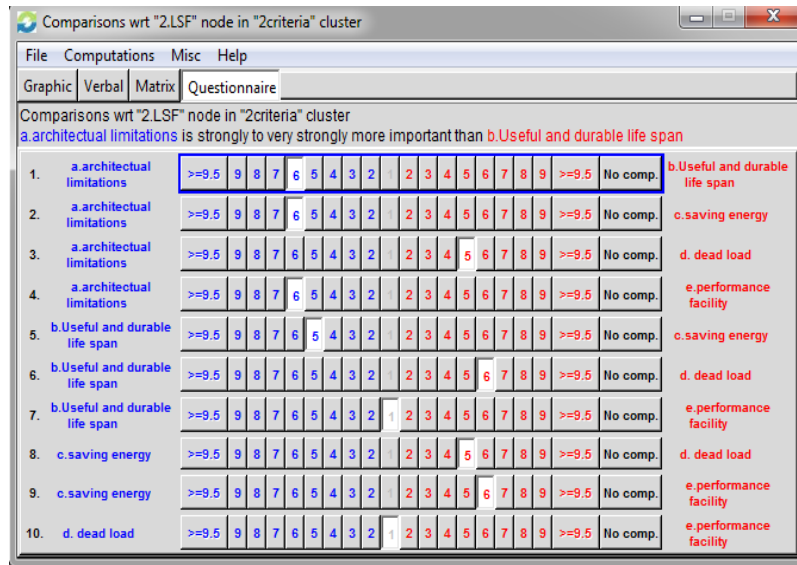


Figure 3-Compare criteria with respect to LSF system in super decisions software

At the end, the right of priority, by the ANP method is based on the following figure, so that the light steel frame (LSF) System as the most appropriate selection and the ICF are after that.

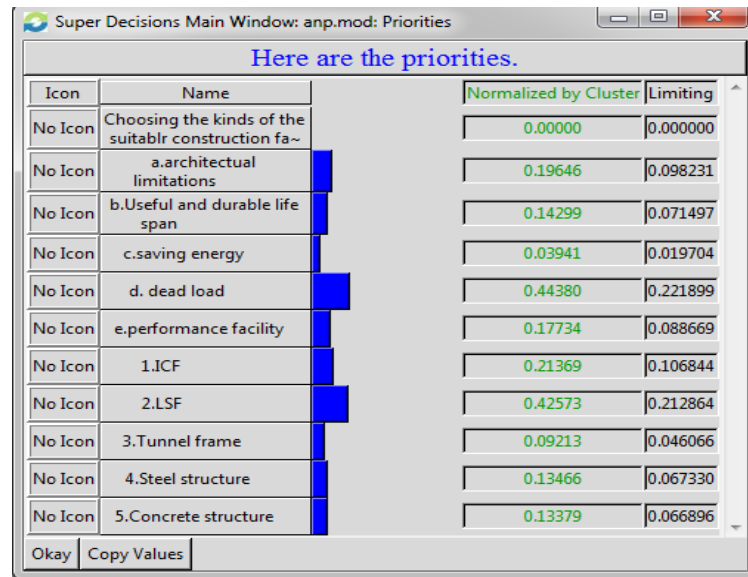


Figure 4-alternative priorities

4.2. The result of the fuzzy hierarchical analysis method

In table (2) , a is the selection of performance facility , b is the dead load selection , c is the saving energy selection , d the effective life span selection , e is the architectural limitations selection .Also

,L , C ,U indicate the low , middle , high limit. The weight mean of low, middle, high limit has been shown in Table 2

Table 2-The weight mean

	Avgl	Avgc	Avgu
a	0.132	0.196	0.356
b	0.144	0.274	0.571
c	0.121	0.288	0.523
d	0.525	0.779	1.086
e	0.026	0.088	0.186

Then, using Yager method, the above data will be in the form of non-fuzzy, that it's results have been shown in Table (3)

Table 3- Non-Fuzzy values

a	b	c	D	e	Avg
1.333	0.792	1.583	0.186	3.333	0.271
1.933	0.667	1.556	0.282	6	0.416
0.967	0.333	1.667	0.306	7.667	0.422
6.667	0.167	3.933	1.667	7.667	0.966
0.767	1.333	0.333	0.333	1.667	0.141

Also, the operations will be reported for the selections. For each of the selections, the above steps will be reported. Finally, regarding the obtained weights, the priorities of the best kind of the factorial systems regarding the above selections, as shown in table (4), will be derived.

Table (4): The final weight of the selections and their ranking

Selections	Weight	Priority
LSF	2.638	1

ICF	1.644	2
Tunnel frame	1.29	3
Concrete structure	0.966	4
steel structure	0.764	5

5. Conclusion

In this study, the effectiveness of the network analysis method (ANP) and the fuzzy hierarchical analysis concerning one of the most significant in mass building, which is the selection an appropriate factorial system through the modern and outmoded system, has been investigated. The suggested systems regarding some of the selections were ranked. After some investigations , the mentioned priority of the systems include LSF,ICF, Tunnel Factor , Concrete Factor system , Steel factor system , clearly , The improved method presented in this study in use of LSF in the framework of the building .

The obtained results show that the reviewed industrial methods regarding the mentioned factors in the mass constructions are more appropriate than the outmoded methods because these construction methods reduce the existing difficulties in the construction industry including low speed of details, weak connections in the steel buildings, high operative costs, wasting the consuming materials, low effective life span of the buildings, low seismic resistance of the building, etc.

Also, comparing these two methods, it can be concluded that for solving this special problem, none of these methods have priority over the other ones. Both methods are obtained the similar responses. These two methods may be used in several fields of engineering and construction management. Hence, it is recommended that these two methods are used in solving important problems such as risk ranking in the projects of dam and road construction, choosing the excavation methods, choosing the contractors and constructive machinery, etc.

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