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An Integrated Approach to Constraints Theory and Fuzzy Analytical Hierarchy Process (FAHP) in Construction Projects (Case Study)

Mohammed jassim Nassir*
Department of Industrial Management
college of Administration and Economics
University of Baghdad
Baghdad, Iraq.
mohammed.jassem1205a@coadec.uobaghdad.edu.iq
https://orcid.org/0009-0008-3584-4365
***Corresponding author**

Nagham Yousef Abdul Redha
Department of Industrial Management
College of Administration and Economics
University of Baghdad
Baghdad, Iraq.
dr.nagham@coadec.uobaghdad.edu.iq

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Abstract:

The research endeavors to harness the benefits stemming from the integration of constraint theory into construction project management, with the primary goal of mitigating project completion delays. Additionally, it employs fuzzy analysis to determine the relative significance of fundamental constraints within projects by assigning them appropriate weights. The research problem primarily revolves around two key issues. Firstly, the persistent utilization of outdated methodologies and a heavy reliance on workforce experience without embracing modern computerized technologies. Secondly, the recurring problem of project delivery delays.

Construction projects typically encompass five fundamental constraint types: cost restrictions, time constraints, administrative and legal limitations, technical and design constraints, and environmental constraints. To address these issues, a field study was conducted, focusing on the development of a housing complex in Qa'imaqamiya, Al-Mada'in district, Bismayah. The researchers propose a three-stage methodology to tackle these challenges. In the initial stage, the theory of accelerated activities is applied to all concurrent implementable tasks. Subsequently, the second stage introduces a hierarchical analysis process, known as FAHP, to quantify the importance of each constraint. Finally, in the third phase, fuzzy logic is employed to calculate the projected duration and associated costs for each activity, ensuring project execution and delivery within agreed-upon timeframes. After applying the proposed methodology, there is a reduction in completion time by up to (23%).

Research Type: Research Paper

Key Words : Project Management, Constraint Theory , Accelerated Project Management, fuzzy AHP, Cost and time relation, fuzzy logic.

1. Introduction:

Most developed countries give great importance to projects, whether these projects are productive, construction, investment or service, the speed of development in this field is moving towards progress and quickly, as the accelerated implementation method of construction projects depends on the principle of overlap between the preparation of the design and the start of the implementation phase in parallel without affecting the basic elements of the project (time, cost, quality) this research came to shed light on the method of critical path and the problems suffered by most of the contracting companies responsible for the implementation of construction projects, so the researcher used the critical path model and control over implementation during the stages of completion of projects in order to identify deviations, whether in cost or time, and then try to find possible solutions for the application, which we can mediate to reduce or eliminate waste to benefit from it in rationalizing the costs of construction projects.

Project management applications have expanded significantly, and project management related to scheduling and determining time and cost has become very important to obtain competitive priorities (Mhna and Khalaf, 2019).

There are a number of factors that lead to project delays, the most important of which is the lack of planning and scheduling that are compatible with the increase and diversity of projects (Kazem and Jawad , 2020).

1.1. Literature review :

Among the previous knowledge efforts of some researchers related to the topic of the current research, it is important to know the goals, as well as knowing the means, methods and standards that are appropriate with our research, including:

Moss (2007) Studied on Improving the quality of service with the theory of constraints in the service sector to solve the problems facing customer service in the service sector by applying the principles of the theory of constraints and knowing the extent of the impact of the principles of the theory of constraints as the use of the principles on which the models of logistics operations are based leads to a significant increase in the quality of customer service He pointed out that TOC applications reduced cycle times by 65%, waiting times by 70%, and inventory levels decreased by 49%.As a result, companies were better able to meet delivery dates for customers on schedule resulting in 44% improved delivery date performance, and improvements were seen on the financial side of companies with revenues, productivity or profits by 76%.

Okutmus et al (2015) urged to use of the theory of constraints to reach the optimal mix of the product: application in the furniture sector to achieve the optimal production mix based on the tools of the theory of constraints, which was to address bottlenecks and reach the most important conclusions that the use of the theory of constraints works to increase the contribution margin, reduce inventory and labor expenses, and improve profitability by exploiting resources efficiently.

Jassim (2016) studied on the application of the theory of constraints to achieve the efficiency of scheduling and improving the performance of operations using simulation / a case study in the Modern Paints Industries Company, as the company was suffering from the instability of task scheduling at workstations and the emergence of bottlenecks between workstations, as well as the low level of exploitation of machinery and equipment, and reached the most important results that the application of the theory of constraints leads to improving the flow of materials and exploitation rates, And the performance indicators of operations in the dye production line after the application of the theory of constraints, and in order to reach this improvement, the study recommended that the production should be divided into batches to reach the length of one batch of 20 days in order to reduce the costs of preparation and preparation when converting from one product to another, as well as adding another manual line

***Wolniak et al* (2017)** Used the theory of constraints for the continuous improvement of the production process - a case study for an electrical equipment production company if it suffers from high costs. They found that the application of the theory of constraints in the production process allows the removal of the so-called choke point or bottleneck by shortening the entire painting process from eight to seven steps. The time required also decreased from 1145 to 1051 minutes, and this process shortened the drawing time by moving from two drawing tasks to one and better planning the entire process

talib (2019) studied the effect of employing the theory of restrictions on the implementation of construction projects (a case study: Babylon Governorate to clarify the obstacles and determine the restrictions suffered by construction projects in the planning and implementation stages and provide an accurate scientific method for allocating work and helping to make decisions, The most important conclusions were reached by the lack of sufficient experience in preparing the project plan in terms of lack of good understanding of the nature of the engineering project and the inability to determine its objectives, as well as lack of experience in setting the timetable for the implementation of the project.

Kazem and Jawad (2020) presented a study on the use of the critical path to schedule the project to establish a sidewalk for the Al-Amel neighborhood with a length of 1.25 km in order to reduce the time required to complete the project, as the municipality of Holy Karbala suffers from reluctance to complete projects and reached the most important results is the preparation of statements correctly to ensure the implementation of work paragraphs within the specified time.

Abd El Jabbar, (2022) investigated on project scheduling and estimating the size of the workforce using dynamic programming in Saad General Contracting Company and its project Expanding industrial water transactions in the fat refinery in Baiji in order to schedule the activities of the project to expand industrial water transactions and find the total period for its implementation And identify the critical activities of the project that can not be delayed in their completion, as well as identify non-critical activities and determine the periods of flexibility for them and know the appropriate limit of manpower necessary for each stage of the implementation of the project and reach the most important conclusions that most of the activities have high flexibility that allows delaying the start of them without affecting the completion of the project in the specified period.

Saleh and Khalaf (2023) suggested a method used for the project of establishing a helicopter airport for oil fields using the critical path method in light of operational risks, as the main problem of the study is the high costs of transporting workers to and from the oil fields and reached the most important conclusions that the establishment of the airport will reduce the costs of a problem, which encourages investment.

Utsav M et al (2020) study on Identification of Constraints in Construction Projects: An analytical study in various construction companies in the city of Gujarat to identify the constraints in the construction of infrastructure projects. By understanding the limitations in starting a project, good performance can be guaranteed later. Classify and remove restrictions from project activities, which helps to reduce doubts in construction procedures and clarify and reach the most important conclusion that construction projects are subject to different types of restrictions, including contractual maturity dates, resource and safety restrictions, as well as land tenure.

Uttpal Rai et al (2021) study on Identification of Constraints in Construction Projects to Improve Performance to identify the main constraints and the level of their impact on construction projects using the theory of constraints A field and analytical study in construction companies in the city of Allahabad in India They reached the most important conclusions that all constraints must be identified at the planning stage (such as environmental and legal constraints) and there must be a plan to address these constraints. There may be a number of constraints that cannot be specified or cannot be grouped into the considered constraints (such as on-site restrictions).

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Social constraints must also be resolved by monitoring the feelings of the local population. Management must provide money, manpower and machinery to implement the project.

The research problem lies in the delay in completing the work of the project (the establishment of a residential complex consisting of (96) housing units in Bismayah) research sample - which negatively affected the time of completion of the project and the override on the cost and the reason for this is due to the reliance on traditional methods in addition to the lack of exploitation of experiences and skills of those in charge of projects (engineers and workers) and not keeping pace with the technological development that the world is witnessing at the present time and thus the failure of the project, The research problem revolved around the following main question:

1- Is it possible to use modern methods such as the theory of constraints in construction projects in order to complete the project within (time, cost and quality)?

2- Does the theory of constraints contribute to addressing the reasons for project delays?

3- Is there a possibility of applying the methods of restriction theory and accelerated implementation by the executing company to complete the residential complex project in Al-Madaen district?

4- Does the theory of constraints contribute to reducing the time and costs required to complete the project?

The research objectives include both the technical and economic objectives and the scientific objectives of the project, as they included all of the following:

1.Finding the least time to complete the project work using the theory of constraints in the management of construction projects in the critical path method (CPM) using the program (MS Project).

2.Calculating the cost of the project using a scientific method such as the critical path method (CPM) to find the cost of completing the project, which in turn reduces the total cost of the project to the lowest possible.

3.Calculating the times of critical and non-critical activities of the project and finding the total flexibility of the project.

4. Identify the basic constraints and the expected operation of the project for the purpose of addressing them.

5. Providing the library of universities and scientific libraries with the results achieved from the research and considering it a scientific source for future studies.

The states of uncertainty and lack of certainty in the various activities and processes that are affected by environmental changes makes fuzzy logic an important tool to get rid of these situations, (Ahmad and Khalaf, 2016)

2. The Methodology Scientific For Research :

The research deals with a detailed presentation no for the research problem, importance research, research goals, chart research procedure, search limits, research community and sample, measurement tool, and as follows:

2.1. Research community: Baghdad Governorate.

2.2. The research sample: A project was selected (the establishment of a residential complex consisting of (96) housing units in Bismayah) in Al-Madaen District - Al-Wahda District Directorate, a sample for research .

2.3. Search tools:

2.3.1. critical path method.

2.3.2. Constraints Theory

2.3.3. Accelerated Projects.

2.3.4. Computer Programs (Ms Project)

2.4. Project Management:

Life activities are many and different, and they are in a state of development, which is one of the characteristics of the current century. Through the idea of making decisions for the future of any organization, and it is not possible to expand or develop without the presence of an aware and capable management to direct and supervise. Where project management has evolved greatly through the diversity of the work carried out by companies, as well as the huge resources used in them, which led to the development of management, functions, methods used, and tools significantly.

2.5. Project concept and project management:

The project is an organization-wide effort and it requires the continuous involvement of several functions. Project management tools and techniques help achieve integration and management. The project manager must meet all the requirements and expectations of project stakeholders and direct their organizations. Continuously to technically manage the project (Al-Raikabi, 2019), so (Krajewski and Ritzman, 2016), the knowledge of the leadership helps in creativity and its application through which the goals are achieved (Muhammad and Dawood, 2021) , Project management is the art of directing and coordinating human and material resources during the life of the project through the use of modern technologies to achieve the specified goals in a way that enables the completion of the project by implementing the content of what is stated in it, and taking into account quality, timing and cost factors, Many researchers believe that the relationship between large projects and small projects constitutes an integrative perspective that contributes to technological development and modernization and is important in contemporary development (Kazem and Abdul Redha, 2016).

2.6. Project Management Processes and Phases :

The project management processes are defined in order to understand the project activities in terms of operations and delivery time. Among these processes were referred to by some researchers, including (Larson and Clifford , 2017; Al-Sahlani, 2022; Al-Sahlani and Dawood , 2022) as in dictates follows:

1- Domain Management: this process is one of the most important project management processes, as the success of the project depends on it by defining the project framework and objectives.

2- Schedule Management: It is the process of setting a schedule for the implementation of project activities after determining the procedures required to implement the work at the specified tim .

3- Budget Management: is one of the most important project management processes due to its importance in the completion of the project and is an indicator of the efficiency of the organization.

4- Team Management**:** An administrative process that relies on skills and experience in selecting the work team according to the skills required in the project. The work team is obtained from appointment or short-term contracting. The team management must provide training courses for the team in order to raise the level of their expertise and more skill.

5- Information Management: Is the special process create collecting project-related information through reports and meetings for the project manager administered stakeholders because the stakeholders are provided with information about the progress of the work and the extent to which the project management adheres to the laws and standards agreed upon.

6- Stakeholder Management: An administrative process through which the requirements of the stakeholders are known and problems are addressed through continuous communication, which is confirmed by the stakeholders for their participation in the project decisions.

It can be expressed as a mediator between the project and the stakeholders through the following processes:(identification of stake holders, analysis, participation, define the flow of information, implementation of the agreement, determine the most important information from stakeholders

7- Contract Management**:** It is an administrative process that includes all the operations needed by the project from an external party, for example, the procurement process is an administrative process within the organization that works to determine the needs in terms of quantity, specifications and when they are needed by defining, implementing and reviewing the supply plan.

8- Risk Management**:** It is the process by which project risks are identified and those risks analysed because they have a negative impact on the completion of the project and the achievement of its objectives. (Identifying risks - analysing them - quantifying - monitoring and responding to them from the knowledge of project management).

We conclude from the foregoing that these processes occur within any stage of the project, which have a positive impact and great importance in achieving the results and thus achieving the goals.

As for the stages of project management, they are represented by a group of stages, which can be classified according to the following:

1.Initiation Phase**:** At this stage, the project idea is defined.

2.Planning Stage**:** All the processes required to design the action plan to achieve the objectives and gave (Abdul & Hassan, 2018) scientific methods must be used to plan and schedule projects in order to carry out the work according to the specified time.

3.Implementation Stage**:** (Kalaf, 2022) Project management developed that it has great importance in determining the time of the activity and depends on the experience of those in charge of implementing the operations that are conducted to complete the specified work.

4.The control Stage**:** All processes required to track, review and regulate project performance, the oversight process also helps in evaluation to choose practices that improve the organization's performance.

5.Shutdown phase**:** the processes that are conducted to finalize all activities, i.e., the project is officially closed, after which a comprehensive report is prepared to determine the success of the project (Heaney, 2012).

2.7. The concept and definition of the theory of constraints:

Many researchers, authors and writers have dealt with the philosophy of the theory of constraints, and there have been many definitions of this theory as a result of the different studies that have been exposed to it and in various journals of thought, production and accounting. Each definition has its own point of view and according to the field and study approved by the author or researcher, and these definitions have included several aspects, some of them considered it an administrative tool, some of them have considered it as a productive flow system, and some of them considered it an entrance to control, Others considered it a strategic tool, and the vast majority of writers defined it as an administrative philosophy, including the author of the idea of the theory of constraints, Dr. Coldrat, as shown in the order below: -

From a broader perspective, it is defined as a management philosophy that reflects a strong basis for making decisions on determining the constraint or set of constraints and how to manage them efficiently and effectively, with the aim of effectively improving the essential success factors of the economic unit in order to maximize operational profits and then achieve its strategic objectives (Al-Hassan et al., 2002)

From a control perspective, it has been defined as a managerial method of improving production processes by measuring the capacity of those processes, identifying key constraints and managing these constraints efficiently and effectively (Hilton, atel., 2002).

From another perspective, constraint theory is seen as a pull system for managing production flows, as the output of the system is determined by the production rate of the resource, which enjoys relative scarcity, and therefore the planning of the production flow in the production system as a whole should be done through restricted resources (Zoukar, 2018).

From a philosophical perspective, it has been defined as a temporary management tool that supports continuous improvement through the correct management of bottlenecks, and the key to the idea is in the process of diagnosing constraints in the system, which prevents the achievement of more goals by loosening those constraints more and more (Al-Balki, 2009).

From a strategic perspective, it has been defined as a strategic tool that effectively helps economic units improve an important factor for success, which is the time management cycle in which raw materials are transformed into finished products by identifying and eliminating bottlenecks in which semi-finished products gather while waiting for their turn to complete the production process (Al-Yamour, 2010).

2.8. Constraint:

Barfield, et al. (2003) is anything that hinders or limits the ability of a person or machine to perform a process or function.

Noreen, et al. (2011) - is anything that prevents us from getting more of what we want. Every individual or organization is subject to at least one restriction.

Anything that prevents an economic unit from achieving its goal of "making more money" and constraints may appear in the form of energy, materials, logistics, market, behavior, and even administrative policies. The idea of the theory of constraints in relation to its goal of making money is directly related to directing attention to the management of the restriction (Cokins,etal.,2006).

2.9. Methods of implementation, delivery and relationships between the stages in the construction project:

It is necessary for any project to distribute the roles to the various parties to find the most appropriate solutions to meet the requirements of the employer interrelated at the same time and balance between cost, quality and project time and that the goal of project management is to complete the work in the best possible period and at the lowest cost and with the best quality, but it is not easy to achieve these goals together and in the same degree of importance, which requires the emergence and adoption of new and different work contexts for the implementation and delivery of the project According to different relationships between multiple stages during the project life cycle, where considerations such as the level of control required, effectiveness and degree of risk determine the relationship that will link the stages to serve the beneficiary, Knowledge Guide to Project Management (2008), and accordingly there is no single method for implementing construction projects**.**

3. Discussion of results:

3.1.General Synopsis For Proposed Approach:

The proposed approach describes a project control system that operates in a completely unstable environment represented by technical, economic, legal and environmental constraints as well as uncertainty that made the use of computer programs indispensable in order to accelerate the completion of the project and within the planned time periods and periods.

3.2 . Data Collection Phase:

The main objective of this phase is to identify the data needed to build an appropriate system that is used by the researcher in the proposed approach. This data is collected from four main sections, namely, data from the beneficiary department, data from the executing company, data from government legislation for government projects, data from the expertise of specialists and experts.

3.3. Calculation of Project Completion Time and Critical Path:

The time of completion of the project was calculated using the MS PROJECT program, as shown Figure (1) , noting that the work progress table that the researcher relied on in preparing the tables was prepared by the executing company using Excel and without clear links between the events, and the researcher prepared a work progress table by the program and its results were relied on in the work .

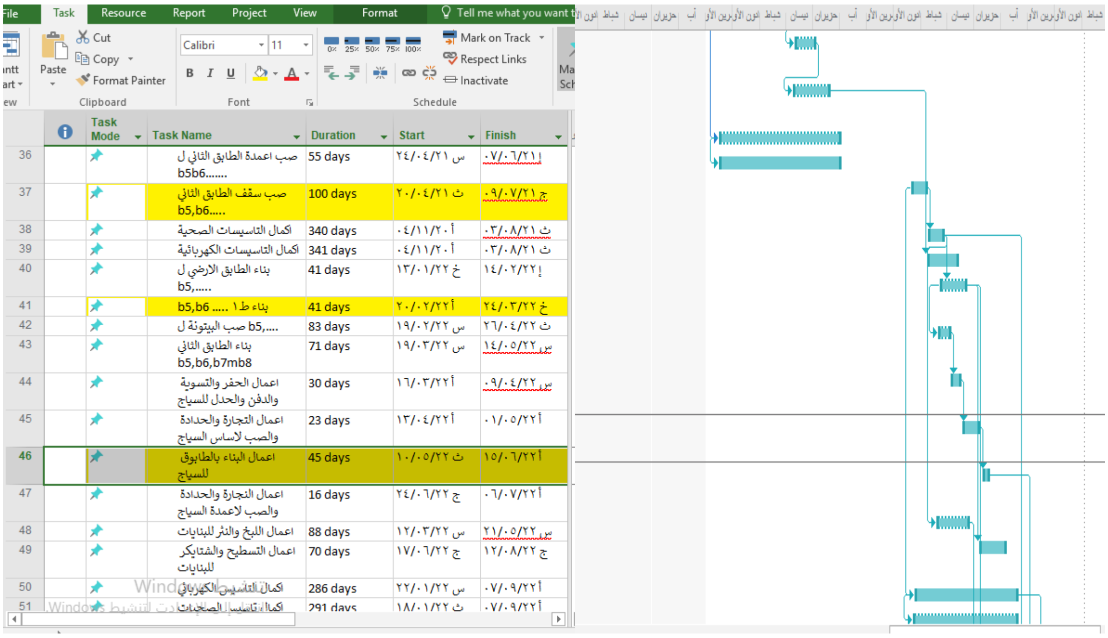

Figure (1): Images of MS Project interface

3.3.1 Calculation of project completion time (before applying the methodology):

Manual calculations were relied upon based on the project activities and events shown in Table (1) to find the project completion time, and the early start of each activity was calculated according to the front calculations to determine the time of completion of the project before applying the proposed methodology as shown in Table (2), and the late start and end of each activity were calculated according to the background calculations to determine the critical path by identifying critical and non-critical activities as shown in Table (3).

Table 1: Project activities and the timing of each activity.

NO.	Activities	symbol	previous	Time
1	Earthworks and site preparation	A		77
2	Blinding casting	B	A	26
3	Casting the foundations	C	B	35
4	Casting the necks of columns and laces	D	C	89
5	Construction under padlo	E	C	153
6	Casting columns	F	D	58
7	Pour the roof of the ground floor	G	F	83
8	Pouring flooring	H	F	73
9	Casting the columns of the first floor	I	G	84
10	Pour the roof of the first floor	J	I	106
11	Casting the columns of the second floor	K	J	118
12	Pour the roof of the second floor	L	K	145

13	Electrical Foundations Works	M	G	135
14	Health Establishment Works	N	H	132
15	Ground floor construction	O	L	84
16	First floor construction	P	O	66
17	Casting the curtain and the bittuna	Q	L	130
18	Second floor construction	R	P	113
19	Electrical Works	S	J	341
20	Sanitary works	T	I	340
21	Interior and exterior finishes	U	O	376
22	Electrical Works	V	K	286
23	Sanitary works	W	K	291
24	Precast Concrete Flags (Tiles)	X	Q	70
25	Construction of a fence	Y	R	213
26	Establishment of Electricals	Z	V	113
27	Sanitary installations	A*	W	114

Table 2: Calculation of early time and end time of each activity

Early start, early finish	Early start, early finish
ESA = 0 , EF_A = 0+77 = 77	ESE = 138, EF_E 138+153=291
ESB = 77,EFB =77+26= 103	ESF = 227,EFF = 227+58=285
ESC = 103,EFC = 103+35=138	ESG = 285,EFG = 285+83=368
SED = 138, EFD =138+89=227	ESH = 285, EFH = 285+73=358
ESI = 368, EFI = 368+84=452	
ESJ = 452,EFJ = 452+106=558	ESO = 821, EFO = 821+84=905
ESK = 558, EFK =558+118=676	ESP = 905, EFP = 905+66=971
ESL = 676,EFL = 676+145=821	ESQ = 821, EFQ = 821+130=951
ESM = 285, EFM = 285+135=420	ESR = 971, EFR =971+113=1084
ESN = 285, EFN =285+132=417	ESS = 452, EFS =452+341=793
EST = 452, EFT =452+340=792	ESU = 905, EFU =905+376=1281
ESV = 676, EFV = 676+286=962	ESW = 676, EFW = 676+291=967
ESX = 951, EFX = 951+70=1021	ESA*=967, EFA* =967+114=1081
ESZ = 962, EFZ =962+113=1075	ESY = 1084,EFY,=1084+213=1297

3.3.2. Background calculations, late beginnings and endings according to the network chart

The table (3) below represents the late beginnings and ends of the network's activities:

Table 3: calculation of last start time and last finish time of each activity

Last start, Last finish	Last start, Last finish
LSA* = 1297-114=1183, LFA* = 1297	LSY = 1297-213=1084, LFY = 1297
LSZ = 1297-113=1184, LFZ = 1297	LSU =1297-376=921, LFU = 1297
	LST = 1297-340=957, LFT = 1297
LSX = 1297-70=1227, LFX = 1297	LsV = 1184-286=898, LFV = 1184
LSW = 1196-291=905, LFW = 1196	
LSR =1084-113=971, LFR = 1084	LSP = 971-66=905, LFP = 971
LSS =1297-341=956, LFS = 1297	LSO =905-84=821, LFO = 905
LSQ = 1227-130=1097, LFQ = 1227	LSL= 821-145=676, LFL = 821
LSN = 1297-132=1165, LFN =1297	LSM =1297-135=1162, LFM = 1297

LSK =676-118=558, LFK = 676	LSJ = 558-106=452, LFJ = 452
LSI = 452-84=368, LFI = 452	LSG = 368-83=285, LFG = 285
LSD = 227-89=138, LFD = 227	LSF = 285-58=227, LFF = 285
LSC = 138-35=103, LFC = 103	LSH = 1165-73=1092, LFH = 1165
LSB = 103-26=77, LFB = 103	LSE = 905-153=752, LFE = 905
LSA = 77-77=0, LFA = 77	

The beginnings and early and late ends were fixed and the flexibility times of the events were calculated as shown in the table (4) below.

Table 4: Activities, Their Symbols, and the Start and End Times for Each Activity

flexible	**LF**	**LS**	**EF**	**ES**	**time**	**previous**	**symbol**	**Activities**	**activity**
0	77	0	77	0	77		A	Earthworks and site preparation	1
0	103	77	103	77	26	A	B	Blinding casting	2
0	138	103	138	103	35	B	C	Casting the foundations	3
0	227	138	227	138	89	C	D	Casting the necks of columns and laces	4
814	821	668	291	138	153	C	E	Construction under padlo	5
0	285	227	285	227	58	D	F	Casting columns	6
0	368	285	368	285	83	F	G	Pour the roof of the ground floor	7
801	1165	1092	358	285	73	F	H	Pouring flooring	8
0	452	368	452	368	84	G	I	Casting the columns of the first floor	9
0	558	452	558	452	106	I	J	Pour the roof of the first floor	10
0	676	558	676	558	118	J	K	Casting the columns of the second floor	11
0	821	676	821	676	145	K	L	Pour the roof of the second floor	12

677	1097	962	420	285	135	G	M	Electrical Foundations Works	13
801	1297	1165	496	364	132	H	N	Health Establishment Works	14
0	905	821	905	821	84	L	O	Ground floor construction	15
0	971	905	971	905	66	O	P	First floor construction	16
276	1227	1097	951	821	130	L	Q	Casting the curtain and the bittuna	17
0	1084	971	1084	971	113	P	R	Second floor construction	18
504	1297	956	793	452	341	J	S	Electrical Works	19
505	1297	957	792	452	340	I	T	Sanitary works	20
16	1297	921	1281	905	376	O	U	Interior and exterior finishes	21
222	1184	898	962	676	286	K	V	Electrical Works	22
216	1183	892	967	676	291	K	W	Sanitary works	23
267	1297	1227	1021	951	70	Q	X	Precast Concrete Flags (Tiles)	24
0	1297	1084	1297	1084	213	R	Y	Construction of a fence	25
222	1297	1184	1075	962	113	V	Z	Establishment of Electricals	26
216	1297	1183	1081	967	114	W	A*	Sanitary installations	27

The critical course of the project and the total time for the end of the events were determined, Critical path; A-B-C-D-F-G-I-J-K-L-O-P-R-Y =1297 Days.

3.4 **Constraints Importance:**

During this stage, we will assess the significance of constraints leveraging fuzzy logic to evaluate their influence on construction projects. This evaluation will be accomplished by implementing the Fuzzy Analytical Hierarchy Process (FAHP) with the involvement of ten engineers who specialize in project management, implementation, and supervision, as illustrated in Table 5 below.

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Table 5: Expert Opinions on the Importance of Restrictions

Expert 1	**Technical and Design Constraints**			**Cost Restriction**			**Administrative and Legal Constraints**			**Time Restriction**			**Environmental Constraints**		
Technical and Design Constraints	**1**	**1**	**1**	**0.4**	**0.3**	**0.285**	**1.5**	**1**	**0.66**	**0.66**	**0.5**	**0.4**	**1**	**1**	**1**
Cost Restriction	**3.5**	**3**	**2.5**	**1**	**1**	**1**	**1.5**	**1**	**0.7**	**0.4**	**0.3**	**0.3**	**1.5**	**1**	**0.66**
Administrative and Legal Constraints	**1.5**	**1**	**0.66**	**1.5**	**1**	**0.7**	**1**	**1**	**1**	**2.5**	**2**	**1.5**	**3.5**	**3**	**2.5**
Time Restriction	**2.5**	**2**	**1.5**	**3.5**	**3**	**2.5**	**0.7**	**0.5**	**0.4**	**1**	**1**	**1**	**1**	**1**	**1**
Environmental Constraints	**1**	**1**	**1**	**1.5**	**1**	**0.7**	**0.4**	**0.3**	**0.3**	**1**	**1**	**1**	**1**	**1**	**1**
Expert2	**Technical and Design Constraints**			**Cost Restriction**			**Administrative and Legal Constraints**			**Time Restriction**			**Environmental Constraints**		
Technical and Design Constraints	**1**	**1**	**1**	**1**	**1**	**1**	**1.5**	**1**	**0.66**	**0.4**	**0.3**	**0.3**	**1.5**	**1**	**0.66**
Cost Restriction	**1**	**1**	**1**	**1**	**1**	**1**	**1.5**	**1**	**0.7**	**0.4**	**0.3**	**0.3**	**3.5**	**3**	**2.5**
Administrative and Legal Constraints	**1.5**	**1**	**0.66**	**1.5**	**1**	**0.7**	**1**	**1**	**1**	**0.66**	**0.5**	**0.4**	**1**	**1**	**1**
Time Restriction	**3.5**	**3**	**2.5**	**3.5**	**3**	**2.5**	**2.5**	**2**	**1.5**	**1**	**1**	**1**	**1.5**	**1**	**0.66**
Environmental Constraints	**1.5**	**1**	**0.7**	**0.4**	**0.3**	**0.3**	**1**	**1**	**1**	**1.5**	**1**	**0.7**	**1**	**1**	**1**
Expert3	**Technical and Design Constraints**			**Cost Restriction**			**Administrative and Legal Constraints**			**Time Restriction**			**Environmental Constraints**		
Technical and Design Constraints	**1**	**1**	**1**	**1.5**	**1**	**0.66**	**2.5**	**2**	**1.5**	**0.3**	**0.3**	**0.2**	**2.5**	**2**	**1.5**
Cost Restriction	**1.5**	**1**	**0.66**	**1**	**1**	**1**	**0.7**	**0.5**	**0.4**	**0.4**	**0.3**	**0.3**	**1**	**1**	**1**
Administrative and Legal Constraints	**0.7**	**0.5**	**0.4**	**2.5**	**2**	**1.5**	**1**	**1**	**1**	**1**	**1**	**1**	**2.5**	**2**	**1.5**
Time Restriction	**3.5**	**3**	**2.5**	**3.5**	**3**	**2.5**	**1**	**1**	**1**	**1**	**1**	**1**	**0.6**	**0.5**	**0.4**
Environmental Constraints	**0.7**	**0.5**	**0.4**	**1**	**1**	**1**	**0.7**	**0.5**	**0.4**	**2.5**	**2**	**1.5**	**1**	**1**	**1**
Expert 4	**Technical and Design Constraints**			**Cost Restriction**			**Administrative and Legal Constraints**			**Time Restriction**			**Environmental Constraints**		

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Technical and Design Constraints	1	1	1	0.3	0.3	0.22	1	1	1	1.5	1	0.7	1	1	1
Cost Restriction	4.5	4	3.5	1	1	1	0.7	0.5	0.4	0.4	0.3	0.3	1	1	1
Administrative and Legal Constraints	1	1	1	2.5	2	1.5	1	1	1	1	1	1	3.5	3	2.5
Time Restriction	1.5	1	0.7	3.5	3	2.5	1	1	1	1	1	1	0.66	0.5	0.4
Environmental Constraints	1	1	1	1	1	1	0.4	0.3	0.3	2.5	2	1.5	1	1	1
Expert 5	**Technical and Design Constraints**			**Cost Restriction**			**Administrative and Legal Constraints**			**Time Restriction**			**Environmental Constraints**		
Technical and Design Constraints	1	1	1	0.7	0.5	0.4	1.5	1	0.66	0.4	0.3	0.3	1.5	1	0.66
Cost Restriction	2.5	2	1.5	1	1	1	0.4	0.3	0.3	1	1	1	1	1	1
Administrative and Legal Constraints	1.5	1	0.66	3.5	3	2.5	1	1	1	0.4	0.3	0.3	2.5	2	1.5
Time Restriction	3.5	3	2.5	1	1	1	3.5	3	2.5	1	1	1	0.67	0.5	0.4
Environmental Constraints	1.5	1	0.7	1	1	1	0.7	0.5	0.4	0.67	0.5	0.4	1	1	1
Expert 6	**Technical and Design Constraints**			**Cost Restriction**			**Administrative and Legal Constraints**			**Time Restriction**			**Environmental Constraints**		
Technical and Design Constraints	1	1	1	1.5	1	0.66	0.7	0.5	0.4	0.4	0.3	0.3	1	1	1
Cost Restriction	1.5	1	0.66	1	1	1	1	1	1	0.334	0.3	0.2	1	1	1
Administrative and Legal Constraints	2.5	2	1.5	1	1	1	1	1	1	1	1	1	2.5	2	1.5
Time Restriction	3.5	3	2.5	4.5	4	3.5	1	1	1	1	1	1	0.67	0.5	0.4
Environmental Constraints	1	1	1	1	1	1	0.7	0.5	0.4	2.5	2	1.5	1	1	1
Expert 7	**Technical and Design Constraints**			**Cost Restriction**			**Administrative and Legal Constraints**			**Time Restriction**			**Environmental Constraints**		
Technical and Design Constraints	1	1	1	1.5	1	0.66	0.4	0.3	0.285	1.5	1	0.7	2.5	2	1.5
Cost Restriction	1.5	1	0.66	1	1	1	1.5	1	0.7	0.6	0.5	0.4	1.5	1	0.66
Administrative and Legal Constraints	3.5	3	2.5	1.5	1	0.7	1	1	1	0.6	0.5	0.4	2.5	2	1.5
Time Restriction	1.5	1	0.7	2.5	2	1.5	2.5	2	1.5	1	1	1	1	1	1

Environmental Constraints	0.7	0.5	0.4	1.5	1	0.7	0.6	0.5	0.4	1	1	1	1	1	1
Expert 8	**Technical and Design Constraints**			**Cost Restriction**			**Administrative and Legal Constraints**			**Time Restriction**			**Environmental Constraints**		
Technical and Design Constraints	1	1	1	0.3	0.3	0.22	0.3	0.3	0.285	0.3	0.3	0.2	3.5	3	2.5
Cost Restriction	4.5	4	3.5	1	1	1	0.4	0.3	0.3	0.33	0.3	0.2	2.5	2	1.5
Administrative and Legal Constraints	3.5	3	2.5	3.5	3	2.5	1	1	1	0.4	0.3	0.3	2.5	2	1.5
Time Restriction	4.5	4	3.5	4	3.5	3	3.5	3	2.5	1	1	1	1	1	1
Environmental Constraints	0.4	0.3	0.3	0.7	0.5	0.4	0.7	0.5	0.4	1	1	1	1	1	1
Expert 9	**Technical and Design Constraints**			**Cost Restriction**			**Administrative and Legal Constraints**			**Time Restriction**			**Environmental Constraints**		
Technical and Design Constraints	1	1	1	0.4	0.3	0.285	1.5	1	0.66	0.6	0.5	0.4	2.5	2	1.5
Cost Restriction	3.5	3	2.5	1	1	1	0.6	0.5	0.4	0.285	0.3	0.2	1.5	1	0.66
Administrative and Legal Constraints	1.5	1	0.66	2.5	2	1.5	1	1	1	1	1	1	1.5	1	0.66
Time Restriction	2.5	2	1.5	4.5	4	3.5	1	1	1	1	1	1	2.5	2	1.5
Environmental Constraints	0.7	0.5	0.4	1.5	1	0.7	1.5	1	0.7	0.6	0.5	0.4	1	1	1
Expert 10	**Technical and Design Constraints**			**Cost Restriction**			**Administrative and Legal Constraints**			**Time Restriction**			**Environmental Constraints**		
Technical and Design Constraints	1	1	1	0.3	0.3	0.22	0.7	0.5	0.4	0.4	0.3	0.3	1	1	1
Cost Restriction	4.5	4	3.5	1	1	1	0.6	0.5	0.4	0.285	0.3	0.2	1	1	1
Administrative and Legal Constraints	2.5	2	1.5	2.5	2	1.5	1	1	1	1.5	1	0.7	1	1	1
Time Restriction	3.5	3	2.5	4.5	4	3.5	1.5	1	0.7	1	1	1	1	1	1
Environmental Constraints	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

After conducting calculations and fuzzy analysis, the importance of weights for the five constraints is clear in the following table(6).

Table 6: Final constraints weights after fuzzy analysis

NO.	Constraint	Weight
1	Technical and Design Constraints	0
2	Cost Restriction	%8,7
3	Administrative and Legal Constraints	%30,4
4	Time Restriction	%60,8
5	Environmental Constraints	0

Table 7: shows the added values of time and cost after the application of the foggy system in its second stage

Activity	symbol	time	Time Severity Indicator	Added time (Day)	The Cost	Cost Risk Index	Added Cost (ID)
1	A	77	0,334	3	2,050,000,000	0,4	60,000,000
2	B	26	0,334	1	198,000,000	0,137	2,000,000
3	C	35	0,334	2	1,323,450,000	0,394	40,000,000
4	D	89	0,361	4	82,875,000	0,137	3.000.000
5	E	153	0,594	7	770,000,000	0,219	30,040,000
6	F	58	0,334	1	123,000,000	0,137	1,000,000
7	G	83	0,334	2	929,500,000	0,294	20,000,000
8	H	73	0,334	2	325,000,000	0,15	4,000,000
9	I	84	0,334	2	123,000,000	0,145	1,000,000
10	J	106	0,4088	3	929,500,000	0,291	5,000,000
11	K	118	0,467	3	123,000,000	0,137	2,000,000
12	L	145	0,573	9	929,500,000	0,288	5,000,000
13	M	135	0,541	4	141,397,500	0,137	4,000,000
14	N	132	0,528	5	143,070,000	0,137	4,000,000
15	O	84	0,334	2	501,666,000	0,14	7,000,000
16	P	66	0,334	1	501,666,000	0,14	7,000,000
17	Q	130	0,519	4	450,000,000	0,138	10,000,000
18	R	113	0,445	2	501,666,000	0,138	10,000,000
19	S	341	0,745	13	141,397,500	0,137	5,000,000
20	T	340	0,745	14	143,070,000	0,137	5,000,000
21	U	376	0,745	28	3,766,000,000	0,45	200,000,000

22	V	286	0,745	11	141,397,500	0,137	5,000,000
23	W	291	0,745	12	143,070,000	0,137	4,080,000
24	X	70	0,334	1	190,000,000	0,137	2,000,000
25	Y	213	0,71	9	278,100,000	0,137	9,000,000
26	Z	113	0,445	2	141,397,500	0,137	2,000,000
27	A*	114	0,445	3	143,070,000	0,137	2,000,000

4. Conclusions:

We note from the previous table and from the calculations of the network chart that the real time to complete the work exceeded the period provided by the company and by more than 100%, and the reasons for this are due to the following : -

1. After applying the fuzzy logic, which was worked in two stages, the construction project, in the case of facing force majeure circumstances, predicting the face of unlikely things, or preparing to work within the environment of uncertainty in the worst case, needs a period of approximately (150) days, in addition to the (831) days that were calculated from the acceleration application, the total period of the project, taking into account all unexpected things, reaches (980) days, which is a period much less than the period of work. The executing company that (1271) days, which means that there is a time saving of up to (23%)
2. The failure to implement the acceleration in the project, which is a cornerstone in the success of construction projects, made the implementation period a very long period as well as extendable.
3. A technical offer was made by the executing company to implement the project during 660, and in fact this period has nothing to do with the project, but was just a prediction, and it was a serious mistake on the part of the company because even with the entry of the dates of the activities installed in this presentation, the period did not appear 660 days as they claimed.
4. Not to link in the implementation of tasks that do not conflict and do not depend on each other (acceleration in the implementation of construction projects) except in some places, which have a small impact on the time of completion of the project.

Authors Declaration:
Conflicts of Interest: None
-We Hereby Confirm That All The Figures and Tables In The Manuscript Are Mine and Ours. Besides, The Figures and Images, Which are Not Mine, Have Been Permitted Republication and Attached to The Manuscript.
- Ethical Clearance: The Research Was Approved By The Local Ethical Committee in The University.

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منهج متكامل لنظرية القيود وعملية التحليل الهرمي الضبابي (FAHP) في المشاريع الانشائية (دراسة حالة)

محمد جاسم ناصر
جامعة بغداد / كلية الادارة والاقتصاد/ الإدارة الصناعية
بغداد , العراق
mohammed.jassem1205a@coadec.uobaghdad.edu.iq
https://orcid.org/0009-0008-3584-4365

نغم يوسف عبد الرضا
جامعة بغداد / كلية الادارة والاقتصاد/ الإدارة الصناعية
بغداد , العراق
dr.nagham@coadec.uobaghdad.edu.iq

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مستخلص البحث:

يهدف البحث للاستفادة من المميزات الناتجة من التكامل بين استخدام نظرية القيود في إدارة المشاريع الإنشائية لمعالجة التلكؤ في وقت انجاز المشروع كذلك استخدام التحليل الضبابي لمعرفة الأهمية المقدرة عن طريق الاوزان للقيود الأساسية في المشاريع. تتمحور مشكلة البحث حول أمرين أساسيين: الأول, استخدام الأساليب القديمة أو الاعتماد على خبرة العاملين دون مراعاة استخدام التقنيات المحوسبة الحديثة, وعدم تسليم المشروع بالوقت المحدد . تعتمد مشاريع البناء خمسة أنواع أساسية (تقييد التكلفة, تقييد الوقت, القيود الإدارية والقانونية, القيود الفنية والتصميمية, والقيود البيئية)

وقد أجريت دراسة ميدانية من خلال تحليل (مشروع إنشاء مجمع سكني في قائمقامية قضاء المدائن - بسماية). واقترح الباحثان منهجية مكونة من ثلاث مراحل, في المرحلة الأولى تم استخدام نظرية الأنشطة المتسارعة وتطبيقها على جميع الأنشطة التي يمكن تنفيذها في نفس الفترة, ثم المرحلة الثانية من المنهجية المقترحة والتي من خلالها تم استخدام نظرية الأنشطة المتسارعة عملية التحليل الهرمي (FAHP) لحساب أهمية القيود. وأخيرًا البدء بالمرحلة الثالثة, والتي تم من خلالها استخدام المنطق الضبابي لحساب المدة المقترحة والتكلفة التي تضاف لكل نشاط, حتى يتم تنفيذ المشروع وتسليمه في الأوقات المتفق عليها.

وبعد تطبيق المنهجية المقترحة هناك انخفاض في زمن الانتهاء بنسبة تصل إلى (23%).

نوع البحث: ورقة بحثية

المصطلحات الرئيسة للبحث : ادارة مشاريع , نظرية القيود , ادارة المشاريع المتسارعة , عملية التحليل الهرمي الضبابي, علاقة الكلفة والوقت, المنطق الضبابي.