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# KEY SUCCESSFUL ELEMENTS OF EPC PROJECTS

Sewage Treatment Industry

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Leila Ghanbari

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## ABSTRACT

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This research aims to investigate and prioritize factors affecting the success of engineering, procurement, and construction (EPC) projects in Iran, considering the dynamic nature of the manufacturing industry and the sensitivity of project implementation stages.

The study employed a qualitative study using a single case study based on an EPC project (wastewater treatment plant) in Iran. The interviews were focused on topics such as the definition of project success, project management, the main challenges of this project and the ways they were overcome. It also benefited from inputs from literature information regarding infrastructure, engineering and energy projects.

The study revealed, along with other aspects, that dedicating special attention to the initial phases contributes to the good performance of the project. A well-executed procurement phase combined with a well-performed engineering design contributed to minimizing risks such as change orders and selection of suppliers with a lack of qualification, which would impact on the next phases. The proper selection of the management team was revealed to be an important factor affecting the schedule and the level of control of the project by the Owner. The results indicate that the contractor, project team, project manager, organization, employer, counsellor, external factors and project were key factors.

Although each project is unique and subject to its environment, political scenarios, and other variables, this thesis's findings can contribute to future engineering projects' success.

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Keywords	EPC, construction, success, project management
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**APPENDICES****APPENDIX 1.** Interview questions in English

# **1 INTRODUCTION**

## **1.1 Background of the Thesis**

The success of the project is an important and biggest goal and concern of managers and all of the people involved in a project, which is a kind of unifying effort of all project team members. Investigating the success and failure factors of projects in EPC projects is more sensitive to the changeable and dynamic nature of this industry at different levels of project implementation.

However, many studies done by a variety of researchers indicated that among the several members of the construction industry, there is no definite general agreement on the definition of project success, or on how to clarify their relation to the contributing factors (Freeman & Beale, 1992; Scott, Chan, & Chan, 2004).

Success is the ultimate aim in every industry and is ideal for everyone engaged in a project. Traditionally, the success of EPC projects has been determined by their ability to satisfy their budget, time, and quality criteria. Having a clear concept of project success helps increase the management's effectiveness. Projects must meet and exceed this scope to be fully believed to be successful. This study aims to identify and rank the main and effective factors in the success of EPC projects.

## **1.2 Research Problem, Research Questions, and Structure of the Thesis**

Projects are now the main means of development, and they unlock the potential of this process through successful technological, tactical, and strategic strategies. Companies are increasing their power by investing greater resources in project management procedures. As a result, success in achieving superior project results gives a competitive edge in the marketplace. (Ghanbari Pour, 2022). For many years, academics have proposed and discussed measuring and analysing project performance based on a number of criteria, but there is still no ultimate consensus on what defines a successful project.



Furthermore, professional institutes such as the International Project Management Association (IPMA) and the Project Management Institute (PMI) have developed many methods, tools and techniques through bodies of knowledge to equip professionals with robust project success measurement tools (PMI, 2017). For many years, delivering project outcomes on time and within budget with all requirements fulfilled has been the main concern of project managers (Ghanbari Pour, 2022).

In recent years, according to the logic of employers regarding the speed of implementation and reduction of excesses in civil and industrial projects and as a result the cost reduction of all projects, the methods of project development have been two-factorial. In this method, the employer outsources the design and construction services of projects from a single external source (Zhang and Xi, 2023). In this operating system, the employer is reduced to the minimum and the designer-manufacturer (resource) is responsible for the coordination between design and construction. This method is also based on a kind of organizational organization. The person who is responsible for the work of this organization may originally have design expertise and perform construction services with full responsibility through a general contractor or several main contractors and using construction management, or originally a contractor organization has been designed services from a design institute while maintaining the responsibility of completing the study and implementing them into operations (Wang et al., 2019).

One of the main features mentioned for the design and construction method is cooperation, coordination and optimal integration of design, planning and execution activities. Design, procurement, and execution projects are moving together, in addition, to projects with more execution capability and more compliance with schedule and higher quality, and finally, naturally, with less cost (Chen et al., 2020). To accommodate the needs of the world today, new legal agreements, institutions and laws have been created to regulate the relationships of individuals and societies. For this reason, in Iran, it is also done to determine the content and

legal structures, and commercial contracts are also part of the same thing (Quan et al., 2022).

The executive operations of central houses include two general parts: the price list and the wholesale part. The list of contract prices from different seasons of building prices, mechanical services, managers of electric lines, airports, infrastructures and railways, rural distribution networks, etc. The second part, which generally includes electromechanical equipment, is estimated by the contractor. The contract must have comprehensive management of both sectors, after the operation, it will fully fulfil the client's expectations. More simply, the purpose of creating treatment plants is to transform or process the quality within the permissible limits to surface water or absorbent wells for irrigation and agricultural purposes. On the other hand, the fulfilment of the above conditions is determined after exploitation (Keshafi and Shrimadar, 2022).

In this main research, the examination of all types of contracts in the absence of output is within the permissible limits despite the payment of a large part of the contractor's claims. It is very important to determine the dimensions and limits of the subject in order to obtain results and reach the answer to the main research problem. In this research, Baharestan wastewater treatment plant contracts will be examined. Since, in the absence of compliance of the output with the defined limits, a project will fail; therefore, it should be determined, the stage from design, implementation to operation, the largest number of non-receipts. According to the mentioned materials, this research aims to evaluate the key success factors in the success of EPC projects (case study Baharestan wastewater treatment plants).

### **1.3 Research Gap**

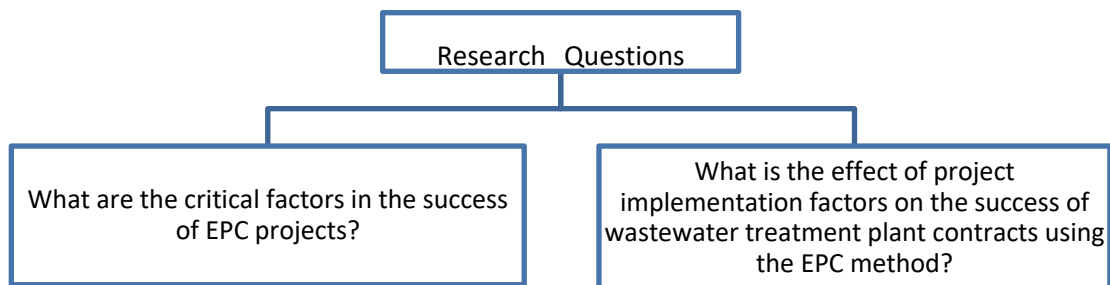
While there have been several studies on project success and several widely used project models and frameworks have been created, there is still a lot of ambiguity about what makes a successful project delivery. Since there is currently no agreement over a set of success criteria that can be utilized for all sorts of projects,

measuring project delivery success has always been difficult for both academics and professionals. In this area, enabling organizations to assess project success would be crucial since it would enable them to create more effective project management processes and boost the effectiveness of their initiatives.

#### 1.4 Research Questions

The research questions can be seen in the framework in Figure 1.

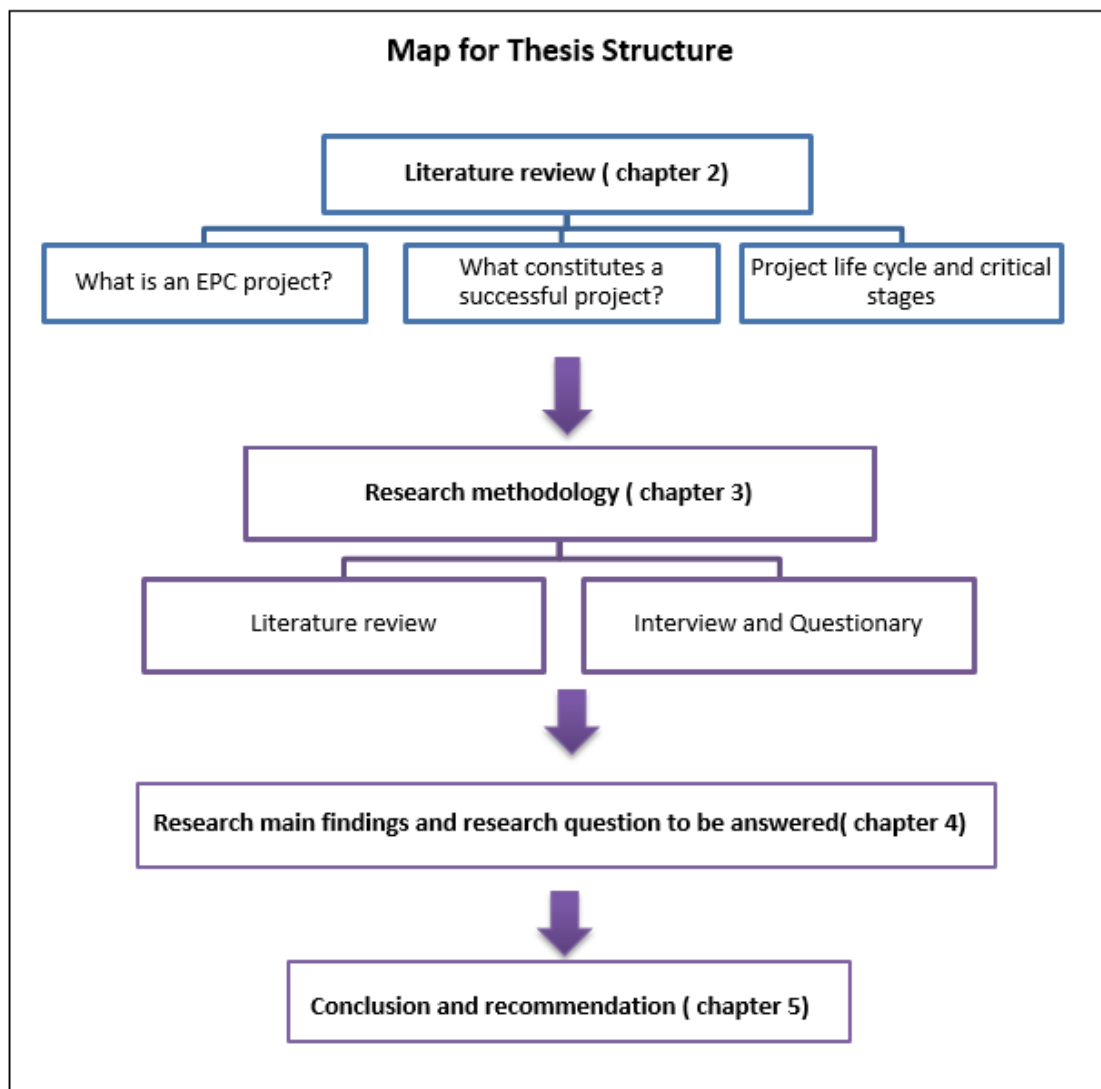
- What are the critical factors in the success of EPC projects?
- What is the effect of project implementation factors on the success of wastewater treatment plant contracts using the EPC method?



**Figure 1.** Research questions

#### 1.5 Structure of the Thesis

The structure of the thesis is presented in Figure (2). The literature review and a more detailed description of the EPC projects, project success, and other components will be included in the second chapter. The third chapter covers the methodology, implementation, and analysis of the study and data collection. In the fourth chapter, the essential research from Chapter 2 will be combined with key results from Chapter 3 to determine the main variables in project success. The fifth chapter contains a discussion and conclusion.



**Figure 2.** Structure of the thesis

### 1.6 The importance and necessity of research

One of the new methods in the implementation of plans is the engineering, procurement and construction method (EPC), which is also called the turnkey method. In this type of contract, the contractor company undertakes and carries out the engineering, procurement and supply of all equipment and construction of the project independently or with persons who are related to the said company. In turnkey or EPC contracts, the contractor is responsible for design, procurement

and construction, and the other party of the contract (employer) receives a completed project according to what was agreed upon (Mo et al., 2020). Contractors in EPC are required to have the ability to operate according to the parameters desired by the buyers of their services. In general, it can be said that EPC contracts include the three stages of engineering, preparation and construction of the project in one contract. In this way of implementing the project, despite the limitations for the employer, by transferring all the activities of the project, including design, procurement and supply of equipment, measures related to construction, installation and commissioning to the contractor, the employer is relieved of responsibility in this field. (Mao et al., 2021).

In the design, purchase and construction method, the employer provides the design and construction services of the project through a single contract with the designer-builder. The responsibility and risk of the employer is minimized in this method, and the single source of responsibility (designer-builder) undertakes all the design, procurement and construction services of the project. In this system, the possibility of simultaneous design and construction is maximized. The risk of the employer in launching the project is related to the information that he produces during the stage of holding a tender or negotiation for the assignment of the design and construction contract (Shi et al., 2021). The EPC contractor usually quotes the price of the design and construction work at the same time. Design and construction may or may not be simultaneous.

In recent years, the implementation of industrial infrastructure projects in developing countries by the EPC method has expanded to the extent that today many activities in progress, especially in the oil industry, are carried out using this method. This method is one of the new methods in the implementation of projects, which is also called the turnkey method because after performing the installation and completion of construction and technical tests and inspections, the employer can withdraw from the project by pressing a key. (Zhang and Xi, 2023). These contracts also have divisions according to the contractor's responsibilities.

In conventional EPC contracts, the employer or the public sector performs part of the design (basic design) and the contractor company continues the design (conceptual design and preliminary design), procurement and supply of all. Contractor is in charge of the equipment and construction of the project independently or with persons who are related to the said company (Quan et al., 2022). But in the turn-key or full EPC method, the contractor is responsible for design, procurement and construction, and the other party of the contract (employer) receives a finished project according to what was agreed upon. This contractual method is an organized program to achieve a better system for implementing projects. In addition, with this contractual method, while borrowing from banks is not the responsibility of the employer, the risks related to construction and new technologies are also transferred to the other party (private sector). Also, many benefits for the employer during construction and after (operation) can be predicted (Wang et al., 2019).

One of the main reasons for the approach towards EPC contracts is the issue of time reduction. The increase in the time of a project in addition to the delay in the exploitation of that project sometimes causes the delay in the exploitation of other projects as well. One of the characteristics of this method is cooperation, coordination and integration between the three activities of design, procurement and implementation, which act as three interconnected factors in mutual relation with each other. Therefore, the importance of conducting this research is that it reduces the time required to achieve the goals and reduces the project claims, improves the ability to build and innovate, and also gives certainty to the schedule, according to the mentioned materials. The review of the current research is important and necessary.

## **2 LITERATURE REVIEW**

In this chapter, a detailed literature review primarily focused on project success will be conducted to give the essential theoretical framework to locate the research gap that this study seeks to solve and to deliver a deeper knowledge of the research topic. This chapter begins with a careful look at the EPC project in the construction industry, and then covers the literature on project success with an overarching focus on success and the obstacles in identifying success from failure in projects. These project success aspects are investigated, providing the basis for using a definition in this study. Cost, time, and scope are expanded to account for varying levels of project complexity. The discovered knowledge gap is utilized to steer the remainder of the research.

### **2.1 Construction Industry Over View**

This chapter describes the construction industry, including the interrelationship between project structures, project management, and project success.

#### **2.1.1 Project Management and Success Criteria**

De Carvalho et al., (2015), in a article called *Project Management and its Effect on Project Success*, made a comparison between different countries and industries. In this study, the effects of project management (PM) on project success based on planning parameters, cost and a probabilistic approach was taken that evaluates the project complexity based on 4 stratifications, the influence of the industry sector and countries. The methodological approach in 3 countries (Argentina, Brazil and Chile) with a business unit of 10 different industries in one 3-year period, a longitudinal survey was conducted. The information related to all 1387 projects was examined to test the hypotheses of the research, structural equation modeling was used, and the results show that there is a meaningful relationship.

There is a positive relationship between the response variable program with PM factors and project management efforts in training and developing capabilities. The complexity of the project has a significant effect on the success of the project.

Pinnington, A.H. (2014) conducted a project entitled Investigating the Value of Project Management. Project management literature shows that despite the progress in project management processes, tools and systems, questions about the value and effectiveness of the project management system remain. This is a research study that examines the relationship between management performance and project success from empirical data. It draws on project management specialists in project-based organizations in the United Arab Emirates. A multidimensional framework has been validated and used in this study to measure management performance and project success. A total of 154 completed questionnaires were analyzed. Double correlation and multiple regression tests showed a positive effect on project management performance and its variables on project success.

Jiang et al. (2023) researched the "mechanism of establishing EPC project consortium cooperation in the context of China". The questionnaire surveys were conducted to collect data from experienced project managers of a design company group and a construction contractor group. The structural equation modelling was used to test the hypotheses in this research. The results show that reputation and communication are important factors in building trust (including computational trust and relational trust) from the design company's point of view. Meanwhile, reputation, interaction and communication are important factors for building trust from the construction company's point of view. Both calculative trust and relational trust are positive factors that influence the intention of the design firm and the construction contractor to cooperate. This research has innovatively added to and contributed to the existing knowledge on the mechanisms of EPC consortia formation (Jiang et al., 2023).



Choi et al. (2022) in their research, investigated "Contractor risk analysis of engineering procurement and construction (EPC) contracts using ontological semantic model and double-band short-term memory (LSTM) technology". The development of intelligent information technology in the era of the fourth industrial revolution requires the EPC industry to increase productivity through digital transformation. The purpose of this study is to automatically analyze critical risk clauses in the invitation to tender (ITB) at the tender stage to enhance their competitiveness for EPC contractors.

This study proposes two models. First, the Semantic Analysis (SA) model is a rule-based approach that applies NLP to extract key risk clauses. Second, the Risk Level Ranking (RLR) model is a train-based approach that ranks the risk impact for each item by applying bi-LSTM. After developing and training an artificial intelligence (AI)-based ITB analysis model, its performance was evaluated through real project data. As a result of the validation, the SA model has an F1 score of 86.4% and the RLR model has an accuracy of 46.8 percent. The RLR model showed a relatively low performance because the ITB used in the evaluation test contained contract clauses that were not present in the training dataset. Therefore, this study showed that the rule-based approach performs better than the training-based method. The authors suggest that EPC contractors should apply both SA and RLR modes in ITB analysis, as one is complementary to the other. These two models are embedded in the Engineering Machine Learning Automation Platform (EMAP), a cloud-based platform developed by the authors. Rapid analysis through the use of ITB's rule-based and AI-based automated analysis technology can help secure timely risk response and eliminate possible human errors in the bidding stage (Choi et al., 2022).

Zheng et al. (2021), in their research investigated "BIM-based digitization improvement analysis in engineering, procurement and construction (EPC) projects in China". Digitalization is considered a dynamic change process, characterized by the rapid development of innovative concepts (for example, building information

modelling) that bring significant potential benefits to the construction industry. However, previous studies on the benefits of digitization (BIM) were mainly based on laboratory data rather than actual methods, which compromised the reliability of the results for construction professionals. This study examined the impact of digitalization on EPC construction projects by integrating descriptive statistics and survey-based exploratory factor analysis (SEFA). After a detailed review of related studies and meetings with experts, ten main variables and 14 integrated variables were identified. Data related to these variables were collected using questionnaires and extracting information from project documents. A total of 62 participants from 33 EPC construction projects responded to the questionnaire survey. SEFA results showed that digitization can improve both cost and time performance, with greater potential to improve time performance for EPC projects. In a scenario with limited implementation of digitization, this research can inspire future researchers to develop more applied research and guidelines to achieve best practices in the field of digitalization of construction projects (Zheng et al., 2021).

Kabirifar et al. (2019) investigated "the effect of engineering, procurement and construction (EPC) stages on project performance: a case of a large-scale residential construction project". The construction industry is a complex and fragmented industry worldwide concerning its supply chain, products, and processes, and it faces a similar dilemma that builders faced decades ago. Scope, time and cost are the three constraints of project management and leading factors in defining project performance. The productivity and efficiency of any construction project is measured through its triple constraints, so the factors that affect the success of the project are significantly important. Despite the importance of understanding project performance indicators, few empirical studies have been conducted in the last decade in terms of analysing the determinants of the performance of tall buildings in engineering, procurement and construction (EPC) projects. Therefore, the purpose of this research was to analyse and rank critical EPC activities in large-scale residential construction projects in Iran, using the TOPSIS method as a multi-

attribute group decision-making technique. The results show that engineering design, project planning and controls are important factors that contribute to project performance. In addition, engineering plays a central role in the performance of the project and this importance is followed in the construction phase. On the contrary, everyone believes that procurement is more important than the construction phase (Kabiri Far et al., 2019).

Based on data from an industry survey, the model is validated. Path analysis shows that partnership not only directly contributes to interface management and risk management, thereby improving project outcomes, but also has a positive impact on risk management through enhanced interface management. The case study shows how partnership is closely related to interface management and risk management to achieve superior project performance and validates the evolutionary game analysis. The results show that the success of contractors in implementing partnerships can serve as an example for other contractors, and governments can create a favourable environment to stimulate partners using a win-win philosophy for better infrastructure development (Yang et al., 2019).

Motaghi et al (2021), investigated "the key success factors of sustainable project management in construction: ANP-SWARA approach". There are many factors affecting the success and failure of projects; however, the literature lacks a comprehensive classification of them, especially in construction. The purpose of their article was to identify the key success factors (CSF) of project management and categorize them into five criterion groups: (1) project, (2) project management, (3) organization, (4) external environment and (5) sustainability. . To determine the interdependence and weighting of CSFs, data were collected from 26 project managers from the construction industry. The contribution of this article is in identifying the cause and effect criteria of CSFs and in identifying their weights. Using the fuzzy SWARA method, it is shown that the organization, external environment and sustainability are the "cause" criteria, while project management and the project are identified as the "effect". The Fuzzy Analytical Network Process (Fuzzy ANP) is

used to measure the sub-criteria considering the interdependence of the main criteria. The findings showed that the highest weights are assigned to top management and sponsor support, stakeholder expectations, and restrictions imposed by end users, respectively. Project managers can significantly improve project success by focusing on the most important success factors instead of paying equal attention to all of them (Motaghi et al., 1400).

Keshafi and Shariat-Madar (2022) investigated "delays in EPC projects using the TOPSIS method and providing a solution (case study: Mashhad Water and Wastewater Company and Khorasan Razavi Regional Water)". One of the main indicators in evaluating the success of projects is their completion on time or their implementation without delay. Failure to complete the projects in the planned time also increases the cost and reduces the quality of the projects, so it is very important to identify the issues and problems that cause delays in the implementation of the projects.

In this research, the reasons for the delay of the EPC projects of Mashhad Water and Sewerage Company and Khorasan Razavi Regional Water were identified using the TOPSIS method, and solutions were provided to reduce the delay in the above projects. In terms of the type of research method, this research is descriptive-analytical and in terms of data collection, it is part of survey research, and the required information has been collected through a questionnaire and analyzed by the TOPSIS method. Finally, the ranking of critical factors of delay origins in three departments of engineering, equipment and construction was presented. Not paying attention to the unknown factors of the project (project risks), delay in payment of the status statement by the employer, and lack of experienced and expert manpower are the most important reasons for delays in the engineering department. In the equipping sector, exchange rate fluctuations, economic sanctions and non-response to contractors' inquiries and imposing high prices, delays in clearance and transportation of equipment were seen as the most critical sources of

delays in the equipping sector. In the construction sector, sanctions, delays in approving status reports and meeting minutes, and unwillingness of consultants and supervisory personnel to complete the project due to financial reasons have been identified as the most important factors of delay. In the end, solutions are presented to prevent or reduce the sources of delay (Keshafi and Shariat-Madar, 2022).

## **2.2 Project Life Cycle**

This chapter focuses on the life cycle of the project body and how the whole life cycle is divided into parts.

### **2.2.1 Defining the Project Life Cycle**

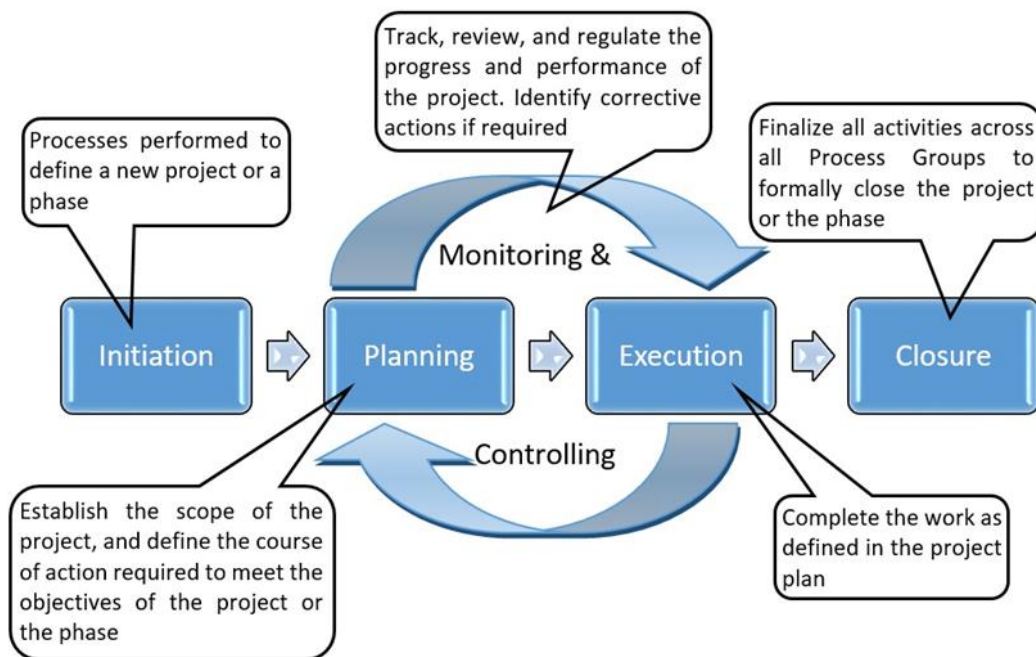
A project life cycle is the sequence of phases that a project goes through from its initiation to its closure. The management of the project, in addition to other criteria such as the project's scope, application, and the organization's requirement to be involved, defines the number and arrangement of procedures. The stages are time-constrained and have a distinct start, middle, and end. The project lifecycle may be tailored to the specific requirements and characteristics of the company. While each project has a clear beginning and finish, each project's specific goals, deliverables, and activities are quite different.

The lifecycle provides the necessary foundation of the actions that have to be performed in the project, irrespective of the specific work involved” (Invensis Inc, 2020). Project life cycles can be either adaptive or change-driven, or predictive or plan-driven. The specifics are established at the beginning of a project with a predictable life cycle, and any variations in the scope are carefully considered in an adaptive life cycle, the product is developed over multiple iterations and detailed scope is defined for iteration only as the repetition begins”. (Invensis Inc, 2020)

### 2.2.2 Characteristics of the Project Life Cycle

The standard project management frameworks consist of the same generic lifecycle structure, including the following phases (see Figure 3):

1. The initiation phase: Start of the project
2. The planning phase: Organizing and preparing
3. The execution phase: carrying out the project
4. The monitoring phase: setting up controls and monitoring
5. The closure phase: close the project



**Figure 3.** Project lifecycle structure (<https://theintactone.com/2019>)

### 2.2.3 Initiation Phase

The initiation phase of a project involves setting goals, establishing scope, and establishing responsibilities. The project manager and stakeholders are responsible

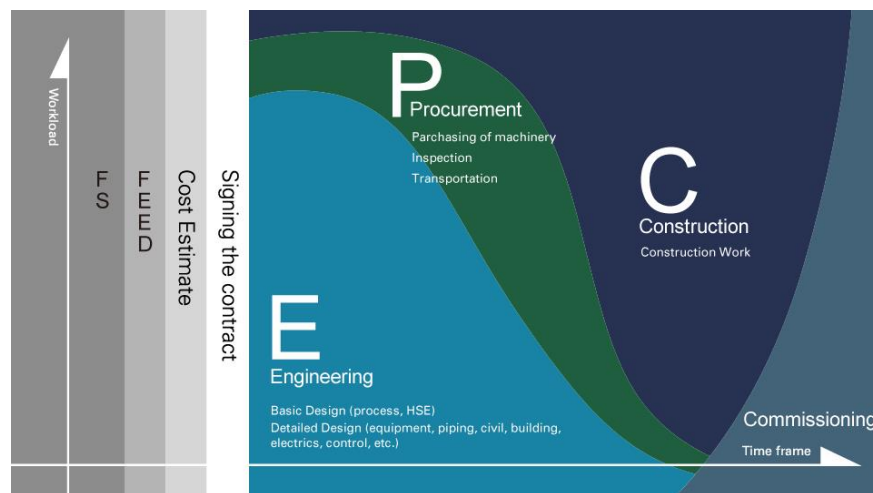
for selecting a consulting team for a feasibility study focusing on economic aspects.

#### **2.2.4 Planning Phase: Feasibility Study, Engineering Design and Procurement**

After the initiation phase, the project's goals and scope are established, along with the project manager and the main stakeholders' responsibilities. In this phase, it is essential to select the consulting team that will conduct the Feasibility Study by focusing on economic considerations. (See Figure 4)

The Feasibility Studies are followed by the FEED (Front End Engineering Design), a critical engineering phase that determines the main inputs for purchasing and procurement. According to El-Reedy (2016, p. 11), "This phase of engineering is one of the most important and most dangerous stages of engineering since the success of the project as a whole depends on the engineering study in this phase." It is critical to emphasize the need of a highly experienced staff during this time once more.

The next phase is Engineering Design. During the Detailed Engineering Design phase, a complete set of construction drawings and specifications is created so that the contractor may carry out the material purchase, production, shipping, and equipment installation.



**Figure 4.** EPC project flowchart (wordpress.com/2018)

Procurement is a crucial phase in a project, involving detailed planning and precision execution of equipment, materials, and services. It is essential to maintain quality standards and prevent late-arriving shipments from impacting the start-up date. During this phase, vendors and contractors are selected, and purchasing strategies, contract nature, and procurement procedures are managed. Critical items to consider include supplier selection, order placement, expediting, traffic planning, material receipt, and documentation/administration. The project team must consider these aspects to ensure successful procurement.

The procurement phase involves communication between the engineering company and suppliers, starting with the public requisition. The Engineering team analyzes technical proposals from vendors, while the Purchasing team evaluates commercial proposals. Once approved and vendors are defined, purchase orders can be issued, allowing for the smooth flow of technical and commercial parts.



### **2.2.5 Execution Phase: Construction and Commissioning**

The execution phase of a project relies on the inputs from the engineering phases, including project design, quality procurement of equipment and materials, construction, and commissioning. This stage involves quality assurance, control, and close control of deliverable schedules. The construction phase is particularly crucial for worker safety, as work on construction sites poses risks due to the inherently dangerous environment. Therefore, measures regarding Health, Safety, Security, and Environment (HSSE) are of extreme importance to ensure the safety of workers during this stage.

The procurement phase results in the selection of suppliers and contractors, which opens the door for the execution phase. During the Execution stage, the construction and commissioning take place, and these phases, if accomplished, allow for the startup of the operations.

### **2.2.6 Monitoring the Schedule and Work at the Execution Phase**

During the construction phase, project managers frequently outsource responsibility for the phase's outcomes to the principal contractor. Nonetheless, project managers must be mindful that they are ultimately accountable for the effective execution of this phase, ensuring that facility construction, equipment, and system installation are correctly planned, implemented, and monitored. Pinkerton (2003) states, "Close monitoring should be the order of the day throughout the construction and installation period." This emphasizes the need for project managers to monitor activities and timelines to ensure that the Execution phase is completed effectively. All the parts, consultants, designers, contractors and owners must work together collaboratively, sharing the mission of quality and excellence.

El-Reedy (2016, 241) suggests that in a way to supervise the works, two options could be adopted by the project Owners.

The initial option would be to have their supervision team on site, while the second would be to select a consulting company that will do both the design and the supervision.

According to Sears (2015), the most challenging part of project management is quality assurance, which is made even more challenging by the use of sophisticated technology, which is prevalent in megaprojects. The complexity of quality assurance can be increased by factors more than only the complicated technology that is typically seen in large-scale projects, such as creative practices, competing interests from multiple stakeholders, and pressure to achieve deadlines and budgets. It is advised that all suppliers align with the targets and the requirements for the products and services they provide and that suppliers participate in these requirements as soon as possible, to maintain control over the quality and adherence to the schedule of the deliverables.

Sears (2015, 155) claims that the preparation of purchase orders needs to be coordinated with the project schedule, early deliveries may lead to disturbances in the storage area and even impact the cash flow of the project, while late deliveries have more obvious and worse impacts, jeopardizing the schedule of the overall project. Regular meetings between the project engineer and the expeditor at the site are essential for identifying any issue areas and aligning the current state of the deliverables, allowing for rapid action in the event of any possible delays and preventing project delays. This need for close work between team members and construction contractors is reinforced by Pinkerton (2013, 196) as a way of planning a realistic schedule for construction activities. Other aspects that impact the schedule of the deliverables need to be planned in the very early phases of the project. The early identification of any possible restrictions is critical for complying with the schedule of deliverables.

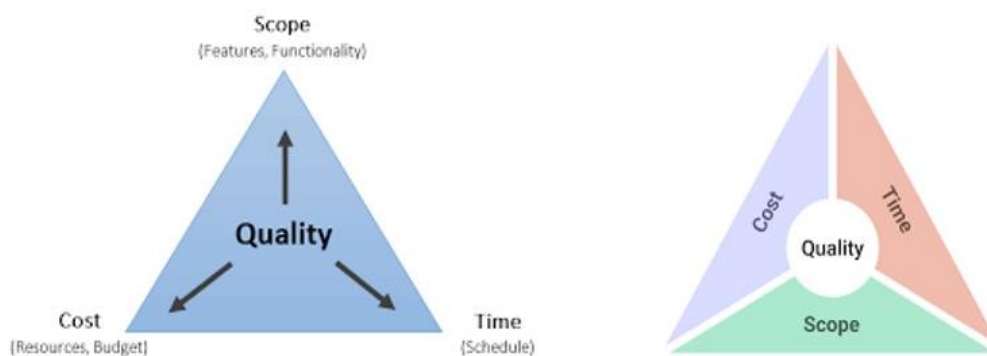
One important tool to be followed by the project manager is the progress report. The report allows the manager to have an overall view of the current status of the project in comparison to a baseline. "The progress monitoring concerns both the

technical phases and the economic trend. As regards the technical phases, the detailed monitoring concerns design, procurement, production, shipment, erection, startup and commissioning” (Tonchia, 2008, 183). The manager, being responsible for the data analysis, and knowing the targets of the project, will be able to activate warnings, when necessary, and propose and implement corrective solutions to identified deviations.

### 2.3 Project Success

The topic of project success, which has been widely discussed in the literature, shows that the basis of project success consists of three main objectives: Time, Cost, and Scope. The fundamental of project success is the ultimate objective of project management to achieve a perfect equilibrium between these three elements.

The Iron Triangle refers to the three key constraints that can affect a project: cost, scope and time (Figure 5). It is rare to change one without impacting the others or damaging the quality of the overall project.



**Figure 5.**Iron Triangle for project management (Harpreet Dhillon.medium.com 2018)

Verzuh (2008, 20) recommends setting realistic expectations about the Cost – Schedule - Quality equilibrium with the project's stakeholders to make sure every part involved has the same understanding of what represents the success of the project. According to Verzuh (2008, 19-20), “delivering a project on time, budget and quality does not always mean that the project is successful, because your definition of cost-schedule-quality equilibrium may not be the same as the client’s.”

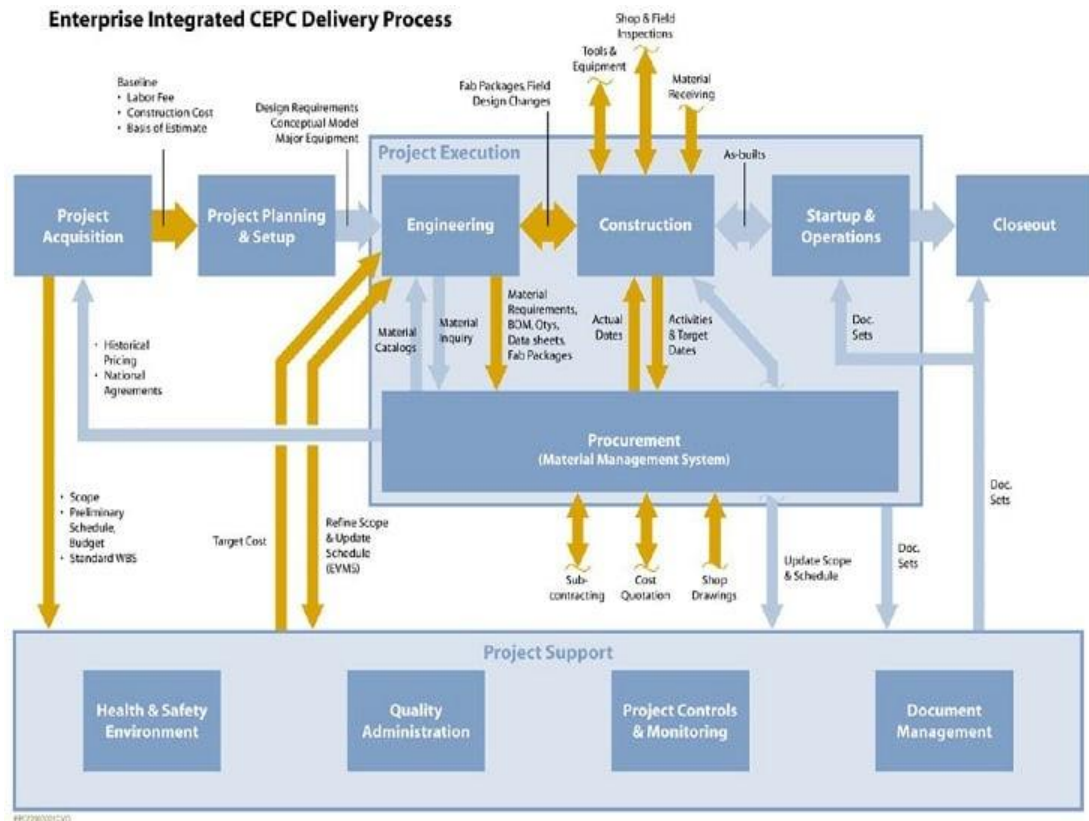
## **2.4 Project Gates**

Project Gates and Project Gate Reviews are both concepts that provide important communication opportunities between stakeholders as projects progress through project processes and application-specific elaboration steps. (See Figure 6)

During management-specific periods in the project life cycle, the project manager analyzes progress, changes since the last Gate Review, and the work plan between Gates. Gates should address scope modifications and risk, formal and informal, as well as new hazards and risk assessments. Gate reviews provide visibility into the project's progress, changes since the prior Gate, and the project manager's short-term strategy. Management can decide to proceed, delay, change, or cancel the project. The project manager can proceed, delay, alter, or cancel the project based on a successful Gate Review, which confirms the project's satisfactory work, risk control, scope address, sound plans, and organizational commitment to the project.

Stratton (2020) also states, “Project Gates are key points in a project where a formal review of the project’s current state is performed. Most often, they appear at the phase transitions of projects and represent a point in the project where the sponsor and stakeholders will incur increased risk, expense, and reward. When a project Gate is encountered, a Gate Review is held to determine if the project

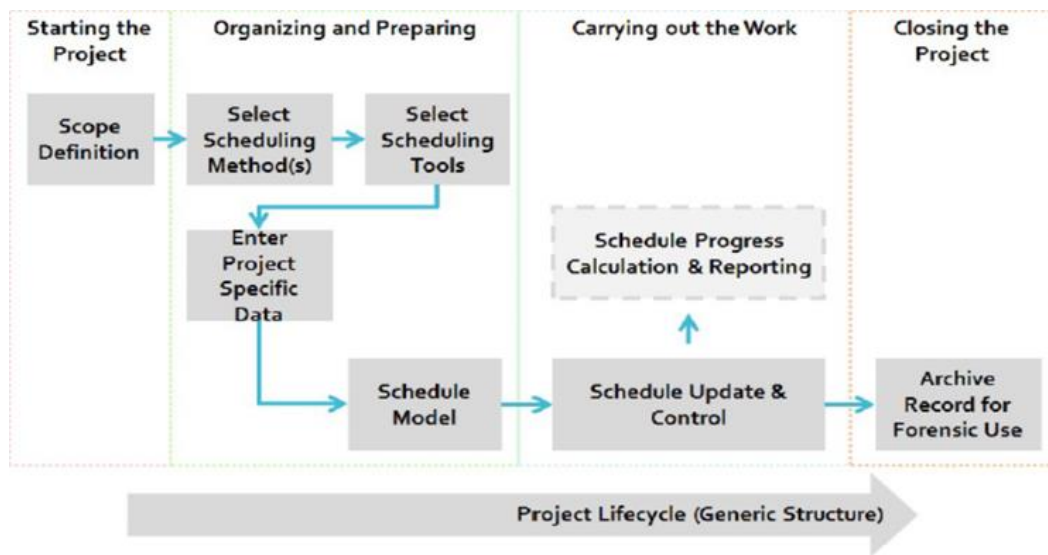
should proceed or not and under what conditions. Although the Gate Review may appear like a project status meeting, it is much more important”.



**Figure 6.** Iron Stage gate model Construction project, (S. Himmelstein, 2018)

## 2.5 Project Milestones

Project milestones are defined by PMI as follows: A milestone indicates the results the project will hopefully reach by some point in the future. It needs to outline the ideal future scenario and condition of affairs. This has two important components. Firstly, the idea is about a single moment in time rather than a duration of time. Secondly, it anticipates our desired outcomes rather than our methods of production. (See Figure7)



**Figure 7.** Project Milestone step-by-step

(VAMK\_IPM1005-3005 Project Control and Monitoring\_Aurangzeab Butt\_2023)

According to Andersen (2006), “many define a milestone as an event in a project, which is not a very sensible definition as it mixes two different things. A milestone should describe what we want to achieve; when we get there, that’s the event.

## 2.6 Delivery models

In this section we focus on two types of delivery models, EPC, and EPCM, EPC (engineering, procurement, and construction) is defined by Hartman (2003, 18) as an integrated service that offers all three of these commodities and services via a single business. According to Loots and Henchie (2007, 5), the EPCM (Engineering, Procurement, Construction and administration) contractor is typically in charge of contract administration, material and equipment procurement, basic and detailed engineering, and design. (See Figure 8)

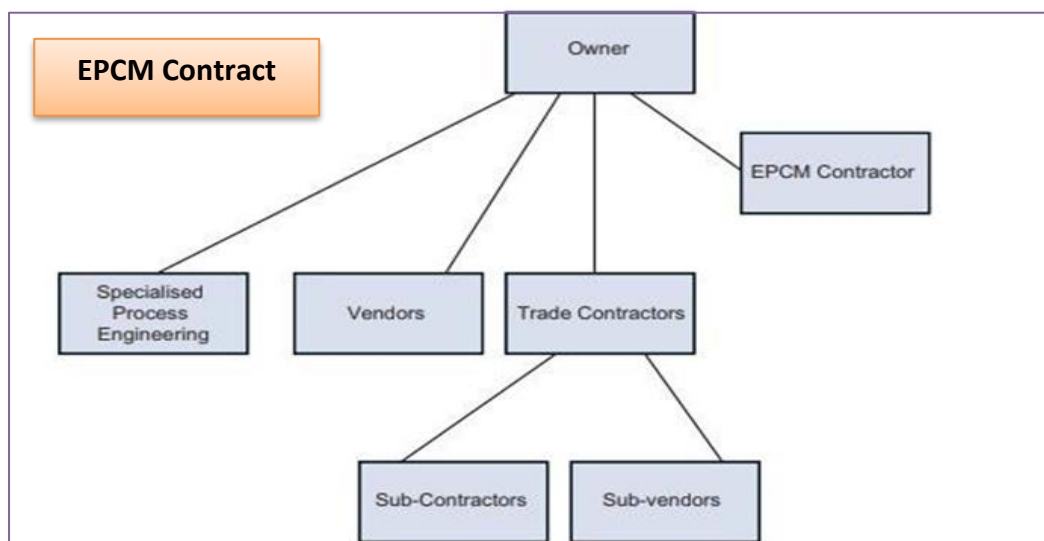


**Figure 8.**EPC (texvyn.wordpress.com, 2015)

According to Loots and Henchie (2007, 1), there has been a rise in the usage of EPCM contracts, which were formerly more prevalent in the mining industry but have lately become more popular in other construction projects including desalination, electricity, and petrochemical projects. The authors explain that in an EPCM type of contract, the contractor creates the design and supervises the construction process on behalf of the owner; the two forms differ significantly in terms of risk distribution and associated legal consequences. The Owner needs to have significant and knowledgeable internal staff capable of handling the range of contracts involved.

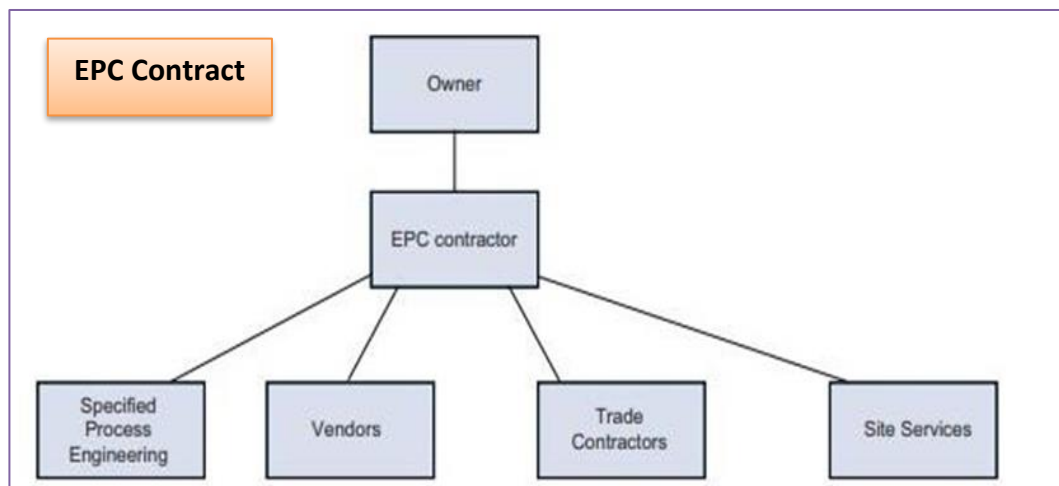
According to Sears et al (2015, 6) on the EPC project, "under the single contract system, the owner awards construction of the entire project to one prime contractor." In this instance, the contractor is fully responsible for completing the task, coordinating all subcontracts, and centralizing and assembling all of the various aspects of the building process. The authors also discuss multiple prime contracts, the EPCM arrangement, in which numerous independent contractors work on the project concurrently, working independently of one another and reporting directly to the Owner.

In an EPCM contract, the Owner supervises multiple agreements with a greater number of interfaces, while in an EPC contract, the Owner retains a single point of contact, the EPC contractor, who is responsible for managing all of the subcontracts. As a general rule of generality for contracting strategy, types of work with which the prime contractor is inexperienced or for which it is not properly equipped are usually subcontracted since qualified specialty contractors are generally able to perform their specialty faster and less expensively than the general contractor



**Figure 9.** EPCM contracts (Loots and Henchie 2007, 6)





**Figure 10.** EPC contracts (Loots and Henchie 2007, 6)

Figures 9 and 10 indicate that in the EPC project, the Owner maintains a single point of contact, which is the EPC contractor, and this contractor is in charge of managing all subcontracts, whereas in the EPCM format, the Owner manages multiple contracts, resulting in a wider variety of interfaces. According to Sears (2015, 8) strategy of contracting is “types of work with which the prime contractor is inexperienced or for which it is not properly equipped are usually subcontracted since qualified specialty contractors generally can perform their specialty faster and less expensively than the general contractor.” The advantages and disadvantages of EPC Projects are presented in Table 1 and Table 2 respectively.

**Table 1.** Advantages of EPC contracts

Item	Description
Turn-key solution	The contractor takes full responsibility for delivering the project, providing a one-stop solution for the developer and minimizing their involvement in the construction process.
Single-point of contact	The contractor acts as a single point of contact for the developer, which can simplify communication and coordination
Reduced project risk	The contractor assumes all the project risks including cost and schedule overruns.
Improved the project quality	The contractor is responsible for delivering the project to the agreed-upon specifications and standards

**Table 2.** Disadvantages of EPC contracts

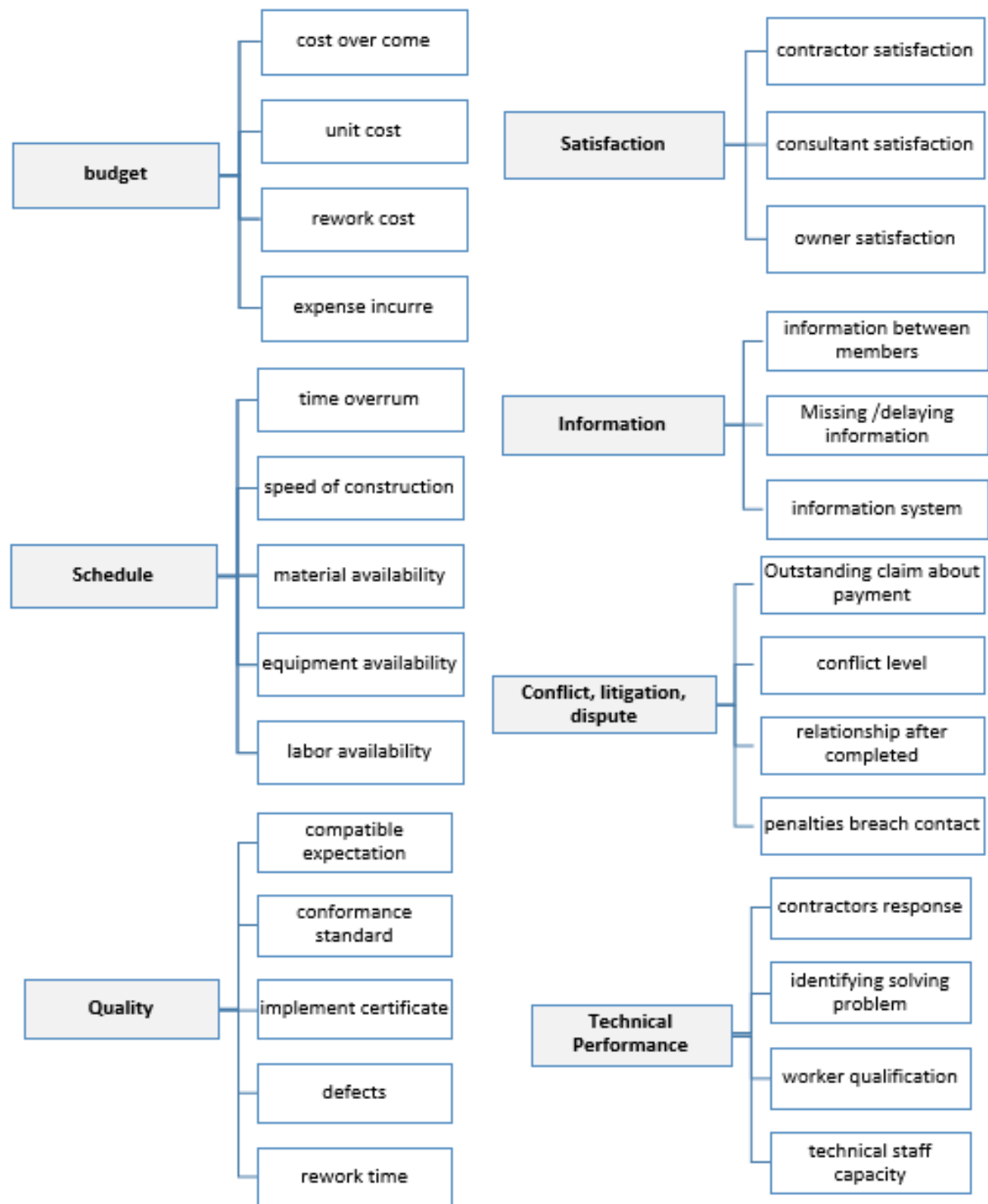
Item	Description
Limited control	The developer has limited control over the construction process, which can reduce their role to make changes if needed
Dependence on the contractor	The project's success is heavily dependent on the contractor's abilities and performance, which can pose significant risks to the developer.
Higher cost	EPC contracts are more expensive than other types of contracts since the contractor takes on more responsibility and risk

## 2.7 Summary of Literature Review

A construction project is a combination of various events and occurrences, whether planned or not, which is during the life cycle of the project and continues its life under many changes in its environment. In this, there are factors whose importance in a project's success or failure is double important. These factors are known as project success factors. They are defined as a group of environmental factors, facts, or influential factors that can influence the project's outputs. They can complete a project, speed it up or facing it with a problem, and they can cause the success or failure of the project, but they cannot be a basis for project evaluation (Assaf and Mohammed, 1995).

The definition of effective project delivery success remains unclear, but it is evident that project success differs from project management success, and stakeholder groups hold influence at different stages of the project life cycle. Comparing and ranking performance for any project type is crucial for success.

Undoubtedly, it will not be possible to achieve success in a project without controlling the factors that lead to failure. Extensive studies have been done in the field of project management and variables influencing the success or failure of projects, but a small amount of these studies indicate changes in performance during the project implementation phase. In this chapter, previous research in this field is reviewed and it was found that in the field of evaluation, there is an open research space for the multi-criteria factors affecting the success or failure of construction projects. The framework of project success according to the literature reviews shows in Figure 11.



**Figure 11.**Project success evaluation framework (Nguyen&Chovichien, 2013)

### **3 RESEARCH METHODOLOGY**

The case study methodology was selected for this study due to its nature of deep analysis of one single project. Even though there is extensive theoretical material available on the topic of project management, our case is focused specifically on the construction of a wastewater treatment plant and its success factors, making it a typical case study.

#### **3.1 Research Strategy**

Different research formats, such as quantitative vs. qualitative, conceptual vs. empirical, action vs. design, or case study, can be used for the type of research. This section describes the research methods for data collection and processing used to generate the outcome of this study. This thesis employs the qualitative approach (Case Study), presented in the next section.

##### **3.1.1 Case Research Methodology**

The case study is a type of research that focuses on a particular unit, being that unit a person, a community, a social group or a company. According to Kothari (2004, 113), “the case study is essentially an intense investigation of the particular unit in consideration.” Dul & Hak (2008, 4) point out two important main characteristics of this type of research. One is the fact that a case study is an inquiry of only one single instance (the case), or sometimes a small number of instances. The second is the context of real life, meaning that the object of study or its environment is not manipulated. Many authors consider case studies as a useful research strategy when the topic is broad and highly complex, when there is not a lot of theory available, and when “context” is very important.

The qualitative study was conducted by interviewing different stakeholders from different departments of the organization. Several professionals participated, in this way, a collection of the interviews was obtained, which could be analyzed more efficiently.

The interview questions are divided into two subject areas: interviewee background, and EPC project details. The project managers received a form-based data sheet for setting out the details required. The questionnaire was a data collection questionnaire for the project and was filled out during the interviews to obtain the information needed for the case study. It asked for some general project details, and then the planned and actual scope, cost and time. The various sections of this questionnaire are described below.

### **3.1.2 Evaluation Criteria for Reliability and Validity**

Reliability and validity are essential in qualitative research. Reliability means the results of the measurements are repeatable, and validity means the research method can measure what it is supposed to measure. Lincoln and Guba (1985) used the “trustworthiness” of a study as an approach to establish reliability in a qualitative study. Trustworthiness is obtained by credibility, authenticity, transferability, dependability, and confirmability in qualitative research. Whitmore, Chase, and Mandle (2001) summarise key features of validity to include:

1. Credibility (Are the results an accurate interpretation of the participants' meaning?)
2. Authenticity (Are different voices heard?)
3. Criticality (Is there a critical appraisal of all aspects of the research?)
4. Integrity (Are the investigators self-critical?)

In this thesis, interviewing different people in the organization and using different information sources generated an in-depth understanding of the study.

## **3.2 Research Setting**

### **3.2.1 Case study: Baharestan Wastewater Treatment Plant**

The case study project of this thesis is the Wastewater treatment plant of the City of Baharestan in Iran. The contractor, is one of the highest recognized EPC companies in Iran, is responsible for the construction of the WWTP, which is expected to be operational in January 2016, to treat the wastewater of this city and produce effluent under the environmental standards. The effluent from this treatment plant is dumped into the river and surface waters.

The City of Baharestan is located in the south of Isfahan city in Iran. The distance between this city and the center of the Isfahan province is about 15 km. This city rises about 1560 meters above the sea level. The length of the sewage transmission line is about 1.5 to 2 km, and currently, its final section with a circular section with a diameter of 900 mm and a slope of 0.0033 is being implemented and is being used. The Baharestan City's wastewater enters the entrance station of the sewage treatment plant at a depth of 3 to 4 meters through the transmission line. The receiving place of the agricultural canal is located in the north of the sewage treatment plant, and the water level in it is about 2 meters from the natural ground level.

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**Table 3.** Baharestan Wastewater Treatment Plant Area

<b>WWTP General Specification</b>
The location of the treatment plant: 5.6 kilometers east of Isfahan, Iran.
Area of the treatment plant: 70000 m <sup>2</sup>
Area of process structures: phase 1 and 2 = 43,460 m <sup>2</sup> ,
Area of different stages of development: 13,515 m <sup>2</sup>
The area of the side structures: 768 m <sup>2</sup> (400 m <sup>2</sup> of administrative building, operation and laboratory on two floors + 112 m <sup>2</sup> of guard building + 276 m <sup>2</sup> of storage and repair building + 180 m <sup>2</sup> of electrical substation)
Green space area: 40000 m <sup>2</sup>

In the aerial map (Figure 12), the general location of Baharstan city and the sewage treatment plant is shown.

Same as above





Figure 12. Baharestan wastewater treatment plant location (Google Maps)

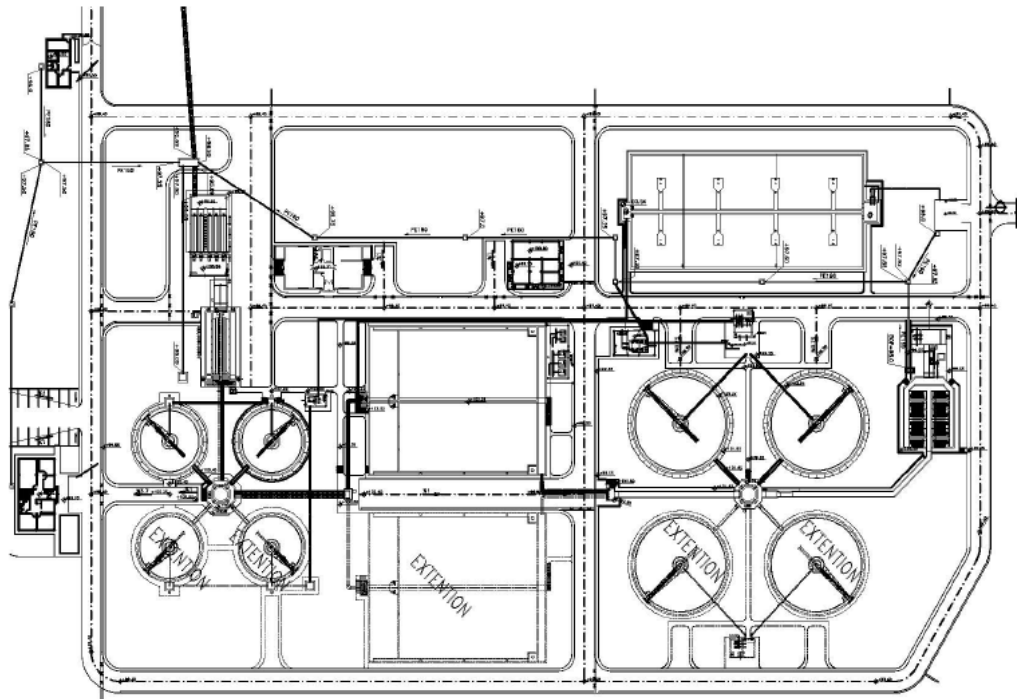


Figure 13. Baharestan wastewater treatment plant Layout (Contractor documents)

### 3.2.2 Wastewater Treatment Plant EPC Scope:

In this section, the Stakeholders and the contract details are shown in Table 4 below.

**Table 4.** Baharestan Wastewater Treatment Plant EPC contract details

Contract Details
Project: Baharestan Sewage Treatment Plant
Client: Baharestan Water & Wastewater Company
Consultant: Water & Wastewater Consulting Engineers
Contractor: Dezone Engineering Company
Scope of work: EPC
Capacity: 46656 m <sup>3</sup> /day
Location: Baharestan City
Type of treatment: MLE process
Duration:48 months

A summary of the work scope of this wastewater treatment plant and the basic process units is shown in Table 5. The operational volume of the work includes the engineering design, construction and equipment of all these process units, including mechanical, electrical and control, as well as the construction and equipment of all side buildings, office and worker's buildings, laboratory, store and workshop and layout construction were within the scope of this contract.

**Table 5.** Baharestan wastewater treatment plant scope of works

<b>Project Process Units</b>
Inlet Pumping Station
Screening
Grit Removal
Primary Sedimentation
Biological Reactor (Anoxic & Aerobic tanks with Diffused Aeration)
Final Sedimentation
Micro straining
UV Radiation
Chemical Preparation and Dosing
Sludge Thickening (Belt Thickener)
Sludge Dewatering (Centrifugal)
Raw, Return, Excess & Thickened Sludge Pump Station
Irrigation Pump Station

The vendor list for mechanical, electrical, and control manufacturers for this EPC project was specified by the project owner. All equipment must be of high quality and purchased from Western European manufacturers.

### **3.2.3 EPC Contractor**

The EPC Company, established in Iran in 1992, is one of the recognized companies specializing in process design, supply, construction and operation of water & wastewater treatment works. With the ability to execute turnkey projects on an international basis, they provides practical and optional answers to industrial, commercial and municipal applications.

Having a dedicated staff of motivated engineers, designers and technicians, makes Dezone successful that it is today. A closely knit professional team executes every project to enable quick decisions to be made at every stage of the project.

During these years the company has not only optimized the existing treatment processes but also developed innovations to lower costs and protect clients' investments.

### **3.3 Data Collection and Analysis**

In this study, the case project is intensively analyzed through a series of interviews with key stakeholders as a way of gathering relevant information on this specific case. The interview sessions were conducted with relevant industry practitioners such as consultants and contractors.

The main reason for conducting the interviews is to understand the actual practice of EPC projects in the sewage industry. The data collection involves 3 interviewees who hold at least senior management positions with direct hands-on experience on EPC projects in Iran. The interviewee's average working experience in the construction industry is around 22 years. Thus, their opinion and findings are considered representative, reliable, and valid for this study.

Open-ended questions were provided to the participants because it allowed the solicitation of actual information by encouraging the interviewees to express their issues or areas of concern freely. The main questions during the interview are presented in Appendix 1, follow-up questions relating to the subject matter were also provided during the discussion. After each interview session, the responses were summarized and returned to the interviewee for verification and approval to ensure reliability and validity. The interview process was conducted in the 4th quarter of 2023. In addition, the interview was conducted in Farsi, to ensure validity and translated to English.

Table 6 below provides an overview of the types of activities that the respondents completed:

**Table 6.** Summary of managers interviewed

	Title	Name	Activity	Date of interview
1	Management-CEO	A	Wastewater treatment Industry	22.11.2023
2	Project Manager	B		10.12.2023
3	Project Manager	C		18.12.2023

Table 6 illustrates that the group of participants is involved in engineering, and site management activities, which are more closely associated with technical fields and building. The CEO, project manager, procurement manager, and director made up the category that followed the management activities.

The documents presented in Table 7 are aimed at reviewing the project during implementation and the best practices used to confirm and provide written information about data collection, all of which are related to the elements of project success.

**Table 7.** List of internal documents related to the project

	Document	Description
1	Progress report	Report informing the status of the project regarding schedule and budget
2	Progress report for design phases	Document from the initial phase of the project, Process and calculation & description, hydraulic and mechanical design documents,
3	Progress report for construction phases	Execution phase document in line with the schedule, and design
4	Progress report for procurement phases	Lists and classified documents to purchase and install according to the schedule and financial sources
5	Lesson learned	Describing the main lesson learned from the project, including unexpected events as well as opportunities and their management

The majority of the data analysis was carried out in order to increase the project's chances of success, taking into account its unique infrastructural features, as well as its significant political and economic effects. Section 3 discusses the results of the data collection.

## **4 FINDINGS OF THE INTERVIEW**

In the previous chapter, the research objectives, questions and methodology were thoroughly discussed. Also, the two instruments that were used to obtain the required data were introduced and described. In that chapter, the ethical implications of this study were explained, too. This chapter showcases the findings from the case study investigated throughout the research.

All the data collected by research and interview, such as the value, efficiency, complication and impact are presented, as well as some information about the type of the project, the contract under which the target organization has undertaken the project and also the client's sector. In line with the purpose of the research, which is examining the main factors, in this chapter, the results from the quantitative and qualitative data collected from the case study are triangulated, and the correlation between the factors score is measured.

### **4.1 Findings from Interviews**

During the interviews, questions were delivered to each interviewee. The interview results do not go into specifics about each interviewee's responses. The analysis attempted to identify the most significant element from the discussion that is important for the study. There is a summary of all the answers from each interview for each of the questions. The identity of the participants is not revealed since it was determined that the interviews would not be authentic or successful unless they were done anonymously.

All interviewees have had a very comprehensive career in sewage treatment projects and other EPC projects and a total of 101 years of experience. All of the interviewees have experience in both site and office work. The mean number of years of experience for this study was 23 years, and the median was 22 years.

**Table 8.** Interviewees' work experience

#### 4.1.1 Interview A:

**Question2: Success project.** In your opinion, what is a successful project?

Project Manager A describes the current state of EPC projects in the country to clarify the meaning of a successful project.

*“In today's competitive predetermined environment, there is a lot of pressure to provide quick results in projects, and today, for the success of a project in achieving goals, multiple factors must be considered. The belief that projects are full of uncertainties such as technical skills or management quality, etc., reinforces the fact that many projects are doubtful in achieving their expected scope, benefits, cost, and time goals”.*

Each project must have a fully defined standard and nature of delivery that can measure its quality with certain indicators. Although the category of quality is vital in engineering sciences, one should not talk about quality in engineering matters.



*"In engineering, the words "good" and "bad", "first" or "greatest" have no meaning, these are indicators that can judge whether something is acceptable under a specific standard or not. The success of the project only means the timely delivery of deliverable items under the set budget. "*

This feature is one of the most controversial issues of the project. However, one should be aware of the stopping point of the project and its success or failure.

Construction projects are completed with the cooperation of various elements that often do not have a single legal personality. On the other hand, the construction activities in these projects are dependent on each other in terms of technical, qualitative, and economic aspects. As a result, in an EPC project, various activities are carried out by different legal entities, and the communication between the activities necessitates the proximity of the various elements as much as possible. Also, for the achievement of the quality goals of the projects in the specified time and with an appropriate cost considering the activities and the complexity of their relations, the definition of the regular structure requires that all connections between different activities be seen.

*" Considering the increase in the cost and time of construction projects in the country and taking into account the important role of external factors of the projects and the lack of obtaining the desired value for the consumed resources, this question is raised what do you expect from a successful EPC project? Were the demands and needs expected by the contractor and the employer are fulfilled and the equivalent values are obtained?"*

**Question 3: Success elements** In your opinion, what elements contributed to the project's success?

*“The first factor affecting the success or failure of construction projects is the clarity of the project's goals...”*

The goal of the project must be specific and clear. Objectives should clearly describe the characteristics of project outputs;

*“In such a way that if another manager fills the place of the current manager, he can easily understand the purpose of the work and continue it...”*

The goal must be realistic and achievable. Goals should be defined in the field of reality. Determining whether the goals are achievable or not depends on the conditions of the project implementers and the project implementation environment.

*“A goal that is achievable in one organization may be considered impossible in another organization...”*

*“The goal must be clearly defined as to how long it will take to reach the point in question; the specific delivery time is calculated to determine the time to achieve the goals based on the facts of the work, the environment and the ability of the organization. The organization must know the time and know how long it can be useful to do a job and after that, doing the job will not be of much benefit.”*

*“The second most effective factor in the success or failure of construction projects is the factor of realistic scheduling.”*

*“In a project, several activities are known during the planning time (before execution) that will be done in a definite and certain way, which are called definite activities. But there may be things that are required to be done. Be it or there may be no need to do them, such activities whose completion is not certain are called probabilistic activities. It is not and this time has a lot of deviation compared to the average limit of estimates. For example, during the rainy season and in rainy areas,*

*construction activities have a probabilistic time due to the rainfall or something like that."*

*"One of the important methods in planning is the CPM method, which deals with planning by drawing the network of activities and identifying the activities and the critical path (the path that has the longest time or the least navigation)."*

A network is a visual representation of the project's operations and their relationships. The network functions as a heart of network analysis methodologies. With the network at their disposal, the project manager, specialists, contractors, and project participants can objectively examine and amend their earlier assumptions about the project's activities and linkages. The relationships between project activities must be defined and determined before the network, which is an objective image of their relationships, can be defined and determined.

In a network, there is a critical path that includes the longest time, from the start to the end of the project. These critical events have the least buoyancy, meaning the difference between the earliest and latest date of occurrence is zero. The most time-consuming sequence of events and activities is the critical path. The critical path method focuses on the duration of time, relationships, dependencies, and the sequence of activities, with the earliest and latest being determined and specified. The main focus is on calculating floating times and allowing flexibility in execution time.

*"The third factor affecting the success or failure of construction projects is the appropriate and sufficient allocation of budget and resources to the project and cost control."*

*"Due to the country's special situation and financial and currency crises, it is not easy to provide the necessary capital for large projects, so choosing the appropriate financing method for projects is an important issue. Thinking of a strategy to*

*provide the financial resources needed by the project from the initial stages is to ensure the completion of the project. In choosing the appropriate method of financial provision in the feasibility stage of the project, one must consider all the issues and requests of different departments. In the project, including the industry related to the project, contractors, buyers, producers, the lending banks, and the issue of risks and in general, all the departments involved in the project, and then he chose the appropriate method according to the preference and importance of each of them."*

One of the most fundamental forms of cost control is earned value management, which allows managers to measure and evaluate the project's actual progress by looking at the total value of work completed, the amount of time invested, and the associated expenses. This method helps to compare the initial plan and the actual progress of the project's productivity. By preparing a picture of the project situation and calculating the amount of the obtained value, it is possible to compare the initial plan with the actual situation of doing things and get a clearer assessment of the progress of the project.

*"To keep the work breakdown structure's costs under control, we compile and calculate all of the necessary items (including materials and supplies, human labour, machines, tools, and equipment), as well as their pricing, at the lowest level of the work breakdown structure."*

*" The approved budget, in fact, the allowable cost for each of the components of the breakdown structure, after performing the above operations collectively, we will draw a cost chart during the life of the project, this chart shows the cost plan of the project".*

In other words, in this method, a budget is considered for the project, and then its costs are controlled. Or the budget is divided into weeks, months or years and

each time the actual cost is compared to the budget. In this way, the budget curve is obtained.

*“The fourth factor influencing the success of a construction project is the definition and use of specialized human resources. “*

*“Increasing the effectiveness and efficiency of projects and making them productive in the group is increasing the effectiveness and efficiency of human capital, and increasing the efficiency of human resources in the group is training and developing knowledge and skills and creating desirable behaviors for them. The cup of successful activities transferred to individuals in projects.”*

*“The fifth factor influencing the success or failure of construction projects is Experience from past projects. “*

The most important activities in projects that can get the best help from previous experiences and documents and accelerate some of the activities in the fastest time and least cost are:

*“the production of engineering documents in the form of copies of engineering vector; producing documents and general procedures of project management and adapting it to the project's requirements; Production of documents related to purchase to accelerate purchase activities; Using the actual schedule of the previous project, which will be much more realistic in the preparation of the new program.”*

#### **4.1.2 Interview B:**

**Question 2: Success project** in your opinion, what is a successful project?

One of the factors of economic growth and development of any society is the success of its construction projects. The most important responsibility and goal of

every project manager is to execute on time according to the budget and taking into account the planned performance.

*“The success of the projects depends on the correct timing of the goals, access to financial plans and proper control to reach the appropriate quality.”*

Achieving the goal of the project and the mission of the project, the performance according to the three key parameters of the project,

*“ time, cost, quality of execution and final delivery of the project and the satisfaction of all the stakeholders of the project team, contractor, investor and employer.”*

**Question 3: Success elements** In your opinion, what elements contributed to the project's success?

There are many influential factors in the success of a construction project, these factors can include: proper planning, timely payment by the employer and timely financing according to the initial schedule for the purchase and supply of equipment, realistic contract period from the employer, financial ability The contractor, the reasonable and real price proposal by the contractor, the estimation of the changes and additions, the quality of the materials and supplies, the fluctuation of the price of the supplies, the problems of providing the supplies at the official price, the frequent breakdown of the device and equipment. And its lack of spare parts, and atmospheric issues be in the region and be limited by the working season.

*“The success of management factors in construction projects management team of employer, consultant and employer”*

One of the main factors of successful project implementation is the project team. The selection of team members should be done in such a way that the team has

all the necessary skills and in other words is balanced. Employing inappropriate people to complete a project or ignoring people's duties can have serious consequences. The idea of setting the interest and ability of the team members for the work they are assigned to will increase motivation and job satisfaction, and as a result, improve the processes and team efficiency and increase the probability of team success. For this purpose, you should use practical strategies to evaluate, form, develop and decorate the project team evaluate its strengths and weaknesses and form a balanced team with appropriate tools

*“Human resource management”* is one of the most expensive centers of the project, which in case of lack of proper management will put a lot of financial burden on the project or cause the project time to be prolonged.

*“It is necessary to use new management tools such as MSP in other projects and also create a team of consultants for human resource management at the beginning of the project, by forming a team of senior people and the expert, the development of this team and the proper management of the project team in We will manage and complete the project accurately with the use of sufficient forces and training, to witness the success of the project in the end.”*

*“Procurement has a great role in the success or failure of the project,*

It can be planned, managed, supervised and completed by using new procurement tools and application software, as well as using experts and people with experience and efficiency.

*“Guide and manage procurement and waste Avoiding side costs and possible costs due to the effects of procurement mismanagement, which sometimes puts a heavy financial burden on the shoulders of construction projects and causes dissatisfaction of the beneficiaries.”*

*"The communication of the project beneficiaries, as well as the design, procurement and implementation teams is the main and basic pillar in a construction project."*

At the beginning of the project, all the stakeholders of the project should be identified and evaluated, and for the communication of the project, basic training and programming should be considered, and by using management consultant teams to distribute information, and manage expectations. Accurate planning should be done with stakeholders and performance reports, the absence of this program Mistakes and disagreements, differences of opinion and management's lack of awareness during conflicts and internal conflicts can lead to disruption and failure of the project.

*"In Iran, projects are implemented under the influence of conditions such as the laws of the country, customs procedures, and extreme fluctuations in currency and international sanctions. It is these conditions that largely determine the success of a project delivery" ..... " the rules, regulations and inspections are contractually very challenging and make projects very difficult to implement...."*

*"Timely delivery of equipment for installation and commissioning at the site is a basic option in the procurement and implementation department."*

*"The installation phase is often the most time-consuming because if and when project goals are achieved, they will have the greatest impact."*

Our biggest challenge is planning. Planning, procurement planning, logistics planning or installation planning. Project delays lead to additional costs for support functions, which significantly reduce the contractor's profit. In the EPC project, the project manager is in charge of all disciplines and has the best ability to control the entire project meanwhile management only depends on the experience and background of the project manager.



At the time of embargo and the impossibility of supplying high-quality equipment from Western manufacturers, finding reliable manufacturers as an alternative will reduce the speed of implementation and delay the schedule....

Following the basic design, executive method, defined supplier and the purpose of the project alongside financial support, makes the success easy but Ignorance of the purpose of the projects can make the action difficult.

#### **4.1.3 Interview C:**

**Question 2: Success project** in your opinion, what is a successful project?

*“The success of a project can be divided into two main parts. The first part involves the success of the project management process and the satisfaction of stakeholders, including the contractor and employer. The second part involves the success of the project product, which encompasses the expectations, strategies, and forecasts of the employer during operation, as well as the profitability and contribution of the contractor to the project.”*

**Question 3: Success elements** In your opinion, what elements contributed to the project`s success?

In this case, like other interviewees, it was agreed that cooperation between the project team and stakeholders, cost and time control are the main influencing factors.

*“The use of powerful executive forces and contractors with high financial power and logistics ...”*

In addition to providing appropriate and timely financing from the employer, as well as the supervision and supervision of the contractor's performance. Dependence on how to implement projects in success Construction projects have problems.

*“The contractor must properly manage his financial resources and cash flow plan according to the employer's payments.”*

Lack of coordination with vendors and suppliers on the one hand and lack of proper forecasting of materials and other equipment needed on the other hand is a problem that will cause delays in the procurement of resources needed for the project and will bring problems to the project.

*“Under the terms of the Iran agreement, the amount of the agreement can change up to 25% compared to the initial amount of the agreement”*. In this case, the following issues are worthy of consideration:

With this amount of accepted changes, the weakness of studies, designs and estimates always remain silent.

Because the price offered by the contractor, which will often be the factor of his choice in the tenders, is a function of the amount of work, therefore, the change in the amount of work makes the prices offered by the contractor less valid. It is better to agree on the full possible effects of the changes between the employer and the contractor and direct costs (employees, equipment machinery and materials and materials), time-related costs (overhead, interest, inflation, etc.), increase in contract time and include other adjustments.

*“Incorrect estimation of projects in the Engineering and design phases, increase in costs, not taking into account the increase in costs due to inflation in the estimates, etc.,”*

Will lead to a lack of credits, and in addition to the problems of the employer's financial obligations, it will put pressure on the financial resources of the government and the progress of other projects.

The employer must be completely sure and aware of all the needs of his project in the initial planning stage and conduct complete research and investigation about the project and the foreseeable and expected conditions to minimize the changes in the later stages. Also, if changes are needed, they should be value-engineered. More care should be taken in the preparation of design documents and errors and defects in these documents should be reduced because they are a common reason for redesigning and preparing drawings and a lot of time may be spent on the necessary corrections.

*"Finding the perfect balance between cost and quality can be a challenge, but it's key to any successful project. Engineering is the biggest bottleneck. Delays or errors in engineering delay the entire project, so accurate engineering has a direct impact on reducing time and costs."*

*"One of the challenges facing the projects is finding skilled labour at a reasonable price that can meet the quality expectations of the project."*

The interviewee stated that

*"The project manager should be involved in the project before the contract is signed."*

*"It is crucial for the success of any project that the project team is involved at the right time. The project manager should be present during the contract negotiation stage to ensure that they have a clear understanding of the deal and its details"*

During the design and engineering stage, important stakeholders should be present at the negotiation table, and it is crucial to have the project manager by our side. This will ensure that the team has all the necessary information for the successful completion of the project.

The project manager and the project team will work together to ensure that all departments involved in the project receive the necessary information on time. Stakeholders will approve plans and an evaluation will be provided before final approval. In EPC projects, a project manager should be selected before the contract is closed. The engineering team will assist the executive team in defining deliverables, interfaces, and critical points, as well as identifying risks and other issues that may arise during project execution.

#### **4.2 The Main Factors Affecting the Success of EPC Projects Based on Interviews**

To complete the extraction of the success factors of an EPC project from the literature review, other variables from the project managers' interview results were added to the primary variables, and these indicators were placed in three general groups including factors related to ideation, planning, design and construction. To complete the research steps, each of these variables was coded, which is shown in Table 9.

**Interview A, B, C:****Table 9.** The main related factors from Interviews

Category	Details	A	B	C
<b>Engineering and design</b>	Skilled and qualified human resources	√	√	√
	collaboration between the contractor (design consultant) and the stakeholders	√	√	√
	Project procedure	√	-	√
	Equipment and BOM	-	√	√
	Design accuracy	√	√	√
<b>Procurement</b>	International sanctions	√	√	√
	Fluctuation of Currency	√	√	√
	Defined the real BOM	-	√	√
	Financial stability	√	-	√
<b>construction</b>	Human resources	√	√	√
	Planning ( 1,2,3)	√	√	√
	Budget	√	√	√
	Site conditions and site management	√	-	√

**4.3 Factors That Have the Greatest Effect on Project Time**

Budget or schedule overruns can be caused by a variety of factors, including politics, economics, financial issues, labor market changes, inaccurate cost, time, and risk assessments, poor communication among project disciplines, disputes, and delays, as well as unresolved regulatory and permitting issues.

Costs and benefits do not necessarily occur concurrently; rather, they occur at distinct periods in a project's life cycle. In most circumstances, the lifetime aggregate of all costs and benefits, adjusted for time of occurrence, is used to assess success when compared to other projects. (Table 10)

**Table 10.** The main related factors on the time

<b>Factors that have the greatest effect on project time</b>	
1	Timely response and collaboration of the employer's engineering unit to the required changes regarding the plans and documents of the project
2	The impact of government programs and laws on supply sector activities (e.g. preventing the importation of a specific product required by the project)
3	Collection of the contractor's claims by the employer according to the schedule
4	Inaccuracies and mistakes in the design (cases such as mistakes in declaring the size, type and materials of the items included in the map, etc.)
5	Follow-up of issues and solving problems (inside and outside the organization) by the project managers of the employer
6	Defined list of suppliers and materials (Vendor List) by the employer and requiring the supply of materials and materials from them
7	Customs clearance problems and prolonged clearance process
8	Planning and using appropriate project control methods
9	detailed work procedure for the employer and coordination between the employer and the contractor (design consultant)

#### 4.4 Factors That Have the Greatest Effect on Project Cost

From a practical perspective, there are an immense number of reasons why budget and cost overruns may occur; some of these reasons are under the organization's control like coordination and cooperation between the engineering department of the contractor and consultant, unrealistic prices at tender phase, while others are not, such as the high exchange rate and sanctions, Un-predictability of inflation rates and material prices. According to the interviews, some of the key reasons include (Table 11).

**Table 11.** The main related factors from Interviews

<b>Types of factors affecting project cost in order of importance</b>	
1	Late response of the engineering department of the contractor (consultant) to the required changes in the plans and... during the project implementation (lack of necessary coordination and cooperation of the engineering department with the implementation department)
2	Sanctions and its effect on the total cost of the project due to the high exchange rate
3	Providing an unrealistic (low) price at the time of the tender by the contractor, only to win the tender
4	Delay in following up on issues and solving problems (inside and outside the organization) by the project managers of the employer
5	Delayed response of the client's engineering department to the required changes regarding the plans and documents of the project
6	Investing professional foreign contractors in the field of EPC projects due to the lack of economic stability in Iran
7	The unpredictability of the inflation rate and the increase in the price of materials and materials compared to the time of providing the price and estimating the project costs

8	Failure to determine the exact amount of required goods or items missing from the list provided by the engineering department for the procurement department of the project
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#### **4.5 Factors That Have the Greatest Effect on Project Quality**

Quality management has a significant role in the success or failure of the project, quality is one of the main vertices of the success triangle. By creating a quality working group in the planning project, quality assurance and quality control should be pursued seriously because a low-quality project leads to the dissatisfaction of the beneficiaries (Table 12).



**Table 12.** The main related factors from Interviews

<b>Types of factors affecting project quality</b>	
1	Expert and experienced forces in the contractor's engineering, execution, procurement and commercial team
2	Sufficient financial resources as well as spending the project budget according to the breakdown of the project by the contractor
3	The performance and focus of the employer's managers and experts on the project implementation process
4	Procurement of materials and materials needed for the project based on the list prepared by the engineer (such as: procurement in sufficient quantity and in accordance with the BOM)
5	Supplying materials and materials with the right quality
6	Follow up issues and solve problems (inside and outside the organization) by the project managers of the employer
7	Limiting the list of suppliers of materials and materials (Vendor List)

## 5 CONCLUSIONS

### 5.1 Theoretical contribution

RQ1: What are the critical factors in the success of EPC projects?

The general definitions of success according to the responses of the project managers' interviews and literature reviews include delivering on time and budget and high quality and meeting the actual needs of stakeholders (Verzuh 2008). This has been discussed in the theoretical part (Chapter 2), and the same finding came up in the empirical study in Section 4.1.1).

Organizations defined project success as a variant of the three restrictions. Over time, it has become the de facto way for defining and measuring project success: some place more emphasis or value on one factor than another or a combination of these factors. In practice, there is no generally recognized criterion for measuring project success; nonetheless, most are based on one or more of the three constraints (Kabirifar et al., 2019) and as discussed in Chapter 2.

RQ2: What is the effect of project implementation factors on the success of wastewater treatment plant contracts using the EPC method?

The management of today's major projects is a complex task, resulting from technical issues and, more importantly, managing a project's soft aspects, such as interpersonal communication, team building, alignments, stakeholder management, trust building, and conflict resolution (Monteiro, M. et al., 2015).

Project success and failure depend upon the project manager's role and team leading, for a project leader success would be meeting cost and time with a strategy that meets the stakeholder's criteria. This happens if the project management

has the knowledge, skills, tools, and techniques to meet project requirements. (see Section 4.4).

While relevant technology, organization structure or processes differ from one project to the other, the management of such projects has several common features with the management of similar types of projects in other industries, because shared management principles do exist. (See Section 4.1.1).

As mentioned before, procurement plays a major role in the success or failure of construction projects, which can be done with the use of new procurement tools and application software, as well as the use of experts and people with experience in the program. The Manage the planning, supervision and finalization should be managed to of procurement and prevent the wastage of side and possible costs due to the effects of mismanagement of procurement, which sometimes puts a heavy financial burden on the shoulders of construction projects and causes dissatisfaction of the stakeholders. (See Section 4.1.3)

Communication is the main and basic pillar in a project, at the beginning of the project, all the stakeholders of the project should be identified and evaluated, and for the communication of the project, basic training and programming should be considered and with the use of consultant teams—management for information distribution, management of stakeholder expectations and reports (Interview B). Accurate planning should be carried out. (See Section 4.1.2)

Human resource management is one of the most expensive aspects of the project, which, if not properly managed, will put a lot of financial burden on the project or cause the project time to be prolonged. It is necessary to use new management tools such as MSP and investigate other projects and also create a team of consultants for human resource management at the beginning of the project, by forming a team of senior people and the expert. The development of the team and the proper management of the project team will manage and complete the project

accurately with the use of sufficient forces and training, to witness the success of the project in the end.

## **5.2 Managerial Contribution**

Based on the results obtained and the identification and prioritization of factors affecting the success of EPC projects, a proposed implementation framework for future projects can be formulated. In addition, project managers play a crucial role at various levels, and upon appointment, they should present their project management plan and execution methods. They should also focus on increasing project management knowledge and training in project teams, providing accurate and thorough project rates and costs, and utilizing project records for better storage of project experiences.

## **5.3 Limitation and Future Research**

It is suggested that the identification and prioritization of external factors affecting the success of construction projects, such as sanctions and economic opportunities, the increase in the exchange rate, the performance of supervisory institutions, and political issues, should be done in independent research.

The method of gathering experts' opinions through interviews, due to the large amount of work of experts and respondents and the impossibility of direct interviews, has made this research difficult in terms of time.

For future research, it is suggested to use new methods of data collection, such as providing survey forms on the organization's website and comparing the results obtained with the research.

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**Appendix 1:**

Interview questions in English

**1. General Questionnaire for the Key Stakeholders of Wastewater Treatment Plant Project**

1. Name -
2. Title of work position in this project –
3. Academic Formation –
4. Company -
5. Working area (geographically: office, site etc...) or An approximate number of projects,
6. Years of experience (Occupation and work experience in years?)
7. Main activities related to the project –
8. Have you worked with similar projects before? For instance, big infrastructure projects, and EPC companies?
9. In your opinion, what is a successful project?
10. In your opinion, what elements contributed to the project`s success?
  - 10.1 What would be the main challenges and how they were dealt with?
  - 10.2 In comparison with past experiences, what were the main positive factors in this project?
11. How would you describe your relationship with the wastewater industry: contractor, consultant and client?
12. How was the communication? Meetings, document flow... What were the positive aspects and what were the opportunities for improvement in the communication system?
13. Is there something that you would improve for the next projects?
14. Were there unexpected events during the life cycle of the project?
15. How was the relationship with other stakeholders in general?
16. Any comments on the project?