iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 5 **Issue:** VI **Month of publication:** June 2017

DOI:

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

Volume 5 Issue VI, June 2017
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

A Comparison the Industrialization and Traditional Systems Using AHP

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Abstract: ***The extensive and growing need for the construction and housing has raised more than ever the necessity for using building systems and new materials in order to increase the speed of construction, lightweight construction, increase shelf life as well as resistance of buildings against earthquakes. Solving problems such as long-term implementation, the low useful life or the high cost of implementing buildings in the housing sector, requires offering strategies to the practical use of modern building systems and new building materials to reduce weight, reducing construction time, better durability, reducing costs and ultimately reducing the implementation cost. These measures in the long-term will cause optimize production, increase housing production in our country and achieve optimal operating conditions. On the other hand, such developments lead to expansion fundamental infrastructure in the housing sector, especially private-sector development. This issue will help the government to achieve its goals in the housing sector. In this study by providing some explanations about a variety of new systems of running the project and studying the advantages and disadvantages of each, modern and traditional systems of construction in Semnan city has been investigated. In this regard using expert's opinions by the questionnaire the criteria are determined and by using these criteria there compared 5 industrialization methods with 3 practical and traditional methods using AHP decision-making method and Expert Choice software. According to obtained results, the LSF system with 16 percent has the most priority and the construction system with masonry materials with 5 percent has the lowest priority.***
Keywords: Industrialization systems, traditional systems, the Analytic Hierarchy Process, AHP method

I. INTRODUCTION

The man has always tried to improve living facilities, enjoying better and more normal, social and cultural conditions and to achieve it had the aim for more optimal production. With the arrival of the twenty-first century, the process of economic globalization of removing boundaries and intense competition has been intensified and has caused the growing importance of innovation (1).

The items that should be considered in buildings in order that cause more strengthening of positive points and reducing weak points we can refer to the link of building with the background and the quality of building architecture. The cost and infrastructure in productivity of constructions directly effective on the prices of houses and consumer goods and strength of the national economy. To build new infrastructures from renewable sources developing high-performance of green buildings that to remain the competitive power in the global market and changes in building design, renovation of the building materials, recycled materials, minimize environmental impact, reduce energy consumption and reduce greenhouse gas emissions, will be essential. The building is built with methods; traditional and industrial methods and based on definition the industrial method is a computed process with considering the components of time management, the cost and quality of applying the standards related to the mass production of buildings and in which all or part of the components of the building are produced under the industrial system in the factory and are tested from the various aspects of quality. Traditional construction (in situ methods) refers to the ways in which the process product completion is finished takes place on the site of the project such as the concrete structure with the clay wall. These methods require a lot of unskilled labor that walking toward implementation of the considered goal. Despite the use of modern materials in the construction of some buildings steel construction methods in major cities as well as elsewhere in Iran, are mainly traditional. However, due to the geographical situation and climate in Iran and locating on an earthquake belt, especially the presence of numerous faults in Tehran, traditional methods of construction on the one hand because of heavy building materials and rubble as well as the abundance of debris with environmental impacts and risks on the other hand because of the length of the period of construction and waste energy from the perspective of construction management faced with serious disadvantages and limitations (4).

Increase in housing demand due to population growth, migration to cities and finally the urban development on the one hand and lack of appropriate supply of housing due to the inefficiency of traditional methods of construction made inevitable using housing industrialization in the various societies. Table 1 shows the difference between conventional and industrial construction.

Volume 5 Issue VI, June 2017
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Table 1. Comparison between industrial and traditional manufacturing systems

Common construction	Industrial construction
Activities performed in various temporary locations	All activities are performed in a permanent location
Long lifetime of a particular product	The low or moderate lifetime of a product
Low standardization, each project has distinctive aspects	A high degree of repetition and standardization
Many tasks require a lot of manual dexterity required to complete a certain project	A few simple tasks is essential for the production of a certain product
Any activity at the extensive workplace is done by the workers commuting from place to place	All tasks are performed in a fixed workstation
hard and harsh workplace	The workplace carefully adjusted based on human needs
Lot changes of workers	In comparison, fixed Task Force
Decision-making authority divided among the sponsor, designers, local government and the contractors	The authority of decision-making for the design, production, and marketing

II. PREVIOUS STUDIES

Kamel in the University of Nebraska in the United States, conducted studies on the thermal and structural behavior of sandwich panels precast concrete, for his doctoral dissertation (5)

Stine and Bush conducted bending experiments two categories of precast sandwich panels which had sheer conductors and different details construction, at the University of Oklahoma.

Subhi and Kamal (2001) reviewed the use of AHP in project management in the selection of project progress. Tiwari and Banerjee (2001) is used AHP for selecting the process of concrete placement (6).

Tabarak et al (2003) by assisting the artificial neural network (ANN) to determine the stability in the preliminary design stage of buildings (7)

Two multi-criteria decision-making approach of AHP2 and ANP3 have used for evaluating the intelligence level of intelligent building systems by Wong et al (2008) (8)

Metin (2008) has used the combination of AHP and PROMETHEE methods (one way to prioritize) for selecting machines on the construction projects (9).

III. RESEARCH METHODOLOGY

A. Geographical location and political divisions in Semnan province.

Semnan Province Because of the special geographical position and location in the center of the country is a safe province and has a lot of environmental, social and human and social potentials development to achieve long-term goals. Existence the capabilities such as suitable substrates for industrial development and unclaimed lands for the development and deployment of large-scale industry, proximity to large provinces and center of the country and having appropriate networks communications between regions, the establishment in the Corridor International East - West, North - South, enjoyment of enriched reserves and a variety of minerals and a high literacy and skilled human capital in the country, the ability to use renewable energy and renewable supply (solar power) and many other cases have caused in the National Archives of development, a special position be considered for Semnan province as an overflow of large neighboring provinces. Accordingly, the development of the province has rest on basis of the development of the industrial, mining, tourism and superior service with an emphasis on higher education. Semnan province limited from north to Golestan, Mazandaran, and Khrasanshmaly, from the south, limited to the Isfahan and Yazd provinces, from the east limited to the provinces of Tehran and Qom and its center is Semnan city.

B. AHP method

The decision-making is one of the basic and major pillars in management science. The managers are always dealing with items that require decision-making so that the correct decisions of managers lead to stimulating and the growth of an institution and the wrong decisions led to the loss of market and eventually it will collapse it. One of the tools for decision-making is AHP group that can increase interaction and participation in decision-making. Under this method, similar to what happens in the human brain, analysis

the issues. In addition, the need for paired comparisons in the AHP is one of the benefits of this method because forces the decision-makers to think more about the weight factors and analyze the opportunity deeper.

Another advantage of AHP is the ability to measure both quantitative and qualitative issues so that subjective preferences, expert knowledge, and objective information are all available in AHP and used in it. Another advantage of this method is giving structure to decision-making issue by creating the decision tree. The classification of criteria from top-down of a decision tree, cause that the complex issues systematically by using AHP and especially taking into account the different views of experts and decision makers to be examined. Some abilities of this method include an easy capability to understand without a need to professionals, providing a structure for cooperation and collaboration in decision-making, using both aspects of systemic approach and part by part analysis to solving problems and having a special scale. This is one of the secure ways to make the calculation of the index weights; because the basic of its work is the comments of decision makers, not a decision matrix. It is assumed that people in pairwise comparisons take the best decision. This method provides the probability to sensitivity analysis on the criteria and sub-criteria. The superior advantages of this method are that the compatibility or incompatibility of taken decisions by decision-makers can be calculated. AHP method is based on three principles: The structure of the model, comparative judgments of options and criteria and determine the preferences. In the first step, a complex problem of decision making is made hierarchical (10).

The second stage is comparing options and criteria after the problem was analyzed and its hierarchical structure took shape, the process of priority begins according to determine the relative importance of the criteria at each level. The pairwise judgments begin from the second-level and at the lowest level which the options placed, they end. The criteria are compared to the higher level in each level as pairwise according to their impacts and certain criteria. (11)

Multiple pair-wise comparisons are done based on the 9 standard scale as shown in Table 2.

Table 2: Paired comparisons of standardized scale

Value	Equivalent	Much important	important	Very important	Extremely important	Intermediate values
The Intensity of importance	1	3	5	7	9	2,4,6,8

C. The introduction of standards and research options

1) Criteria: at first a questionnaire was set to determine the criteria and 15 items that were obtained by studying the books and articles were chosen as effective criteria to start the survey. A questionnaire was used to prioritize these criteria and the comments of experts were used to prioritize the criteria by the Likert scale and according to the obtained results, 9 of 15 criteria were chosen for assessing the electoral system. The criteria are:

2) *Construction costs:* these criteria include, costs of production, the cost per square meter of building, materials, transportation and the cost of implementation and maintenance.
3) *Ease of implementation:* this criterion includes access to the specific machines and the need for skilled workers as well as simplicity and safety installation.
4) *Energy savings*: Parameters and indicators of energy in the perimeter wall, placement in standards and building regulations and the ability to use energies available in the conditioning, heating, and cooling are the most important criteria in energy assessment.
5) *Dead load:* In order to reduce earthquake damage, the building should be design and run based on seismic and the latest regulations and the minimum weight.
6) *A number of floors:* The number of floors and the maximum height of buildings is the most important factors in mass construction projects.
7) *Useful life and durability:* Durability of materials, corrosion resistance, and structural stability are the most important evaluation criteria for the structures.
8) *Fire resistance*
9) *Construction time:* Whatever in the mass construction projects the construction time is less, economically is more affordable and is better.
10) *The project location:* the fitness of considered construction system with the location of project implementation that is Semnan city.

11) *2-options:* In the new building systems, more briefly five building systems confirmed by building and housing research center and from the traditional systems 3 systems have used to compare traditional and industrial systems. The reason for choosing these systems because of their widespread use in numerous construction projects in Iran with cooperation and coordination with relevant professor.

C. These systems include

1) Light steel frame LSF: Light steel frame is one of the structural systems which not only has the probability of industrial and pre-fabricated production but also due to the light weight of the system during the occurrence of an earthquake the vulnerability of the buildings will be minimized. Researchers conducted by researchers has shown that the value of base shear in the LSF system in comparison with reinforced concrete system will be reduced 55.5 percent and this value in the metal system is reduced 38.1 percent (12). In LSF system the value of the most displacement of the roof mass center in comparison with RF is reduced 56.2 percent and in comparison with a metal, the system reduced 38.1 percent. The total weight of the building in the LSF system in contrast with RF system 72.8 percent and in contrast with metal system will be reduced 55.8 percent (12)
2) The amount of concrete used in the LSF system compared to Reinforced concrete system 78.9 percent and in comparison with metal system 56 percent is reduced. The amount of used steel and armature in LSF system in comparison with RF system is reduced 24.5 percent and in comparison with a metal, the system is reduced 54.3 percent. The advantages of this system include: The speed of construction, ease of maintenance and repair, the possibility of implementing the system in different ecological zones, earthquake resistance, sustainable development and environmental protection, ease of implementation facility due to the open space between the walls for pass through facilities, saving energy through insulation against heat loss and ability to adapt architecture.

D. Three-dimensional panels

The properties of 3D panel buildings include lightweight structures, stand, no debris, making a maximum of two floors, heat resistance, sound insulation and moisture transport speed and ease of implementation in lift, applicability in a wide range of buildings, more useful space due to the width of the wall, ease of use of a variety of views and impenetrability. In addition, the system provides a clean workshop and free of debris and modified polystyrene core is not burned and not harm the ozone layer.

1) *Insulating concrete form (ICF):* Reinforced concrete system with lasting insulation (ICF) are filled walls with the concrete that the form of the wall is permanent and after concreting considered as a part of the wall and acts as a thermal insulation. The major advantage of this system to improve the implementation speed and its major problem is the thickness of the walls. The thermal performance of this system is very well. This good performance, in addition to the layers of polystyrene, thanks to the presence of concrete in the middle layer. The features of this system includes light weight, ease of installation, speed of execution, lack of dependence on multiple machines, lack of skilled manpower and its most important features to increase the speed of construction, ease of implementation, reduce the cost of construction, building integrated systems, efficient use of energy in buildings.
2) *Tunnel Formwork system:* This system is one of the modern methods of construction with load-bearing walls and concrete ceilings. In this system, the walls and ceilings of Reinforced concrete at the same time will format, concreting and amateur placement. In this system, the structural walls, due to lack of beams are the essential elements for enduring and transferring gravity and lateral loads. Buildings and structures with a tunnel system due to simultaneously concreting of the walls and integrated ceiling its members and connections have good seismic performance. System integration and improvement the seismic behavior due to boxing performance of the structure, change from the state of stress concentration from the node and concentration mode to the extended mode due to the structure of the beam and column to slab and wall, increase the degree of structure uncertainty and more delay in the formation of plastic joints structures, high-speed performance for concurrent execution of wall and ceiling, concrete consumption reduction compared to conventional concrete structure and reduce the waste of materials are the most important features of this building system. The measurements of being justified by the form of tunnel include cost reduction and the cost of improving the quality of the staff security.

TRONCO system: this system in many ways similar to the LSF but they differ in construction because in this system there is no STUD (vertical elements in the LSF system) and the galvanized pipes with 90-degree are connected to each other angle by wired or dual connections and in the corner and arranged to each other in the middle. The connecting of this structure to the foundation is done by welding. For this purpose, already the pages are considered on the foundation that the structure is welded

to it. The pipes connected to each other by galvanized belt fasteners and bolts that will have the ability to bear lateral forces. Also in this system, there is no beams and columns and walls of the building playing the holding role. Ceiling and walls acting integrated which this feature contrary to common structures make no problem in the joints between beams and columns. So against the forces such as earthquakes is pretty good (13). In this way filling the empty spaces inside the tubes and the walls and the roof using panels made of EPS is the best way in energy consumption and yet light weighting of the structure.

E. The system of buildings

The building structure is a type of structure that the independent units are used in its construction that among them the mortar is used. The benefits can include:

1) Building these structures due to the use of local materials is very inexpensive
2) the advanced technologies are not required for its construction
3) materials such as brick or cement higher the thermal storage of building
4) The building of materials construction than wooden buildings have more age
5) The system of the concrete wall: a concrete structure is a structure that in its construction the concrete and reinforced concrete (cement, sand, and steel as simple or ribbed rebar) has been used. The main advantages of concrete structures consist of:
a) The main material of concrete that is sand is cheap and readily available
b) Concrete structures that have been designed and implemented in accordance with the regulation principles, namely, in the harsh environmental conditions, are more resistant against the buildings made of other material
c) Due to the high configurability of concrete, the probability of manufacture of concrete structures such as bridges, columns, and various forms is possibl
d) Concrete structures became more resistant against high temperatures caused by fire.
6) Steel Building Systems: Steel as a material with specific and unique features, has long been used in the construction of buildings. The strict implementation capability, the certain behavior construction behavior, the ratio of resistance to the appropriate weight, along with the ability to run fast steel structures with architectural details and delicacies have raised the steel as a unique and inexpensive material in the building structures. To some extent, if the limited weakness of this material such as low resistance against corrosion and lack of resistance in severe firings correctly applied and controlled provide a wide range of possibilities to the designer that is not available in any other matter. In the economic evaluation of a steel building the following items should have considered:
7) The price of land: Because of the small cross sections in steel buildings, less space occupied by the skeleton structure
8) Availability of the materials
9) the final value of the building: The shorter the construction time, its final cost will be less

The advantages of steel buildings include High resistance, uniform properties, durable, elastic properties, ductility, building continuity, strengthen accountability and to strengthen, easy installation, fast installation, less loss of materials, less weight than concrete structures.

IV. THE PROCESS OF GATHERING THE COMMENTS OF EXPERTS

According to the options and assessment criteria, some questionnaires including a pairwise comparison of each option created and the then questionnaire to determine the validity were distributed were distributed, 3 experts. This term refers to the stage of validation. After obtaining the opinions of the experts in the stage of validation, the accuracy, clarity, and transparency of were questions generated, verified and questionnaires were prepared for distribution. In order to obtain the opinions of the experts, the number of 17 questionnaires were distributed between them. Among the distributed questionnaires, 12 of them were returned. Two questionnaires due to the deficit in completion and wrong insertion of information were removed. Therefore, every step of the analysis was conducted on the remaining 10 questionnaires.

V. ANALYSIS OF THE QUESTIONNAIRES

The method of asking questions and answers has been by using the Analytic Hierarchy Process (AHP). Analytic Hierarchy Process is used to convert qualitative opinions of experts in small amounts to calculable and comparable values. The main information that can be obtained using this method, is the comparison between traditional and industrial methods and their ranking that is the goal of distributing of questionnaires. Given the number of questions for ranking the methods of industrialization, all the questions were

Volume 5 Issue VI, June 2017
ISSN: 2321-9653

summarized in the form of 10 separate matrices. Then the different levels of hierarchical analysis on obtained data matrix was implemented and the final conclusion was provided with respect to the output of the analysis by the software Expert Choice 2000.

A. Ranking the comparison criteria

The obtained results of questionnaires suggest that 47.63 percent of respondents are believing that the importance of Materials Price Index is more than other indexes and in contrast, 21.5 percent of them believing in the more importance of the index of ease of implementation of the method in comparison with other indexes. In total, according to the scores given by the experts to compare each of the five indices, the indices were ranked that its result presented in Table 3. Also the results of the prioritization criteria shown in Figure 2.

Table 3: the obtained AHP coefficients from the comparison of evaluation criteria for industrial and traditional manufacturing systems

Respondent	Construction cost	Ease of implementation	Energy saving	Dead load	Number of floors	The Useful life and durability	Resistance against fire	Time of construction	Location of the project
1	0.4	0.105	0.172	0.184	0.041	0.05	0.192	0.047	0.169
2	0.075	0.04	0.108	0.044	0.084	0.203	0.122	0.232	0.091
3	0.186	0.033	0.186	0.089	0.165	0.13	0.08	0.105	0.026
4	0.135	0.036	0.216	0.116	0.069	0.1	0.046	0.251	0.032
5	0.213	0.118	0.202	0.043	0.03	0.1	0.102	0.158	0.034
6	0.19	0.118	0.107	0.195	0.041	0.056	0.095	0.136	0.062
7	0.106	0.078	0.033	0.216	0.074	0.143	0.07	0.144	0.037
8	0.176	0.074	0.097	0.036	0.236	0.062	0.046	0.119	0.153
9	0.107	0.092	0.034	0.131	0.073	0.28	0.068	0.16	0.054
10	0.166	0.032	0.103	0.096	0.052	0.107	0.237	0.164	0.043
Mean	0.175	0.073	0.126	0.115	0.087	0.123	0.106	0.152	0.07
Percentage	17.04	7.11	12.27	11.2	8.47	11.98	10.32	14.8	6.82
rank	1	8	3	5	7	4	6	2	9

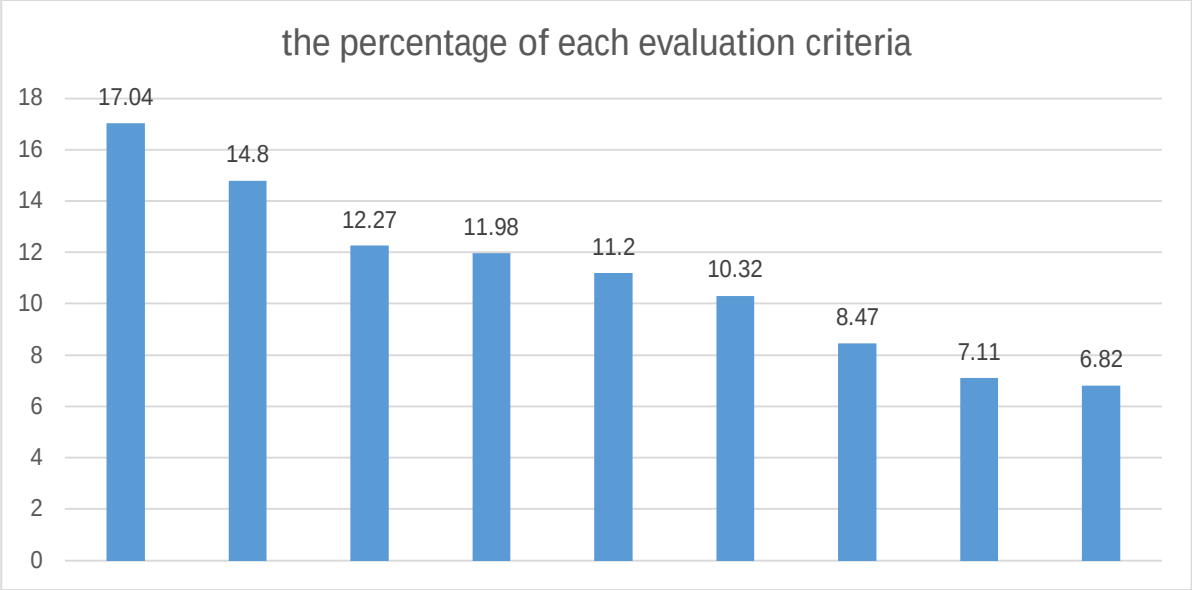

Figure 2: the ranking results of comparison criteria of traditional and industrial systems

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ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

B. Comparison and ranking all types of construction

Table 4 and Figure 3 shows the average coefficient of AHP of every system in various criteria, for each of the respondents. According to the obtained results, the industrial manufacturing systems have higher scores than traditional construction systems and in total have 71.5 percent of the coefficients in contrast of 28.5 percent from traditional systems. The results show that in the traditional construction systems, concrete systems have the highest rating sand steel structure and materials systems are ranked respectively in the next rates.

Table 4: The average of AHP coefficients obtained from a questionnaire on various criteria

Respondent	LSF	3Dpanel	ICF	Tunnel system	TRONCO system	Material structures	Concrete structures	Steel structures
1	0.026	0.021	0.022	0.024	0.02	0.008	0.017	0.01
2	0.016	0.014	0.01	0.02	0.011	0.008	0.017	0.009
3	0.02	0.018	0.011	0.013	0.013	0.006	0.015	0.012
4	0.015	0.02	0.015	0.015	0.011	0.006	0.013	0.011
5	0.018	0.018	0.016	0.016	0.019	0.007	0.011	0.016
6	0.023	0.016	0.015	0.014	0.017	0.006	0.01	0.0117
7	0.014	0.014	0.007	0.012	0.008	0.004	0.011	10.54
8	0.016	0.016	0.015	0.018	0.014	0.006	0.014	7
9	0.017	0.016	0.015	0.016	0.019	0.004	0.012	0.01
10	0.017	0.015	0.009	0.013	0.016	0.006	0.018	0.009
The average of coefficients	0.0182	0.0168	0.0135	0.0161	0.0148	0.0061	0.0138	0.012
Weight percentage	16.4	15.14	12.16	14.5	13.33	5.5	12.43	0.011
Rank	1	2	6	3	4	8	5	0.016

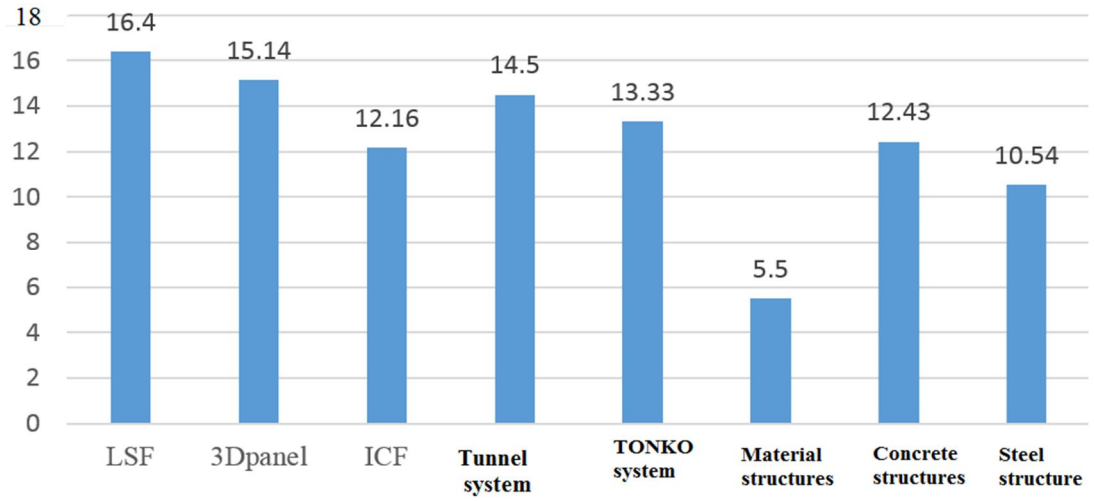

Figure 3 the results of the ranking all types of industrialized and traditional building methods

As the results show the prioritizing of building industrial and traditional systems, according to experts, includes respectively; LSF, 3D panel, tunnel system, TRONCO system, concrete building system, ICF system, metal building and building structures.

Another result that is obtained from the analysis of the questionnaire is a percentage that each system is allocated to build on each evaluation criteria, these results are shown in Table 5 in which columns are shown with the highest percentage.

Volume 5 Issue VI, June 2017
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Table 5: a percentage related to any industrialized system in each evaluation criteria

	LSF	3Dpanel	ICF	Tunnel system	TONKO system	Material structures	Concrete structures	Steel structures
cost	21.24	16.06	13.27	15.09	13.61	4.95	7.92	7.86
Ease of implementation	19.86	16.55	14.62	16.55	11.03	6.07	6.48	8.83
Energy saving	20.41	20.09	15.66	5.78	18.35	4.19	9.02	6.49
Dead load	26.3	14.8	12.35	4.15	25.88	3.3	4.47	8.73
Number of floors	6.31	9.86	11.12	20.41	6.42	4.36	22.36	19.15
The useful and durable age	11.5	19.11	12.24	14.39	12.99	4.38	14.06	11.33
Resistance against fire	3.67	13.24	12.16	22.54	6.08	8.14	25.49	8.68
Speed of implementation	20.38	11.9	9.17	17.37	16.67	4.06	8.19	12.25
The location of project	11.61	14.45	8.64	15.3	3.54	13.46	17.85	15.16

VI. CONCLUSION

The optimum method presented in this study, implementation of a building using thin steel sections of LSF in the building structure that not only possible its industrial production, but also the lightweight of the system will reduce the forces during an earthquake and thus reduces the vulnerability resulting from an earthquake. Therefore, reducing the weight of the components of the building and using lightweight materials can be considered as a solution which can increase the speed of construction and reduce the cost of building implementation.

Frequent and extensive use of prefabricated and manufactured components with industrial methods is necessary to reduce costs. The prefabricated building methods in comparison to traditional manufacturing have advantages such as improved quality control, reduce construction time, reduce debris and construction and demolition wastes, reduce dust and reduce the need for manpower at the site. Industrial production of the building from using non-standard design with modular elements and characteristics led to achieving greater stability components. Techniques advanced industrialization could have significant economic and environmental benefits.

The building systems of TREMOR, steel, and TRONCO in remote and rural areas due to the lack of need for mechanical equipment and special tools and a high speed of implementation is the best choice is to build a two-floor industrial building.as well as the selection of these systems due to low building costs for rural areas with the philosophy of using this system corresponds for low-income people.

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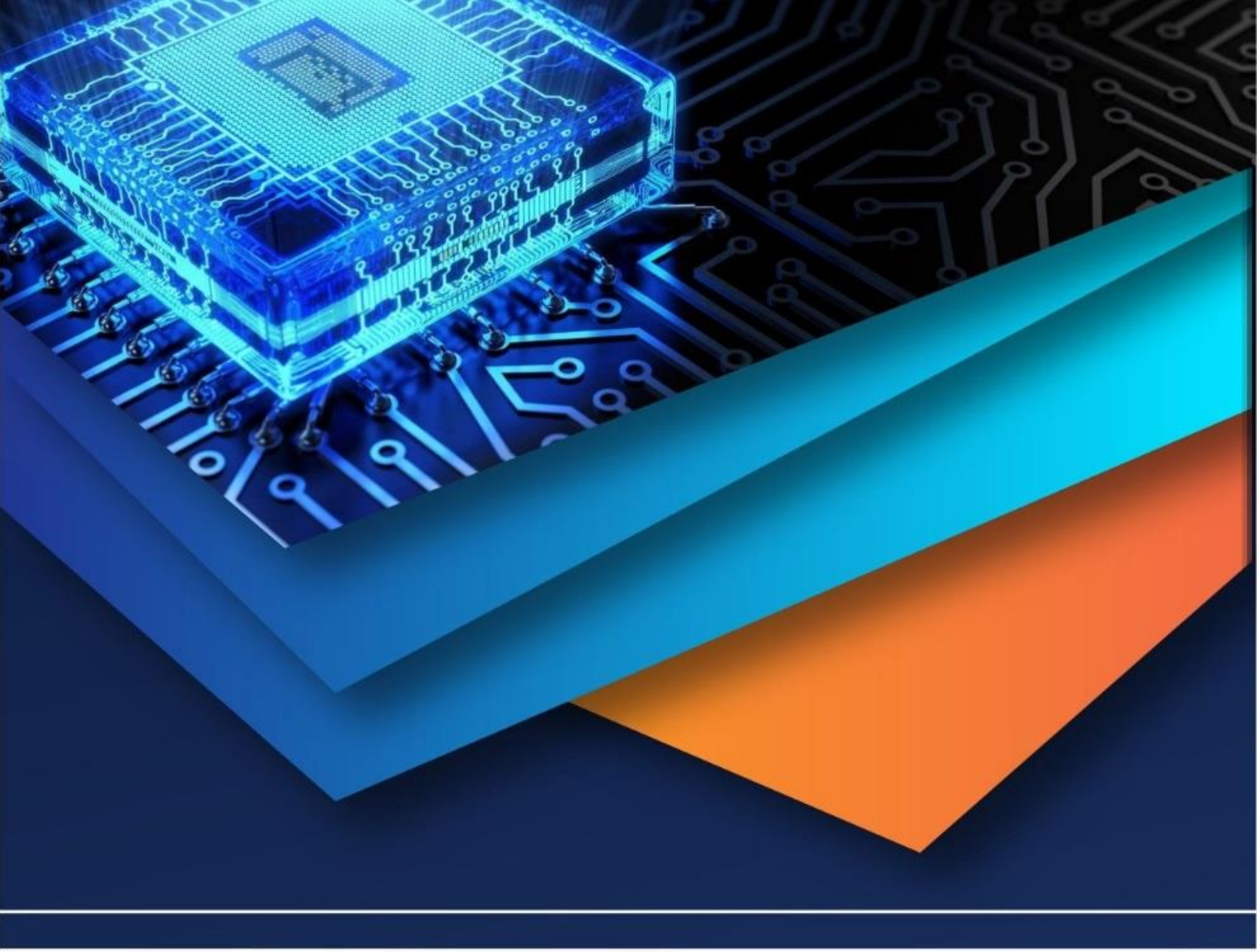

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