Quality Assurance of Construction Design and Contractual Phases in Syria Within BIM Environment: A Case study

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Abstract

Globally, the Quality Management System Research in the construction sector has not received sufficient attention compared to the industrial sector. The modern construction industry is known as complex due to magnitude of the projects on one hand, and the diversity of the works included in the project, on the other hand. The establishment of projects is no longer limited to the implementation of a few types of work or activities in the project. However, it is increasing in response to the overall technical and urban development of life, and to the increasing requirements of the beneficiaries of these projects. Projects nowadays are integrated and complex systems of different works and contracts, which are connected with each other to perform the overall function of the project, which, in return, has evolved as well as its qualitative content. This research aims to improve the quality of design, and contracting phase of the State Company for Engineering Studies in Damascus's projects, by examining the current reality of practices and methods in quality management during the designing stages and pointing out its weaknesses. Determining the factors affecting the quality of the contractual phase of the company, through a survey published online. Twenty-two engineers working in the company have responded. It was estimated that the company's realities and the extent to which the employees understood the importance of quality. Through this research, a system of procedures was proposed to ensure the quality of design and contractual phases with ISO 9001: 2015 Integrate it with building information modelling technology that addresses or overcomes current problems. Using BIM provides an effective means to increase the overall quality of the company's projects.

Keywords: Quality Management, Quality assurance; Design Phase; Contract Phase; Building Information Modelling (BIM); The General Company for Engineering Studies (GCES)

1. Introduction

The construction industry is one of the oldest industries known to mankind and has flourished in decades of history and has achieved advanced degrees of excellence in its products and methods of implementation of these products. Ancient monuments such as the pyramids of Egypt, ancient Roman theatres, the Great Wall of China and others are also testament to the grandeur and prosperity of this industry in the past. Their products have been and continue to reflect the extent of civilization and sophistication. This is confirmed by the

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great diversity of their modern cultural achievements within which people live, walk, work, and affect the social, political and economic life of man [1].

The construction industry is a service industry, although it consumes about 10% of the national income results and 50% of the total funds invested in industry projects annually through the contracting of varying size and value, underscoring the importance of the construction industry in human life and in the national economy of various countries [1].

The Construction sector in Syria is adversely far beyond other industries in terms of economic growth rate and technological advancements, in what makes AEC projects less committed to schedule, cost, and quality [2].

The engineering project is undergoing two critical phases. The first is the preparation phase, which includes studies, design and contracting, and the second is the implementation phase. These two phases constitute the main pillars of an engineering project. They may be a reason for its success or cause for its failure or failure. The success of the second phase depends, to a large extent, on the success of the first phase because it is the first step to initiate the project. The first phase of project preparation, consisting of studies, planning, design, contracting and the resulting documents, is the beginning and the basis for a successful engineering, economic and operational project if it is better invested [3]

This confirms that achieving quality in this industry has economic repercussions that reduce production costs by eliminating costs of correcting defects and errors and costs of reinstating certain rejected work, achieving user satisfaction and satisfaction and reducing maintenance costs during the period of uses business, increasing its share of the labor market and allowing it to compete and sustain [4].

The adoption of Building Information Modelling (BIM) has increased significantly over the last few years [5], however, the adoption level of BIM remains much lower than expected [6]. Due to not only solving the massive problems with AEC industry projects and reaping the benefits from implementing BIM but also improving the project's performance and efficiency [7]. Also, BIM helps in conducting building life cycle assessment [8]. However, most workers in the construction sector are unaware of the importance of BIM system and do not have the knowledge and skill to apply it at present. Although it is implemented by some consulting offices [9].

In spite of, the government and clients playing a vital role in the mandate of BIM, the mixed approach (top-down and bottom-up) is recommended to expedite BIM implementation [10]. The work of BIM Champions ("change leaders") in each location is to evaluate the implementation of BIM and control the direction of its development, as in the UK where their strategy has included it as part of its Plan of Work. These Champions have proven to be a key element in measuring and assessing needs to enable the achievement of technology adoption [11]. A six-step methodology to implement BIM namely; raising awareness; perceived benefits; AEC industry readiness, and organizations' capability; identifying the barriers; removing the barriers; and defining the key factors influencing the implementation [12]. In addition to have a great potential to solve problems between disciplines, it has become a crucial technology in modern times, with its influence extending to almost all disciplines [13].

The most significant barriers against BIM adoption as Lack of expertise, Lack of standardization, and protocols to mention but a few. And, most influential drivers from both adopters and non-adopters as the Availability of trained professionals to handle the tools, Proof of cost savings by its adoption, BIM Software affordability, and awareness of the technology among the industry stakeholders [14].

Companies could improve their BIM performance by using the BIM maturity matrix (BIM3) through three stag 1) Identifying BIM and its performance, 2) Performance measurement, 3) Performance improvement [15]. Deterred the implementation of BIM were personal correlated issues such as resistance to change and lack of appropriate awareness of BIM [16].

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BIM can be applied to several topics. Using BIM with partnering agreements improves stakeholder behaviour in Construction Mega-Projects. enhancing stakeholder relationships reduces disputes, eliminates conflict of interest, and allows sharing of knowledge, healthy interaction between project stakeholders, and improving problem-solving techniques [17], All this leads to an improvement in the quality of the studied stages.

To conduct risk management considering BIM technology, the management system should review the conventional risk assessment procedures, and developed criteria must be introduced and become an everyday practice of all construction projects [18]. Furthermore, BIM can be applied in the transportation industry for instance, a real way construction projects [19].

Currently, the Syrian AEC industry is witnessing the transformation from CAD to BIM so it must be encouraged by the government and other related firms and individual expertise to spread it as much as possible in order to keep up with the ever-evolving world of technology [20].

BIM&SM synergy and proposed IE Workflow strategy during the planning phase in MCPs. However, information exchange (IE) needs to be planned from the beginning of the process, agreed upon between different parties, tested, and verified [21].

Syrian educational Institutes are taking a huge amount of time to implement digital transformation. All that is due to the lack of engineering and technological knowledge and experience that is influencing the AEC sector in Syria, where most engineers didn't experience working in new-technology-and-methodology-based projects [22]. Accordingly, the Syrian educational bodies need to allocate more time and effort to qualify engineers and help them keep up with the latest technologies [23].

Al Hammoud and Ahmed (2022) develop a new plan which is expected to prepare a new generation of architects who are High-tech qualified and fully aware of BIM and its general ideas, which makes it easier for these architects to emerge within the job market and fulfill AEC firms' requirements [24]. Of course, this would also help to promote the quality of AEC phases.

1.1. Quality management in construction projects

The concept of quality in construction can be essentially linked to the following main aspects and concepts: Function is origin performing its purpose. Economic: Is origin a value for money? Age: Is the origin durable and sustainable with time? Aesthetic: Is the origin satisfied with the appearance and fits with the facilities around it? Depreciation and economic strength: Is origin a good investment?
In construction projects, they begin to determine their requirements from the employer and translate the work in the initial planning phase of the project from a basic idea into design principles, costing and determining the scope of the project. These principles are then developed into designs, specifications and quantitative tables at the design preparation stage for adoption at the implementation stage. If quality assurance in the implementation phase depends primarily on workers' skill, time and cost, considerations compete with quality very influentially in the planning stages of the design in conflict towards the highest investment value. Then the consultant and owner accept certain specifications in exchange for an acceptable cost and the appropriate duration of its implementation. This clearly explains that the project parties' personal perspectives, making it more difficult to measure, influence quality in the construction sector [25].
Therefore, in the last decade of the last century, there have been releases of the World Organization for Standardization. ISO 9001 International Quality Management System Standard. ISO certification is an important requirement in construction and ISO companies. ISO standards have been developed to determine which quality systems should apply to industrial, service and engineering sectors. Global models, patterns and metrics are developed to improve the efficiency of the production process and reduce costs [25].

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1.2. Quality Management in Building Information Modelling Technology

In the process of modelling information building, monitoring, reviewing and controlling data for the construction information model, the processes and activities associated with this model are essential to ensure that the best practices of the model construction process are followed from the start of the project and during its development until the end of the project to become a usable product [26].
Therefore, the quality of the model must be reviewed and checked before it is received to any project party during the stages of development of the project. This is to ensure optimal data exchange between the project team, which requires all beneficiaries to perform the necessary quality measurement tests before delivering the BIM forms or any content associated with the project from the team. Each section or specialization should be prepared if it requires proof of their review of the BIM model, and approved in accordance with the BIM guidelines [26].

1.3. Quality in design phase

Design quality is defined as the ability to provide the construction contractor with all the necessary information for construction of origin as required, efficiently and without hindrance. There is a general understanding of the construction industry that design quality has increased significantly over the past 15 or 20 years [27]. It is the design team that provides planning, written representation that allows major, secondary contractors transform ideas, concepts into physical realities, the effectiveness and efficiency of such conversion depend mainly on the quality of design and contract documents [28].

Quality at the design stage has a significant impact on the full performance and efficiency of construction projects. Quality at the design stage is of interest to many parties involved in the construction industry. The report of the Institute of Australian Engineers identified several specifications to be provided in design documents [27]:

1. Appropriate to the project.
2. The situation and logical interdependence between them.
3. To present in a timely, accurate and integrated manner.
4. Offer maximum extent of economic and safety.
5. It is in line with the owner's requirements as in the project description.

Researchers have confirmed that documentation and document management are an important factor in any quality system. The management of design documents is a very important process for the designer's office because it is closely linked to the design review, production and revision of any document produced by the design process [29].

1.4. Quality in the contracting phase

The presentation stage is the most important stage of the project for the company because its success means signing a new work contract [30, 31]. Therefore, there must be a clear understanding between the Contracting Parties of exactly what work will be done before the contract is signed, Acceptance criteria must also be defined in appropriate measurable formats. It is very important to provide the customer with information as much as possible and as early as possible. Failure to provide information will delay the design process. If the design process is completed, this will lead to failure, loss of time, effort and increased cost [32].

The information may change from project to project but a list of information may be shared and useful for all projects. All contract documents and any project-related documents must be set [33].
Review of the contract to prevent incorrect understanding among the parties involved in the contract shall be considered in two stages [33]:
1. The first review is at the presentation stage to ensure that the customer's requirements are defined in the charts - specifications and the company can achieve these requirements technically and financially.

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2. The second review is after approval of the offer before the official signature and the aim is to re-resolve the cases that appear as a result of changes in design requirements or specification requirements.
Requirements must be circulated to all business operators. The standard requires the company to identify and apply effective arrangements to communicate with customers associated with the adjustments, as there must be knowledge of the amendments to the relevant parties [34].

2. Literature Review

1- In a study conducted by: The publication series "Common BIM Requirements 2012" is the result of a broad-based development project entitled COBIM. The need for these requirements arises from the rapidly growing use of building information modelling in the construction industry. During all phases of a construction project, the parties on the project have a need to define more precisely than before what is being modeled and how the modelling is done. "Common BIM Requirements 2012" is based on the previous instructions of the owner organizations and the user experiences derived from them, along with the thorough experience the writers of the instructions possess on model-based operations [35].
Property and construction modelling aims to support a design and construction lifecycle process that is of high quality, efficient, safe and in compliance with sustainable development. Building information models are utilized throughout the building's life cycle, starting from initial design and continuing even during use and facility management (FM) after the construction project has concluded.
The main goals of Quality Assurance are twofold: first, the quality of each designers own design work shall be improved and secondly, the exchange of information between the parties, thus also making the overall design process more effective.

2- In order to another study conducted by: (Nur Emma Mustaffaa), Shaun Kok Zhen Xiongb), Muzani Mustapa, Hamizah Liyana Tajul Ariffin and Fuziah Ismail), Management of Contractual Risks in a BIM-Enabled Project [36].
Building Information Modelling (BIM) transforms the construction industry and one of the major hindrances highlighted is a lack of BIM standard form of contract. The consequence thereof, there is no standard clause which laid down the provision for variation order in a project which adopt BIM. This may lead to a contractual risk in running a BIM enabled project. In theory, it has been stated that no variation order is issued as visualization of the project is enhanced through models developed. Nonetheless, from practitioners' point of view, variation order still exists in BIM-based projects. Hence, this research tries to have a better understanding on the significance of variation order in the context of a BIM-enabled project and highlight the major requirements to be incorporated into variation order contractual provisions in the light of the establishment of a BIM standard form of contract. The research adopts a single case study approach based on a government administrative building and adopt interviews and documentary analysis as data collection methods.

3. Research methodology and tools

The questionnaire was selected as one of the research tools used in this study to explore views and investigate reality. It is the collection of information and data on the subject studied its identification, and then the statistical analysis of the results for the purpose of assessing attitudes and views on the subject and making appropriate decisions and disseminating them to the studied society [37]. This questionnaire aims to investigate field information about the quality of the contractor and design phase of construction projects within the State Company for Studies in Damascus.
The questionnaire was accompanied by a cover letter explaining the title, sponsors and purpose of the search. Questions also varied between closed and open-type questions and leaving room for respondents to add any feedback or suggestions they deem appropriate.
The questionnaire consists of a set of questions of the closed type, where all questions are pre-answered and only the respondents choose the answer they deem appropriate. Open type to leave room for respondents to present their opinion or make any suggestion or enquiry.
The questionnaire performs two types of functions:
Description: Data describing the characteristics of the sample in question in terms of level of education, nature of work, experience, etc. An accurate and correct description of these

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elements is necessary for research and researcher to reveal the relationships between different elements and variables and helps to explore and anticipate the study community.
Measurement: These are those that reflect the measurement of opinion trends of sample individuals on objects, or topics that the researcher wishes to measure opinion trends towards. For ease of presentation, the questionnaire was divided into:
Section I: General information on the nature and experience of the respondent in the construction sector within the State Company for Engineering Studies.
Section II: Information on the company's quality and quality organizational structure and how to control and control products and processes.
Section III: Information on the performance of the company's construction projects, the proportions of simple and large design errors and the proportions of exposures between engineering schemes and the proportions of projects carried out within their cost and contract time.
Section IV: Information on Building Information Modelling Technology and Extent of Use at the State Company for Studies.
Section V: Open questions about weaknesses in both the design and contractual phases and factors affecting the quality of the contracting phase and suggestions that the respondents can propose to ensure and improve the quality of each phase.

4. Research Objectives

This research aims to develop procedures to improve the quality of the contractual and design phase of construction projects in Syria at the State Company for Studies in Damascus, by examining the current reality of the practices and methods of quality management during these two stages and illustrating their weaknesses. Identify and assess the factors affecting them and indicate their impact and prevalence in Syria's construction industry, as well as propose some remedial measures that address or overcome current problems. Also, improve the construction process and quality assurance process by changing the way project participants interact with each other using building information modelling technology, as the use of BEM provides an effective means to increase the overall quality of the project.

5. Research Problem

In addition to the conditions affecting the local construction sector, especially recently, the study and design phase suffers from a range of erroneous practices. Studies have shown that there is a weakness in the attention paid in this phase, although it has been emphasized that the design problem is of the highest importance and impact on the project's performance, which is a source of confusion and multiple problems in the implementation phase. Low quality in contracts and design, which in turn reduces the quality of projects with increased cost and delay, as well as low project performance and lack of achievement of the project's objective at the investment stage.

Quality management in engineering projects and studies is a continuous process throughout the project's life cycle. Nevertheless, each phase of the project has a certain specificity in terms of inputs, outputs and management. However, the correlation between them is that the outputs of each phase constitute the inputs of the next phase and thus ensuring the quality of the outputs of any phase is thus ensuring the quality of the next phase's inputs, as a result of overcoming possible obstacles and raising the quality of the entire project together.

6. The importance of research

The implementation of quality management mechanisms is one of the most important processes for implementing construction projects to achieve better performance, save time, satisfy project stakeholders and increase profits, reduce costs, and achieve safety requirements while maintaining coordination and complementarity with the project's core determinants (time, cost, quality).

While developing countries lack of sufficient studies dedicated to improving the quality of construction projects, commensurate with their economic, social, political and technical conditions, the West and East Asian States have made strides in this area. Studies have been conducted specializing in the costing of quality degradation in design and implementation,

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other studies specializing in identifying factors influencing quality, and studies on the development of quality systems and management. Studies specializing in quality measurement methods, all of which emphasize the need for local studies to improve quality in construction projects based on the characteristics of local experiences accumulated as realistic and conditions-compatible data. Rather than being regarded as impediments to the application of imported philosophies as long as they are misapplied and do not serve the intended purpose. This requires a shift in the way the topic is dealt with intellectually from the traditional method of adopting prefabricated roads, to a dynamic and interactive method of studying and solving the problem, ensuring continuous quality improvement in the construction sector.

In the information-building modelling process, data control, review and control of the construction information model, the processes and activities associated with the model are essential to ensure that best practices for the model's construction process are followed from the start of the project and during its development to the end of the project to become a usable product.

7. Search Limits

The research aims at construction projects in Syria and focuses on the study of quality in the design and contracting phase of the State Company for Studies in Damascus. The State Company for Studies was selected because its projects are broad and span many locations and are considered to be one of the most strategic and important projects. By collecting data from stakeholders involved in construction projects, influencers or directly and indirectly affected by the research topic. The questionnaire also includes a survey of employees of the State Company for Studies in Damascus.

8. Results

By examining the reality of quality management in construction projects at the State Company for Studies and Research in various aspects, and by examining the means, methods, systems and nodal procedures related to quality management of construction projects at the State Company for Engineering Studies in Damascus. The quality management of the State Company for Studies was found to suffer from certain weaknesses and factors affecting the quality of the design and contractual phase based on the results of the survey. It needs a new formulation that ensures high quality and as a result of this research, it is clear that:

8.1 Weaknesses in the design phase

One of the factors influencing and responsible for the design quality is the designer engineer or design consultant. The designer is responsible for the design quality. It is incumbent upon it to identify requirements from other parties involved in the project to provide all the requirements and ensure an adequate working environment with a view to achieving valid results that avoid most of the claims and disputes that may arise due to inadequate design documents or numerous interpretations of some of their provisions. The responses of the engineers presented with the questionnaire show the most significant factors affecting the design phase's quality, and negatively affecting it:
The proportion of errors in which work is interrupted whether due to simple design errors (10% -39%) or larger errors (less than 10%) may negatively affect the project due to:
• Little or no use of modern technologies in the design process and not optimally employing them to serve the project.
• Failure to take care of the production of schemes with sufficient details of implementation and not to prepare them systematically according to the required specifications.
• Selecting a team that is unable to meet the workload and is busy working on more than one project.
• Inconsistencies between engineering schemes at work: the proportion of individuals who were unanimous in that the inconsistency ratio ranged between 10% - 39%) was 68.2. This is due to:
• There are a large proportion of matching issues between on-the-job engineering schemes and a lack of specifications.

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• Insufficient coordination and cooperation between members of the design team and different disciplines.
• Lack of a specific and clear timeline for the design phase.
• The designer does not keep up with the construction and implementation technology and the quality of materials available for use in the project.
• Time constraints available for the design phase and implementation phase imposed by decision makers.
• The technological situation in Syria and the inability to obtain software systematically and licensed by the parent company lead to a return to the use of manual and approximate solutions that take time and effort, which in turn leads to many errors in the work.
• Copying and modifying previous projects.
• Failure to take into account the detailed study of projects and their quality and the partnership's reliance on scrutiny rather than on the system of oversight:
• Insufficient attention to quality of construction project workers.
• Other reasons:
• Not choosing the designer on the criteria of experience and competence - not having qualified members deal with the studied project or choosing them based on personal relationships or lower pay at the expense of engineering experience.
• Low design fees of 2.5 project cost fees that are not commensurate with the design team's fees to the nature of the project and its implementation.
• The owner's lack of awareness of the importance of the design phase and its lack of adequate time and budget to complete its work.
• Unstable stability of the construction industry's workload and its impact on the stability of the national economy due to the availability of materials.
• Negative impact of personal relationships between team members.
• The absence of motivation and reward system in the company.

8.2 Factors that affect the quality of the contracting phase

The most important decision to be taken in construction projects is the choice of an appropriate contracting strategy, which is often ignored in construction projects in Syria, where a single contracting strategy is often adopted. This is incompatible with major developments in the world in the area of various contracting strategies.
The unsuccessful selection of the contracting strategy leads to numerous problems in the project that adversely affect its completion, such as delay of time and high costs, and thus low quality and thus lack of success in achieving the consent of the entrepreneur [38].
The most prevalent and well-established contracting strategy in construction projects in Syria is the traditional contract also called the "Design/Tender/Construction" contract, where the phases of the project work are divided into two separate phases: the design phase and the construction phase according to this contract. An independent consultant engineer is selected to complete the entire project design and prepare the so-called tender term, Prior to the selection of the project contractor and the commencement of the construction phase normally carried out by a general contractor selected on the basis of competition at the lowest price, which is often done through a public tender. The consulting engineer shall supervise and ensure that the execution conforms to what is contained in the tender term [39].
Based on the responses of the engineers presented in the questionnaire and previous studies and research, the most significant factors affecting the quality of the contractual phase and affecting them negatively are:
• Projects carried out within their cost and contract time (10% -39) amounting to 72.8 were due to:
• The existence of binding contracts to be executed by the company no matter how good or negative the contract is for matters relating to decision makers in the construction sector because of the existence of traditional contracts ready without considering the nature of the various projects.
• The company's lack of study of project scheduling and its dependence on scheduling it for any other project.
• Insufficient clarity within quality responsibilities between the construction parties (owner, designer, outlet, supervisor).
• A lack of legislation and regulations on quality or deficiencies in their application.
• A lack of economic feasibility study and financial planning in many projects.
• Availability of creation documents (specifications, schemes, joules of quantities).

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• Market instability and price volatility.
• A lack of codes and general specifications to follow during the construction process.
• Insufficient interest in achieving quality engineers in construction projects.
• The unstable workload in the construction industry and its impact on the stability of the national economy due to the country's material availability.
• Easy access to the labor market in the construction sector, regardless of the necessary conditions and possibilities to achieve the required factors.
• Failure to secure materials and equipment for timely construction of a large section of projects.
Adopt the method of dealing with price increases or falls in accordance with Law 51, since the contractor's rate of increase [in accordance with article 63 subject to article 49 and article 53, of these Regulations (article 49 on advances)], is 15%, which is considered to be high, especially since the contractor's profit rate in the item in which this increase may not exceed this proportion essentially.
The high-uncompensated ratio also often prompts exhibitors to take them into account when submitting their submissions, which means an increase in the overall value of the submissions to avoid this risk. (By the bidder) in the event that it occurs, and in the event that this price increase does not occur, the public entity in this case is the loser that the contractor has raised its price in advance to avoid loss.
• Some contractors may resort to compensate for the loss in attempting to increase prices by manipulating the quantities performed or even cheating the quality of execution, which will eventually be reflected in the public ownership of the project.
• Insufficient mechanism for dealing with changing material prices and exchange of currencies established in construction contracts in Syria, and workers' dissatisfaction with the mechanism and their consideration that it is the first factor causing disputes in construction projects.
• The vagueness of the grounds for dealing with price rises or falls, the lack of detail and the absence of many controls and provisions governing addressing price increases or declines other than the unfairness and fairness of the mechanism followed.

8.3 Weaknesses in the contractual phase

These shortcomings associated with this contractual strategy, which is mainly the separation of the design and construction phases and the resulting increase in the duration of the project and the control of the unfriendly atmosphere between the project parties, lead to the reflection on new types of construction contracts, as the most important weaknesses facing the contractual phase that are included in the respondents' answers are:
Through employees who agreed that the projects carried out within their cost and contract time (10% -39) amounted to 72.8 were due to:
• Accept traditional contracts even if they contain errors to maintain the company's functioning.
• Insufficient commitment by the Department in the efforts required to implement successful quality management.
• Lack of effective communication and adequate coordination between the elements of the construction team (owner, designer, outlet, and supervisor) and between senior management and constructing sites.
• Lack of efficiency and training frameworks and hence failure to perform their functions to effectively achieve quality management objectives.
• Lack of planning to implement and achieve effective quality management.
• Ignorance of quality concepts and tools or misuse.
• Ignorance or misuse of modern engineering equipment and technologies.
• Insufficient preparation of project plans and specifications before they are announced for contracting and lack of efficiency from contractors implementing construction projects.
• There is a shortage of the study process, as detailed study is often initiated without discussing the project's legal and regulatory requirements and better implementation modalities.
• In most projects, the study is not audited by another party.
• There is an imbalance in the method of choosing the examiner depending on the financial evaluation more than the technician.
• There is a lack of study and design and the study does not accurately match reality.

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• There is a lack of efficiency of contractors as a result of random entry into this area of work and the lack of focus in the selection of contractors with prior experience in "similar" funds.
• Selection of the contractor in most projects based on financial valuation at the expense of technical evaluation.
• Failure to comply fully with the terms and specifications by the contractor in order to pursue a greater profit.
• Negligence of the supervisor in a section of projects in applying good control and conducting all necessary tests during implementation and relying only on some tests at the end of an implementation upon receipt.
• The Department's engineering methods are not used during on-site operations such as time programming and resource programming that help to control implementation. Timely completion at the lowest possible cost and with the required quality, relying primarily on experience in the management of implementation.
• Lack of coordination between project parties and lack of contractual requirements that include effective coordination.
• The main tool for resolving disputes in construction projects under Law 51 is access to justice or arbitration Law 51 did not include an attempt to settle the dispute amicably before recourse to justice or arbitration, which has a negative impact on the course of business and on all parties involved in the project. Litigation procedures are also considered complex and difficult to resolve disputes. This often results in an additional and influential increase in the project's duration and cost and is detrimental to the relationship between project parties, where disputes are often characterized by hostility and lack of confidence among themselves.

9. Quality assurance proposals integrated with building information modelling applications

9.1 Project-level proposals in accordance with the ISO9001:2015 system of integration with the BIM environment

Determining the quality requirements for each stage of the project is necessary at an early stage of the project's life. This determination is in accordance with the standards, codes and requirements of the customer by preparing the necessary procedures and designing the most effective functionality.
Construction Information Modelling (BIM) is an innovative process to create a digital database for collaboration and management of construction data during their life cycle and to preserve information for reuse additional construction industry applications.
Building information modelling applications help improve visual representation and detect conflicts. They are an excellent tool for developing project phase plans, studying and coordinating the project during the project's life cycle, preparing actual final plans for the building, and during project maintenance.
It also uses software and processes to digitally develop construction data in a cooperative and integrated manner, which has fundamentally changed the design and construction industry as a new business philosophy that is more effective, not just using tools that adopt sophisticated software, where design and construction team members are enabled to participate in virtual co-construction, development of project design components and operational requirements, and accurately arrive at a virtual construction design [40].

9.2 Contracting phase and BIM's role in improving its quality

The BIM system imposed itself in the modern construction industry rapidly and made changes to the parties' obligations, posing challenges to contracts used in the construction industry and its associated supply chain. There are contracts that can be fully applied within this environment such as the DB Design and Implementation Contract with minimal amendments to Contracting Parties' obligations, and some conventional contracts - For example, the design-contract-DBB implementation cannot be used without modification to match the cooperative BIM environment from level two, but can be applied partly at the design stage for example, or between the main contractor and subcontractors due to the benefit of avoiding conflicts between subcontractors.[41].

❖ The customer's requirements are clearly defined and this is done through meetings with the customer. Previous projects or visits to the project site can be relied upon to clarify a

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particular idea and using the Customer Requirements Information model, which includes the main items in the design and technical specifications of the originator by:
- Identify the design field requirements that must be included in the BIM file, unequivocally define, and provide information, thereby meeting the intended purpose.
- Identify a means of communication either via the Internet, sharing the site, or communicating via email.
- Coordinate a client's file containing the determination of its requirements and the customer appoints a BIM manager with the necessary knowledge and tools to ensure the quality of the design of the customer.

❖ The contract documents and the liability of both Contracting Parties shall be specified, including the contract documents:
- Legal contract terms and methods of dispute resolution.
- Financial contract terms include payment method and delays.
- Technical specifications.
- Design specifications with mention of approved documents.
- Used codes.
- Schemes.
- Lists of materials.
- The appalling quality plan within the design, manufacturing and exile stages.
- Inspection and Plan.
- Approved means of communication and language used in correspondence.
- Observations (future expansion - mortgage status).
- Special storage requirements.
- Special transportation requirements.
- Exceptions.
- The time of the company's project officials.
- The Agreed time for maintaining project records.

❖ Review the contract to verify a company's ability to meet contractual requirements and identify responsibilities and evidence using the contract checklist model.
Using construction information modelling a BIM contract can be employed where the contract documents (schemes - computer form - BIM pre-contract implementation plan - BIM post-contract implementation plan - mean all quantity tables and specifications extracted from the computer model. The application of BIM contracts of the traditional contract method, which saves time and money for the contractor and subcontractor by allowing them to pre-manufacture their systems using BIM, and makes the initial assessment process easier for the contractor. Reports generated from BIM that convey the designer's intention are narrative and easy to use for external parties and hence BIM contract documents visualize the project.

❖ Contract change management:
Through a formal change control procedure, whether at the request of the customer or at the request of the same company, each designer informs the project team of the adjustment or the change he has made himself. This allows designers to focus on the most relevant changes affecting their design and handling. Designers should also verify changes or modifications made to their outputs before sending them to other designers. Thus, unintended changes to the following documents proposed by the change management researcher are avoided:
* Template for recording the proceedings of meetings within the company or between the company representative and the customer representative
- Request change.
- Record of contract amendments.

* Continuous improvement of contract management through the use of a questionnaire proposed by the researcher in which contracting and design officials participate and demonstrates the relationship between the problems apparent in the client's information and the most widespread causes of these problems. This is useful in identifying the underlying causes of contract problems through the analysis of Barreto.
(20 percent of unsafe behaviors will cause 80 percent of the incidents reported)
The results are also documented in the customer's file.

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Conventional contract:
The design and construction contract later - through contracting is the most traditional delivery method practiced today in the construction industry, in which case the owner has two contracts, one with the designer and the other with the contractor. There is no overlap between the design services and the contractor's services, all communication between the designer and the contractor takes place through the owner, and the design phase ends with a tender - with a tender - as the owner anchors the project to the lesser bidder contractor.
The "added" value of BIM for the traditional contract is:

- When the BIM is applied in the traditional contracting method, Design-Bid-Build (DBB) the BIM design team is mostly used for their own benefit or due to the owner's requirements.
- Establishes a basis for contractors and subcontractors to coordinate electrical and mechanical engineering systems (mechanical/Electric/plumbing/sanitary).
- Time and money can be saved for the subcontractor by allowing them to pre-manufacture their systems using available models.
- It makes the initial estimation process easier for the contractor, although this depends on the quality of the model.
- Gives another level of clarity to all members of the design and construction of the project, which was previously only available 2D [41].

9.3 Design phase and BIM's role in improving its quality

An engineer's guide, such as the company's executive guide, provides a base for any design process, where it can be placed on the company's Intranet to facilitate the currency of access to information. The Guide contains the following items:
1. Definition of the terms used.
2. Identify the codes used.
3. Excel plates programmed and used in design.
4. Standard construction details divided into groups by type of construction element, showing the detailed dimensions required for the company's execution.
5. Quality Check Sheet checklists in order to check detailed charts in proportion to the company's execution methods, as well as identify the plans required for them.
6. Propose a standardized model for project archiving.
7. Standardized method of numbering projects, schemes and elements.
8. Cliché is uniform for each scheme.

BIM also has a high ability to improve the design quality by:
1. Creating three-dimensional models that improve geotechnical element analysis improve visual visibility and help solve conflicts and issues, and enable the development of virtual reality and augmented reality (VR/AR) solutions that increase accuracy and understanding of design through visual modelling using Revit.
2. The ability to create three-dimensional models that improve the analysis of geotechnical elements, improve visual visibility and help solve conflicts and issues, and enable the development of virtual reality and augmented reality (VR/AR) solutions that increase accuracy and understanding of design through visual modelling using Revit.
3. Reduces errors due to better coordination between documents and the entire team during design placement, thereby reducing conflicts and disagreements using BIM 360 software.
4. Helps improve and finish the implementation at lower costs and shorter lead-time by simulating project implementation using Navisworks.
5. Obtaining accurate and consistent information where electronic inspection of the schemes is carried out using Model checker -SOLIRIBI and production of engineering documents and design information in electronic form in IFC format and tables of quantities generated from the models.
6. Helps effectively manage maintenance by providing timely and relevant information for Asset management facilities management early in the design phase.
BIM's environment helps to provide timely and appropriate information to enable better decision-making and results that contribute to productivity gains and operational efficiency. The UK PAS/BS 1192 BIM describes a process that encourages thinking about the operation and impact of assets from the outset and provides information management specifications for the establishment and delivery of construction projects using building information modelling and explains:

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- How the original will run
- What information is needed to achieve its results?
- What is required during the capital delivery phase to protect the effective operation of the asset and provide the benefits of the business?

The creation and management of current assets tend to benefit from the data revolution, where asset information is digitized in a standardized format, supporting improved asset planning, maintenance scheduling and standards compliance control.

IOT Internet of thinks can increasingly be used to transfer factory information and services to asset data centres, support improved maintenance programs, and minimize the operational impacts of business.

The BIM process creates associated information and information models that are used during the life cycle of construction/infrastructure installations or assets. The information delivery and project management cycle also illustrates the overall process of determining the project's need (which may be for design, construction or goods supply services), procurement and award of the contract, supplier mobilization and production generation of relevant information and asset information [40].

9.4 Continuous improvement of design and audit processes by identifying a person responsible for

- Conduct interviews to gauge the client's internal satisfaction (school and auditor) and gather information through a proposed questionnaire in order to assess design quality items in terms of relevance and performance from the customer's internal perspective, identify suggestions and recommendations for improvements and avoid repeating fault.
- Develop the documents used and detailed quality plan for the design process.

Manufacturing Phase:

The following processes are included in the manufacturing phase:

- Selection and evaluation of suppliers.
- Procurement and receipt of materials.
- Manufacturing process.

Implementation phase:

The following operations are included in the implementation phase:

- Shipping process.
- Installation process.

Continuous improvement of the proposed quality assurance system:

❖ Analysis of data through Quality Check Result verification results by applying it to the manufacturing and installation phases of projects before and after the application of the quality system to compare the ratio of non-conformities relative to the number of pieces according to the following indicators (subsequently suggested by the researcher):

- Business mismatch model indicators (RD redesign - neglect of UAI mismatch - RE recycling - RP repair - SC damage).
- Cause indications of business mismatch status (DD design defects - DF manufacturing defects - DE installation errors).

Based on reports of non-conformities, this is useful in determining the high repetition of errors and thus prioritizing improvement.

❖ Interviews with external customers to find out their opinions and suggestions on the quality of the business provided by the company and document this in the client file Customer File which gives an indicator of the frequency of work and the questionnaire (Questionnaire - External Customer) proposed by the researcher based on the matrix(Importance - Impact) is used to prioritize improvement in terms of identifying items that give added value

❖ Internal audit aimed at auditing the company's proposed quality system with the requirements of ISOAND audit results that give an indication of the quality situation in the company. This is done using the following documents:

- Check page for Audit Checklist audit process that includes ISO9001 system requirements.
- The page of audit views includes the objective evidence Audit Observation Sheet.
- Request for corrective action for the audit in case of non-conforming sightings of ISO9001 items (CAR)
- The internal audit report contains the summary of the Audit Report.

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− The implementation of BIM as a methodology gives the best result to date, it improves the quality of information delivered, promotes cooperation in an orderly manner and integrates it into the project management process.

10. Proposals

10.1 Proposed actions to ensure design phase quality

The quality management assurance system not only connects quality to the finished product, which is the design documentation, but also extends the quality concept to the accompanying practices and procedures. Ensuring the quality of this phase in the General Company for Studies depends primarily on improving practices during the design phase. Subsequently, it was ascertained to what extent the design documents were free of any deficiencies, deficiencies or deficiencies before they were submitted for contracting and then commencing the construction phase. The results of the questionnaire have also paved the way for the proposal of procedures to ensure the quality of the design and the development of these procedures with BIM technology to reach the best possible outcome.
Raising and ensuring design quality basically depends on three main principles:
1. Prevent errors from occurring, as more emphasis should be placed on preventing errors than on trying to detect such errors at advanced stages of design.
2. Ensure that errors have been monitored and processed as early as possible in the project. Therefore, the art of quality control, which includes verification and auditing processes, must be carried out during all stages of the project.
3. In addition to monitoring errors, the causes of such errors must be excluded to prevent their recurrence, re-occurrence and accumulation.
Herein, some design process practices that should be focused on at the design stage and done optimally are reviewed, which contribute to ensuring their quality:
1. Use of modern design tools:
Frequent changes and modifications are one of the design team's biggest challenges, as continuous adjustments and changes require the ability to respond quickly, collaborate and coordinate highly among design members. To achieve this and to ensure a flexible design process, there is a need to create a qualified environment for joint cooperative action and to use technology to help achieve this. Perhaps the best example of this environment, which provides building information planning model tools, is the building information modelling technology, which reflects an environment suitable for managing change at the design stage. BIM solutions help create and operate digital databases to ensure collaboration between the relevant parties in the project, so that any change occurring in any part of the database and all other parts is coordinated, together with the collection and preservation of information for reuse additional applications. By storing and managing existing construction information in ways suitable for design team members. In addition, by storing information as a database, changes that often occur during design can be disseminated and managed throughout the project's life cycle.
BIM models help manage relationships between construction elements allowing for design information during the design process and reduce conflicts that may arise between different disciplines.
2. Coordinate between different disciplines and detect errors before starting the project and select materials, raw materials and supplies before starting the project to fit the design, complete project visualization and real-time cost update by using BIM technology.
3. Strengthen the work together and the good cooperation of all project parties in defining the project's vision and objectives since its inception.
4. Effective communication between all parties and permanent coordination during decision-making processes from the beginning to the end of the project.
5. In-depth and detailed study of design documents prior to the contracting phase.
6. Study the detailed timeline well and study and audit engineering schemes by another
7. Attention to the preparation of the study of the project, whether preliminary or detailed, and the need for its scrutiny by another.
8. Save enough money and time to complete the design phase.
9. The design selected based on value and efficiency.
10. Use checklists at the design stage as a quality control tool.
11. Involve key designers in the implementation process and thus give them an opportunity to improve the quality of the design phase.

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12. Activate the owner's participation in the design process by holding periodic meetings that allow him to see the workflow.
13. Follow a methodology of quality assurance procedures using construction information technology.
14. Training and qualification courses for the company's employees on software, which should be used in a systematic manner to avoid technical errors within the program.

10.2 Proposed procedures to ensure the quality of the contractual phase

1. Use of BIM contracts that guarantee the rights of all parties involved in the project

Major construction projects in Syria have been implemented over the past few decades by public authorities and financed from the State's general budget. The implementation of these projects, contracts based on the provisions of Law 51 of the end of 2004, which contains the system of contracts and covers possible contractual strategies for public entrepreneurs in Syria.
By examining the various articles of the law, the entrepreneur would face very great difficulties in adopting any of the new contracting strategies, as well as the legal impossibility of applying some of the modern construction contract strategies, to face difficulties in applying any of the improvements in the traditional contract strategy developed to overcome the fundamental problems of the traditional contracting system.
While witnessing the progress and evolution of the schemes provided by the professional engineering offices in the Syrian Arab Republic following the BIM approach, Syria is continuing to suffer at the legal and contractual levels even though they constitute the most important aspect of all in practice, Syria is in the process of adding the most important points of the new system as facilities added to construction contracts, including a great benefit for all Contracting Parties and for their explanatory services and facilities when contesting and many clarifications before commencing work.
Coordinating today's goals and efforts is essential and generally achieved through the BIM Protocol and the BIM Implementation Plan, both of which are essential documents for reaching and understanding work in this environment.
The designer needs to understand and work on the levels of design (or details) (LOD-Levels of Design) that will be explained in these documents to ensure that there are sufficient details at each level to allow all designs to progress efficiently and avoid unnecessary changes.
It should be noted that improving the quality of label projects using BIM could lead to a significant reduction in differences. It is also worth considering how the contractor and employer's traditional roles in this new structure are appropriate.
In general, Building information modelling technology is suited to deliver integrated projects, including construction design and operating projects where early proactive engagement of the design engineer, contractor and employer is necessary. If advanced levels of BIM are expected for the project, the possibility of adding operation and maintenance elements to the constructed facility can be considered.
2. Keeping abreast of global construction contracts and developments in this area.
3. Take into account the specificity of the construction sector and the projects of public entities in Syria.
4. Cover the shortcomings in the provisions and texts contained in both the contract system and the general condition book and increase the explanation, detail and clarity thereof, rather than omitting certain provisions and cases or shortcuts that cause confusion and ambiguity in understanding the texts and their intention (since it is better mentioned than omitted).
5. Review the gaps in 51 law in almost 20 years' time and work to amend and improve them.
6. Review the contractual method that gives a financial evaluation greater importance than technical evaluation.
7. Increase flexibility and speed during the contracting phase and in the completion of contract items and avoid the project's potential to waste money or delays during its completion.
8. The existence of a Financial Legal Engineering Committee to develop correct formats of contracts.
9. Enhancing the role and powers of the supervising engineer to manage and implement the contract between the public owner and the contractor.
10. Balancing both parties to the contract (public and contractor).
11. The treatment of the public sector and the private sector's imposition of fines in delays.

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12. The best way to address the risks that project implementation may face is to implement, manage, not conceal or neglect. The public owner of the project is better placed to bear the unforeseen risks than to leave them to the contractor who will do so as he deems appropriate to cover them.
13. Rely on scientific engineering management methods such as time programming, resource programming and cost calculation.

11. Future recommendations

The research concluded a set of recommendations aimed at ensuring design and contracting quality and the study covered only two design and contractual phases. Based on the findings of this research, the importance of ensuring the quality of these stages is commensurate with the company's realities by incorporating ISO9001:2015 specifications of BIM technology and its ability to use and apply these procedures. This is not difficult for the company as mentioned earlier. So:
1. Apply quality assurance procedures and integrate them with the information modelling technology proposed in chapter V.
2. The need to take care of training and qualify personnel in the field of construction of BIM technology and its programs in addition to including it in the training curricula of engineering institutes, colleges and specialized academic institutions and the provision of courses and qualified trainers, and to cooperate with qualified companies to provide the necessary support for the application, as well as to focus on specialized and accredited training courses in this field.
3. Prepare and encourage the State Company for Studies to move from using programs such as AutoCAD to BIM-based programs by gradually moving after the completion of all necessary preparations for the application of training, technical support, programs and qualification of workers to accept a smooth transition to the application, as well as to focus on specialized and accredited training courses in this field.
3. Prepare and encourage the State Company for Studies to move from using programs such as AutoCAD to BIM-based programs by gradually moving after the completion of all necessary preparations for the application from training, technical support, programs and qualification of workers to accept a smooth transition to the application, which is applied to a limited number of projects initially and then gradually to all projects.
4. Government support for BIM technology by issuing binding rules to require their use in major and special projects to obtain approvals and licenses from municipalities and relevant government agencies, initiating a gradual transition to disseminate to other projects, and preparing specifications, codes and contracts regulating the use of technology in the construction sector. Otherwise, steps by application will be slow compared to other countries.

5. Provide the necessary physical capabilities to start the application of BIM technology and technical support to the institutions and stakeholders choose the appropriate programs and techniques for the application and prepare all the documents and contracts required for the application.
6. Research on the impact of engineering contract types and methods of delivery of the most compatible projects with BIM:
(Design Build – Design Bid Build – Construction Management at Risk- Integration Project Delivery IPD)
7. Search the right ways in modelling to get the right quantities and search with other components of the building to enhance understanding of software requirements to calculate the quantities of construction elements.
8. Research the assessment of quantity calculation software by linking with cost estimating software, which will reduce the difference between contractors when submitting submissions. The available module information will better communicate design intent and reduce misunderstandings of schemes and projects as a whole.
9. Working within a working group that includes all specializations, engaging the owner and contractor for the project and the initial stages thereof, and familiarizing the working group with their respective responsibilities. The working mechanism within this environment allows the Panel's members to arrive at one common model simultaneously through the centralized model, which is more collaborative and the real-time updating of the modular project by all parties.

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10. Holding periodic meetings, which are the basis of the BIM application, by discussing the workflows and problems encountered during the design phase.
11. Although there is a quality management department in the company and employees are aware of quality concepts and culture, and the company has obtained a ISO9001:2015 certificate for administrative work, there are no procedures in place to ensure the quality of engineering studies. The quality of the project in its final form is a product of systematic application of quality control and assurance at all stages, and in coordination with all parties involved in it. The tasks of quality assurance include:
− A procedural work plan in a structured and sequenced manner to review all design documents at the last two stages of design to ensure that the design is sound and the terms of reference are compatible with each other before these documents reach the rollout stage of implementation through technical review.
− Determine the responsibility for these records and the authority to disseminate or modify them and the rules for their use, by establishing a system of documentation, control and control of records.
− Activate the regulatory system that is necessary to follow up on the company's business and complements the planning process. The regulatory system followed is effective when an effective documentation and archiving system is established to facilitate the work and compare the results reached with the objectives identified during the planning.
12. The need to identify the most important factors that would affect the project accurately and to determine the relevance of each of them, assess their likelihood of occurrence and the extent to which the project would be affected if it occurred, as well as the lack of a project management office within the company. Although they deal with multiple and different types of projects, as a result of the lack of useful project management from the labor market and local companies.
13. Applying the system of incentives and rewards to good cadres and linking them to achieve quality concepts.
14. Applying a system of punishment to the cadres who fall short of work, which significantly affects the course of the engineering process.
15. Quality assurance system documents must be understandable, uncomplicated and do not cause staff burdens of paperwork and increased bureaucracy.
16. Review the quality assurance system continuously at least annually to ensure its effectiveness and relevance to the company's quality policy and objectives.
17. Measuring the efficiency of the quality assurance system by selecting appropriate performance measurement indicators.

12. Conclusion

It is essential that the project management process remains the same, with all the necessary basic knowledge and expertise. BIM brings additional tools, metadata and concepts to the same basic traditional design, planning, tender, implementation, communication and coordination processes. This naturally leads to improvements in the reduction of financial losses, savings and time, thereby improving the quality of the project stages.
Here, it is noted that the proposed system documents comply with the requirements of the ISO9001:2015 standard regarding the project's phases and the continuous improvement of the system.

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