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Building Information Modelling (BIM) in Managing Construction Claims: Now and Beyond – A Review (Jordan Perspective)

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***Abstract:** As the intricacy of construction projects is amassed, prospects for tribulations are mounting, depicting negative impact on projects' cost, time and excellence. Thus, eliciting claims that aredisruptive to projects, time consuming and exorbitant. BIM holds enormousprobable in prosperous claim management practices. The progression of BIM can enrich knowledge sharing for information of a building or facility. It forms a vitalbase for decision making throughout the life cycle phase from the conceptual design to demolition. BIM is also, a valuable multidisciplinary cohesive source of information technology that posts benefits and disputes in the construction industry. The main aspiration of this paper is to appraise how and to what magnitude BIM can help evading and plummeting claims in Jordan construction industry.The paper ran a literature review on recent research, industry reports, and other sources to seehow they identified claims, its classifications, benefits, impacts and challenges of BIM on construction projects.Also, the paper acknowledgedcontemporaneous challenges in the claims field and the construction industry as whole. The attained outcomes have shown that BIM overtakes traditional claim management practices in many aspects including recognizing and investigating claims, where the benefits are comprehended in time and cost savings, less change orders, less rework. Moreover, the information and knowledge management that BIM postulates can improve many aspects of claim management.*

***Keywords:** Building information modelling (BIM), Contracts, Claim Management, Dispute, Avoidance, Mitigation*

I. INTRODUCTION

In Jordan, construction industry is a dynamic, complex, as well as fragmented process, and the traditional methods and systems of construction industry use technology in isolation (Figure 1).

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With the continuous advancement in technologies, new techniques are constantly being developed in order to improve engineering implementations for the construction industry. One of these promising developments is Building Information Modelling (BIM) where it facilitates a more integrated design and construction process that results in better quality buildings at lower cost and reduced project duration [1]–[3] ,but there is tremendous lack of information about the implementation of building information modelling as claim control tool in building projects in Jordan.

Figure 1. Jordan's Industry and Building Sectors

Therefore, there is a clear need and motivation to have cleary understood about the project delivery method which is the first arm to create problems or to increase the interoperability between all stake holders.Also, there is need to have clear definition about BIM and Benefits from Implementing BIM in the construction industry, challenges and drivers that control the process of BIM adoption ,types of claims and their causes, and Impacts of BIM and claims on construction projects[4]–[10].

II. CONSTRUCTION PROJECT DELIVERY APPROACH

The architecture, engineering, and construction (AEC) industries have traditionally assimilated a fragmented approach when it comes to project procurement[11]–[13]. Current project delivery processes are primarily dependent on paper-based modes of communication. Paper-based modes of communication have been common practice among the AEC industries for so long that incorporation of technology to supplement the current delivery process will not only require team members to learn a new skill set, but also the changing of an industry mindset.

The AEC industries have not completely ignored the incorporation of technology into the project delivery process; many of the activities associated with the delivery process are now performed and delivered faster via the use of software and web-based technologies. Estimating and scheduling activities for example can now be performed faster via the use of digitizers, digital drawings, and estimating and scheduling software. Information exchange between the contractor's field office (project site) and head office, architect/engineer office can now occur in real time via email and web-based programs. Arguably the cost implications associated with incorporating technology into the project delivery process among smaller sized firms could be the primary limiting factor. Due to the rapid advancements in technology, computer software and hardware costs become secondary to the costs of training staff to properly implement such technologies [14]–[17].

1.1.2 Design-Bid-Build (DBB) Project Delivery Method

With this method, documents are fully developed by a designer paid by the owner before bidding by multiple contractors. This method limits a contractor's ability to use BIM to its full potential as a coordination tool[18].

Traditionally, the Design-Bid-Build (DBB) structure has been the common delivery method employed in the construction of new facilities[19]–[21]. In 2002, a survey published by the Design-Build Institute of America estimated that approximately ninety percent of public buildings and about forty percent of private buildings where constructed using the Design-Build delivery method[22].Typical Design-Bid-Build timeline is illustrated in Figure 2.

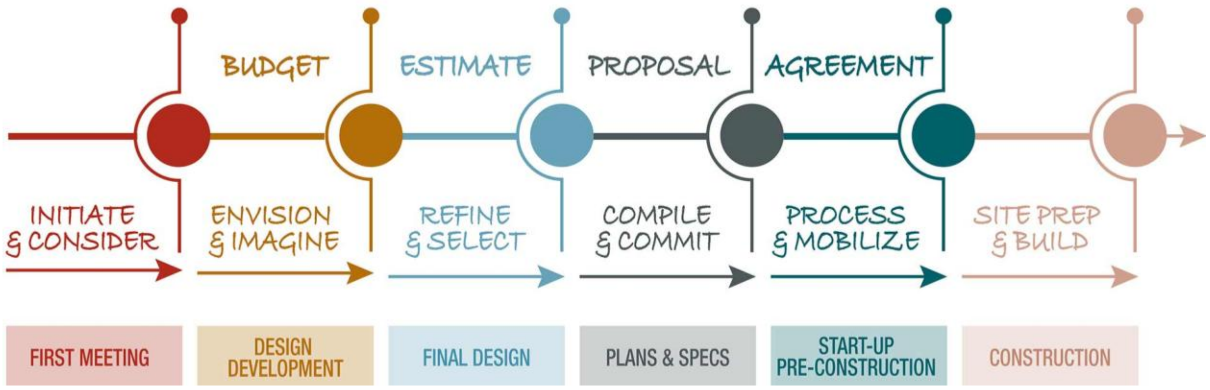

Figure 2. Typical Design-Bid-Build timeline (Eastman et al., 2008)

A typical Design-Bid-Build (DBB) project process begins with an owner contracting a design firm to develop project documents based on a specific program. In a building (commercial/residential project), the architect generally takes the lead during the design phase to develop project documents, drawings and specifications intoa construction document bid set to be issued for bid solicitations.

The next step in the DBB project process involves the solicitation of bids. Bid solicitation can be done via an open forum in which any contractor is able to submit an offer or via a private process in which only "pre-screened" contractors are invited to bid and participate. The owner and/or architect then make an award based on the best value to the owner; typically the lowest responsible and responsive bidder. The construction phase is then commenced during which the successful contractor must organize his or her team of subcontractors and suppliers and begin construction operations based on the project documents.

It is during the construction phase that a majority of the problems associated with the Design-Bid-Build project process materialize. Errors and omissions by the design team are identified, unanticipated site conditions can cause changes to the design, and new requirements by the owner can arise. All changes deviating from the original design intent thus lead to monetary costs, time delays, and increased tension among the project team.

In the Design-Bid-Build delivery method each of the phases has its own project leads assigned the task of carrying the project through their respective phase; and for the most part, have traditionally operated independently of each other see figure (2.2). The final step in DBB project process is the operation and maintenance phase implemented by the building manager(s) for the life of the building; the Design-Bid-Build delivery method has advantages and limitations as follows:

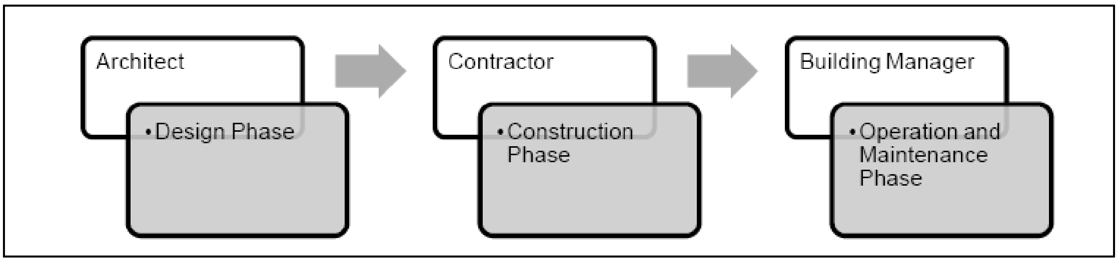

Figure 2.2: Design-Bid-Build Delivery Method [1].

Advantages of the Design-Bid-Build Delivery Method: The main benefit of the Design-Bid-Build project delivery method is an owner's ability to obtain competitive bids and thus in theory construct the project at the lowest possible cost.

The economic benefit attributed to the DBB delivery method is only valid assuming changes in the project scope during the construction process is minimal. This assumption, however, is not accurate. Research conducted by the Construction Industry Institute estimates that direct costs caused by rework in the construction industry average five percent of the total construction costs of a project [23]–[26].

Limitations of the Design-Bid-Build Delivery Method: There are a number of disadvantages associated with the Design-Bid-Build project delivery method largely attributed to errors and omissions in the design documents during the construction process[27]–[32]. The design team develops documents based on known conditions and constraints which could potentially differ from the actual site conditions encountered by the contractor during the construction process. Moreover, because of potential liability issues architect may choose to incorporate fewer details in the construction documents or include verbiage indicating that the accuracy of the plans cannot be relied on solely and that the contractor is ultimately responsible for verification of dimensions and constructability of design. Discrepancies such as these can lead to disputes between the contractor and architect and can lead to added costs, and time delays for the project.

Another major limitation associated with the DBB project delivery method is its emphasis on project delivery fragmentation. The contractor typically has no input during the design phase and thus the contractor's knowledge of constructability, material availability, value engineering, and other such construction related information is lost and can only be incorporated into the project execution in a very limited way. Similarly, a project manager's experience and knowledge on what it takes to build a project is lost. The project manager is thus left to build the project reactively based on the architect's and engineer's decisions during the construction phase.

1.1.3Design-Build (DB) Delivery Method

With this method, one entity performs both architectural/engineering and construction under a single contract. The design-builder warrants to the contracting agency that it will produce documents that are complete and free from error[18], [33]–[35].

Although the Design-Build contract method is considered to be one of the oldest project delivery approaches, it is now regarded as a new alternative delivery method. During ancient times, a master builder was charged with the task of both designing and building projects within an empire. Advances in science and technology during the 19th century eventually led to the development of architecture and engineering as two independent professions and subsequently the fragmentation of the building process.

The Design-Build Institute of America defines a Design-Build contract as follows: a method of project delivery in which one entity - the design-build team - works under a single contract with the project owner to provide design and construction services. One entity, one contract, and one unified flow of work are from initial concept through completion[22], [36], [37].

A general project organizational chart based on the Design-Build delivery method is illustrated by figure 3.

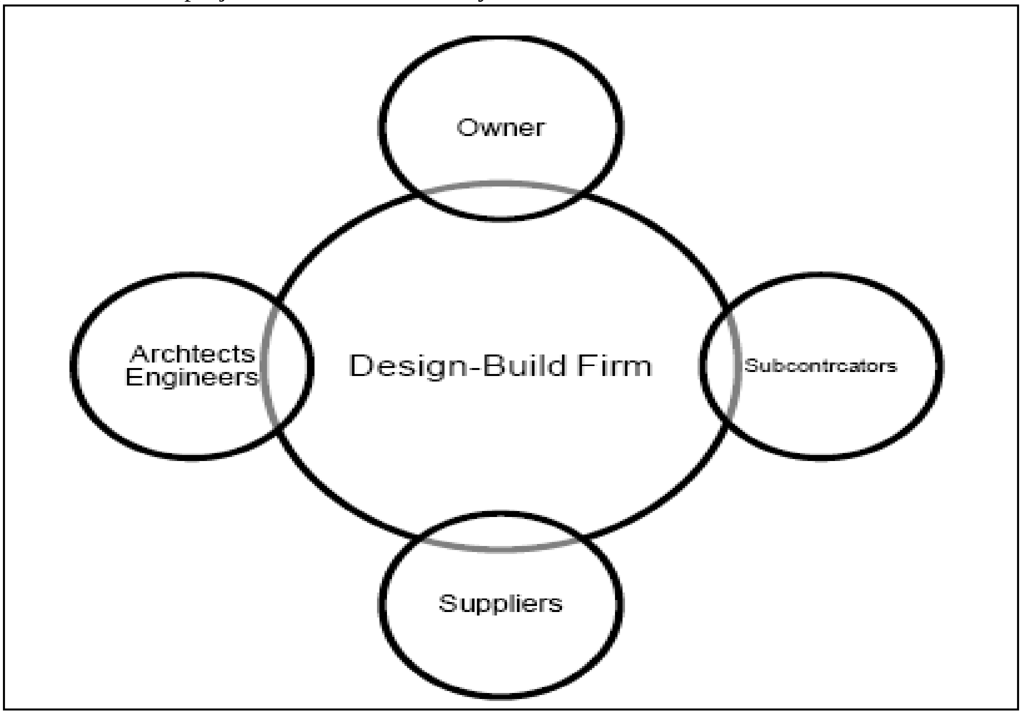

Figure 3. Typical Design-Build Organizational Structure[1]

A typical Design-Build (DB) project process begins with an owner contracting a design-build team to develop a building program and design. The design-build team then typically submits the design, and estimated cost and time to the owner for approval. Upon approval by the owner, the design-build team can begin and complete construction; the Design-Bid-Build delivery method has advantages and limitations as follows:

Advantages of Design-Build Delivery Method: In a design-build contract the owner benefits from faster delivery because the designer and contractor are working together.

The administrative burden of managing multiple separate contracts for the owner is decreased as well as accountability and risk in that one entity, the design-build team, is now accountable for cost, schedule and performance, as well as assuming the risk of any errors or omissions. The collaborative environment particular to a design-build contract also facilitates the incorporation of innovative technology and construction techniques such as Building Information Modeling and Leadership in Energy and Environmental Design (LEED) certification where communication among the project team is vital to the successful implementation.

Limitations of Design-Build Delivery Method: One of the drawbacks of the Design-Build delivery method is loss of flexibility for the owner to make changes after the initial design it is difficult for a project owner to obtain comparable competitive bids from different DB teams for a particular project. This is because each DB team would have his or her own interpretation of what the design should reflect; unlike in the DBB delivery method where all bids are based on interpretation of the same design.

1.1.4 Integrated Project Delivery (IPD) Method

This method calls for integration at the onset of a project, and utilizes up-to-date technology to foster flexibility and successful project outcomes. This method collaboratively harnesses the talents and insights of all participants, fosters a great degree of communication, and promotes intense collaboration among the project team.

Integrated Project Delivery (IPD) is a project delivery approach that integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to optimize project results, increase value to the owner, reduce waste, and maximize efficiency through all phases of design, fabrication, and construction[38]–[44].

IPD principles can be applied to a variety of contractual arrangements and IPD teams can include members well beyond the basic triad of owner, architect, and contractor. In all cases, integrated projects are uniquely distinguished by highly effective collaboration among the owner, the prime designer, and the prime constructor, commencing at early design and continuing through to project handover (Figure 4) integrated project organization; IPD delivery method has advantages and challenges as follows:

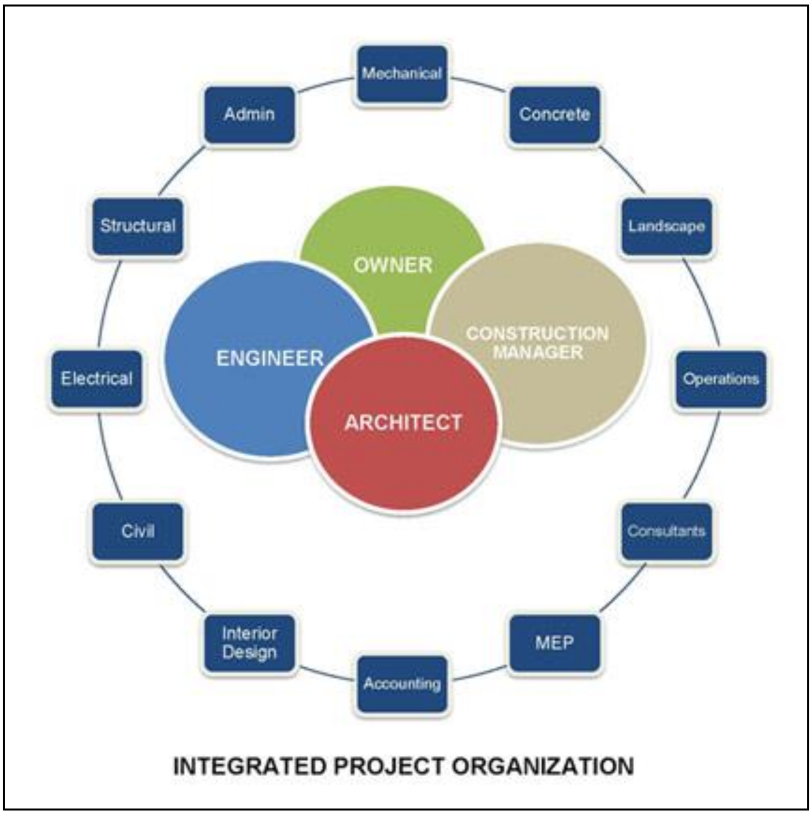

Figure 4. Integrated Project Organization [18].

Advantages of Integrated Project Delivery Method:

For Owners; early and open sharing of project knowledge streamlines project communications and allows owners to effectively balance project options to meet their business enterprise goals. Integrated delivery strengthens the project team's understanding of the owner's desired outcomes, thus improving the team's ability to control costs and manage the budget, all of which increase the likelihood that project goals, including schedule, life cycle costs, quality and sustainability, will be achieved (Figure 5).

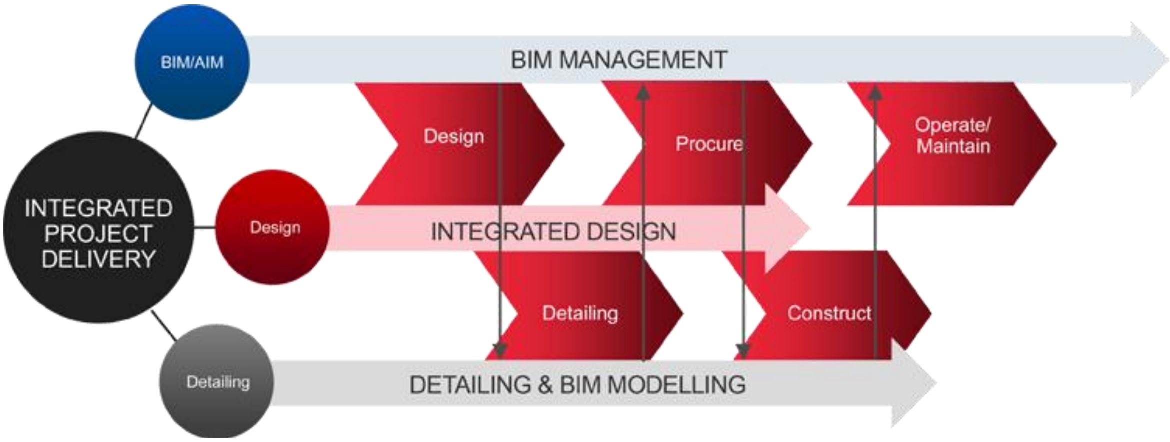

Figure 5. Integrated project delivery philosophy

For Constructors: the integrated delivery process allows constructors to contribute their expertise in construction techniques early in the design process resulting in improved project quality and financial performance during the construction phase. The constructor's participation during the design phase provides the opportunity for strong pre-construction planning, more timely and informed understanding of the design, anticipating and resolving design-related issues, visualizing construction sequencing prior to construction start, and improving cost control and budget management, all of which increase the likelihood that project goals, including schedule, life cycle costs, quality and sustainability, will be achieved.

For Designers: the integrated delivery process allows the designer to benefit from the early contribution of constructors' expertise during the design phase, such as accurate budget estimates to inform design decisions and the pre-construction resolution of design-related issues resulting in improved project quality and financial performance. The IPD process increases the level of effort during early design phases, resulting in reduced documentation time, and improved cost control and budget management, all of which increase the likelihood that project goals, including schedule, life cycle costs, quality and sustainability, will be achieved[45].

Challenges to IPD:Integrated project delivery can be challenging because it is new and completely different than the "traditional" way the industry has been doing business. IPD requires greater collaboration resulting in new technologies, new software, equipment, and training all combined with IPD's expectations. Also, Change always comes with great effort and several challenges. As is the case with any new process, integrated design brings some new challenges for the owner, design and contracting teams. Fortunately, education and familiarity are the largest challenges to face in integrated design and project delivery. These can be readily met through early goal setting sessions and owner/design/builder team discussions of project expectations, budgets and life cycle costs. The next major challenge understands each other's roles, skill sets and communication protocols.

It's very important that owner's understand that design fees can increase as a result of the integrated design process. Thus, we must always remember to educate the owner regarding the long-term financial benefits of integrated design and project delivery so they can readily understand that the increased value far surpass the potential increased first costs.

It is also important to understand that spending more during design and planning and use of integrated delivery techniques can substantially reduce construction process costs, change orders and requests for information. Since all team members have gained familiarity during design and planning stages, everyone is on the same boat and sailing in the same direction.

Other issues arise when contactors and sub-contractors are asked to revise their construction management and processes to more fully execute integrated project delivery. For example, contractors may not have the mechanisms in place to manage the waste and material documentation that is required of them and therefore incorrectly estimate the cost and perceived hassle of implementing these measures into their processes.

III. BUILDING INFORMATION MODELING

Regardless of the delivery method implemented in a project the underlying short coming in the AEC industry is project integration and data integrity. The AEC industry is taking steps towards addressing this issue and Building Information Modelling is being considered the applicable solution.

Building Information Model (BIM) is emerging as a tool that helps project teams' work together to increase productivity and improve outcomes for all stakeholders[4], [6]–[10], [46]–[53]. This is driving the most "transformative evolution the construction industry has ever experienced". The American Society of Civil Engineers ASCE has reported that "the potential of new technology based tools such as four-dimensional Computer-aided design (CAD) or building information modelling (BIM) have not been fully realized. This area could also include validation of new constructability software"[54]–[56]. Building Information Modelling (BIM) is a tool that has already changed the ways projects are conceived, designed, communicated and constructed by integrating the fragmented Architecture, Engineering, and Construction (AEC) industry. BIM has proven to reduce risk while improving collaboration and communication which ultimately enhances the overall productivity of the project. Thus, the A/E/C industry will definitely benefit from new tools and implementations in the area of improving constructability of projects and reducing claims in construction projects as shown in figure 6.

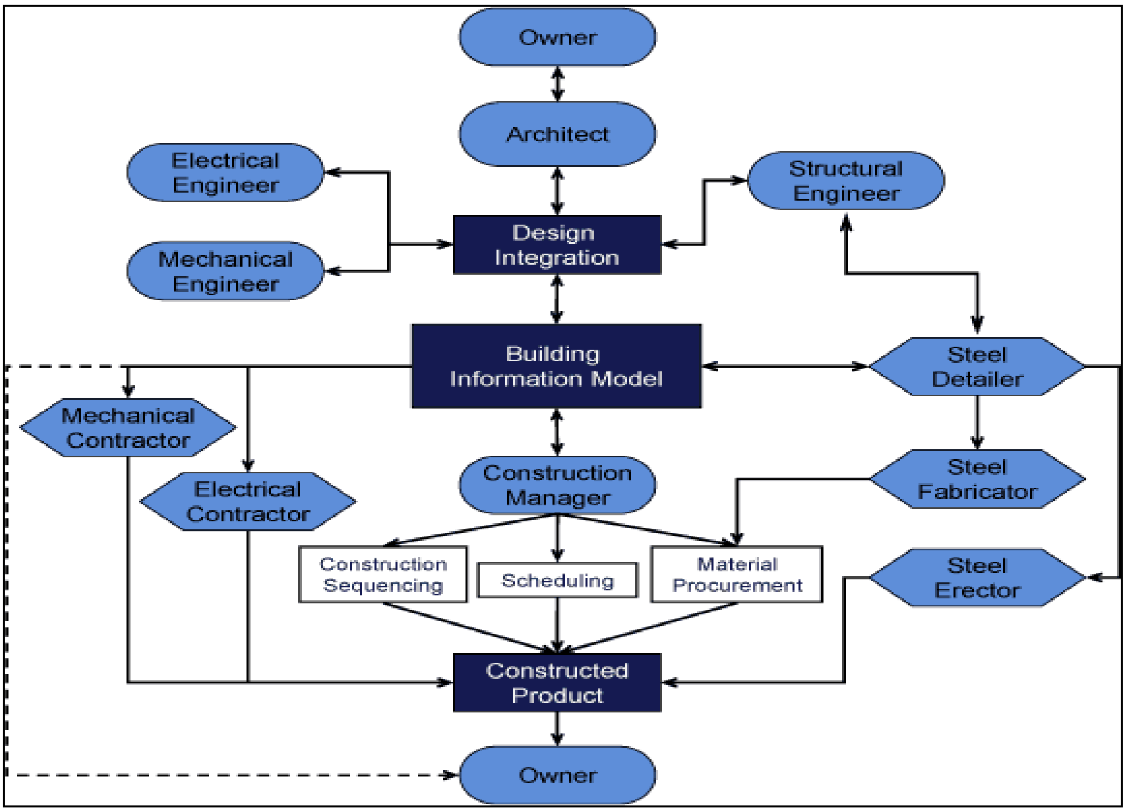

Figure 6. Collaboration among A/E/C industry[56]

2.1 History of BIM

Three-dimensional design based on solid modelling or 3-D shapes enclosing a volume was developed in the late 1970's and early 1980's (Figure 7). Early modelling software was difficult for users to use because they were used to two-dimensional design tools. It was also expensive and computers where often not powerful enough to support the operational needs of the software. Manufacturing and Aerospace needs spurred the creation of more useful design tools utilizing parametric object-based modelling in which each shape is defined and related to others so that components are represented and changed easily.

Since the 1990's, mechanical and steel trades rapidly embraced the modelling tool because their fabrication processes utilized the model's output very efficiently. With the advancement of computer speed and memory, designers and other contractors began adopting BIM to integrate the various components of the building. In the last decade tools available to the AEC industry have been able to relate connected components ina defined space andinclude information about the object being modelled.

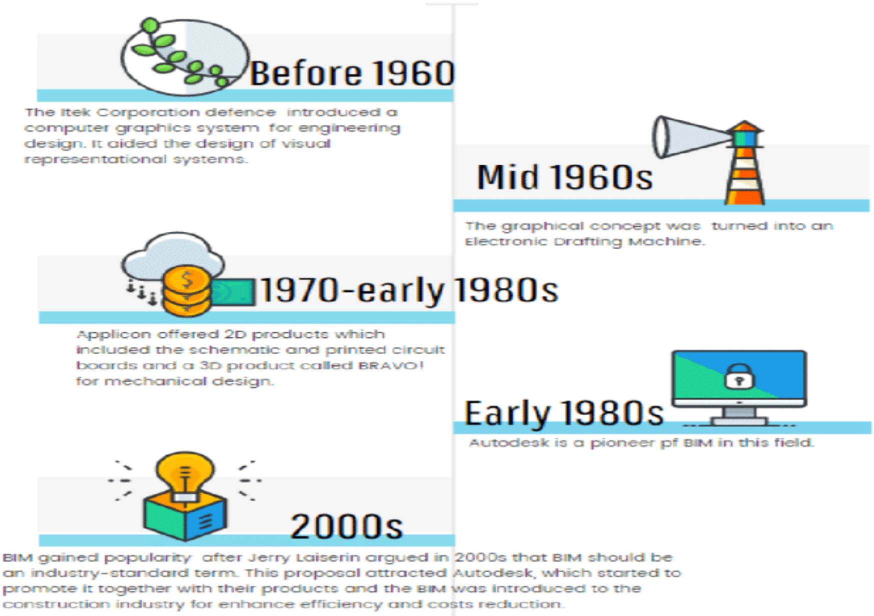

Figure 7. A brief history of BIM

The American Institute of Architects (AIA) Building Information Modelling Protocol Exhibit defines the Building Information Model as "a digital representation of the physical and functional characteristics of the Project and is referred to in this Exhibit as the "Model(s)," which term may be used herein to describe a Model Element, a single Model or multiple Models used in the aggregate. This definition refers to the data organized to represent the project electronically. The document then defines Building Information Modelling as "the process and technology used to create the model"[57]–[60]. The product, or representation, is differentiated from the process of designing and organizing.

The exact inception of the acronym "BIM" to describe the evolution of computer-aided design (CAD) from a two dimensional platform to an object or parametric based design technology is debatable. Authorship of the phrase, however, is widely attributed to Jerry Laiserin. Jerry Laiserin is an industry analyst specializing in future technologies for the building enterprise and on collaborative technologies for project-based work[61]–[81]. In the introduction to Building Information Modelling, the authors present the case that the term "BIM" first came into popular use as a result of its publication by Jerry Laiserin in his authorship of Laiserin Letter No. 15:

"In the December 16, 2002, issue of the LaiserinLetterTM…. Citing a recent meeting of building industry strategists… Laiserin made a cogent argument for the term "building information modeling," or BIM, as the best term to describe "the next generation of design software".

Although the popularization of the term "BIM" is attributed to Laiserin; Laiserin considers himself as one of many contributors to the development of the term and notion of "Building Information Modelling." As cited in the foreword of the "BIM Handbook," Laiserin accounts that:

"The earliest documented example… found for the concept we know today as BIM was a working prototype "Building Description System" published in the… AIA Journal by Charles M. Eastman… in 1975".

According to Laiserin the first documented use of the phrase "Building Information Model" in the English language appeared in the paper Automation in Construction published by G.A. van Nederveen and F. Tolman in December 1992. Regardless of the origins of the acronym "BIM," building information modeling is popularly considered among the architecture, engineering, and construction (AEC) industries as the future of how we design, construct, and operate the built world.

2.2 BIM Definition

A Building Information Model, (BIM) is a digital representation of physical and functional characteristics of a facility (Figure 8). As such it serves as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its lifecycle from inception onward. A basic premise of BIM is collaboration by different stakeholders at different phases of the life cycle of a facility to insert, extract, update or modify information in the BIM to support and reflect the roles of that stakeholder. The BIM is a shared digital representation founded on open standards for interoperability as defined from National Building Information Model Standard (NBIMS) committee (Life-cycle management of the built environment,2013).

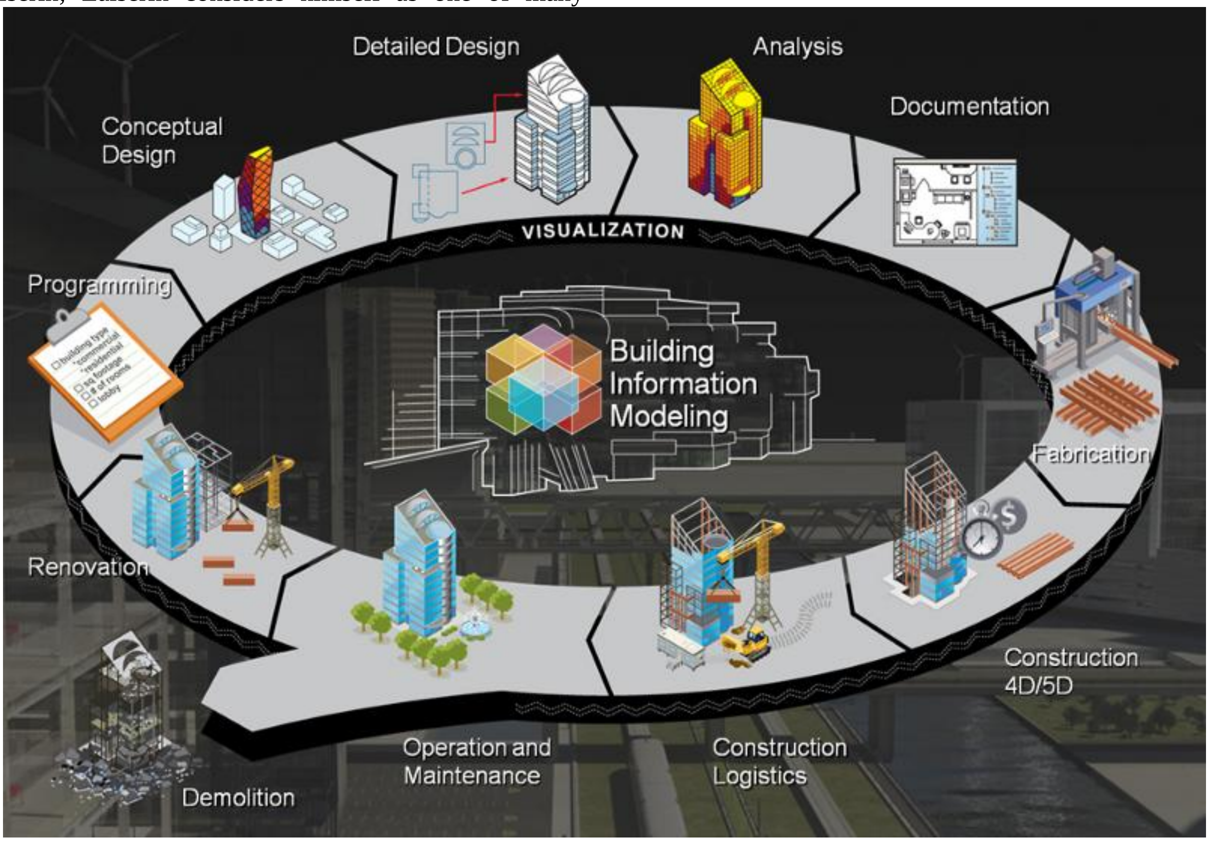

Figure 8. A Building Information Model, (BIM)

When used as a verb, Building Information Modelling refers to the act of simulating real activity relating to a building or construction project .
Similarly, the BIM Smart Market Report by McGraw-Hill defines BIM as “the process of creating and using digital models for design, construction and/or operations of projects”[82]–[86]. Whichever the case or tense, BIM refers to a relatively new technology that supports visualization and communication of building design and construction processes. Rather than a software, BIM is “a systems approach to the design, construction, ownership, management, operation, maintenance, use, and demolition or reuse of buildings”. The most important part of BIM is not the software functionality, but collaboration in the design and planning process which speeds the process and clarifies design. Depending on context “BIM” may be used to represent either of these definitions in this work.
BIM is a modelling technology and associated set of processes to produce, communicate, and analyse building models. Building models are compiled using intelligent digital representations of building components embedded with parametric data that describes how they behave; these components are also known as parametric objects[17], [46], [87]–[91]. The building models developed are also consistent and coordinated such that the possibility of redundancy in data is eliminated.

2.2.1 Benefits of Implementing BIM in the Construction Industry:

Although the application of BIM technology is relatively new to the construction industry three applicable benefits based on the current level of development of this technology include,
1. *Construction Planning and Phasing* – the linking of a construction schedule to three-dimensional objects in a design to simulate the construction process and observe the status of a construction site at any given point in the schedule. This particular attribute can be beneficial to contractors as an aid in coordinating temporary construction elements, staging areas, and potential safety issues.
2. *Pre-Construction Clash Detection* – since in a building information model all aspects of the project are developed in a 3-dimensional environment from which 2-dimensional drawings are extracted discrepancies in drawings are eliminated. The routing of components for multiple systems can be adjusted to eliminate both hard and soft clashes proactively in the model’s simulated environment as opposed to reactively in the field.
3. *Quicker Response to Design Changes* – the parametric nature of the building information model’s components enables a contractor to obtain rapid information in reference to changes associated with the design. The associative properties of the model elements allow any changes made to the design to propagate throughout the model and the revised information withdrawn from the model itself as opposed to the manual updates, checks, and data collection of traditional systems.

2.2.2 Pre-Construction and Post-Construction Benefits to Owner

Owners and operators of facilities can derive enumerable benefits from initiating, funding and maintaining Building Information Models. Building Information
Models help owners increase the value of their buildings by facilitating energy design and analysis earlier on in the project. Building Information Models can help shorten project duration by providing opportunities to coordinate the design and prefabricate building elements. A high level building information model built at the programming stages of a facility‘s lifecycle can provide reliable and accurate cost estimates which the owner can use at a stage where project decisions will have the greatest impact. Owners can be assured of program compliance per the design and code requirements through a building information model. As built information from a Building Information Model can be used to populate the facility management database with information regarding rooms spaces and equipment. Building components can be associated with maintenance timelines and costs to get financial condition assessment information over a period of time. A building information model can also be used to rapidly evaluate the impact of retrofit or maintenance work on the facility.

2.2.3 Design Benefits to Architects and Engineers

Building information modelling can benefit all stages of the design process from the conceptual and schematic design phase to producing construction documents for review. The schematic design phase shows the design of the programmatic requirements, massing of the building, possible materials and finishes and types of building systems and subsystems. The design development phase develops generic details for the structure, walls, facades and MEP (Mechanical, Electrical and Plumbing) systems. The construction detailing phase shows detailed plans for demolition, site preparation, and detailed specification of building systems, sizing and connection of components. The construction review phase facilitates coordination between details and as built conditions. Building information modelling helps in redistributing the effort from the later stages of design to the earlier stages of design where changes to design have a higher ability to impact cost see Figure 9.

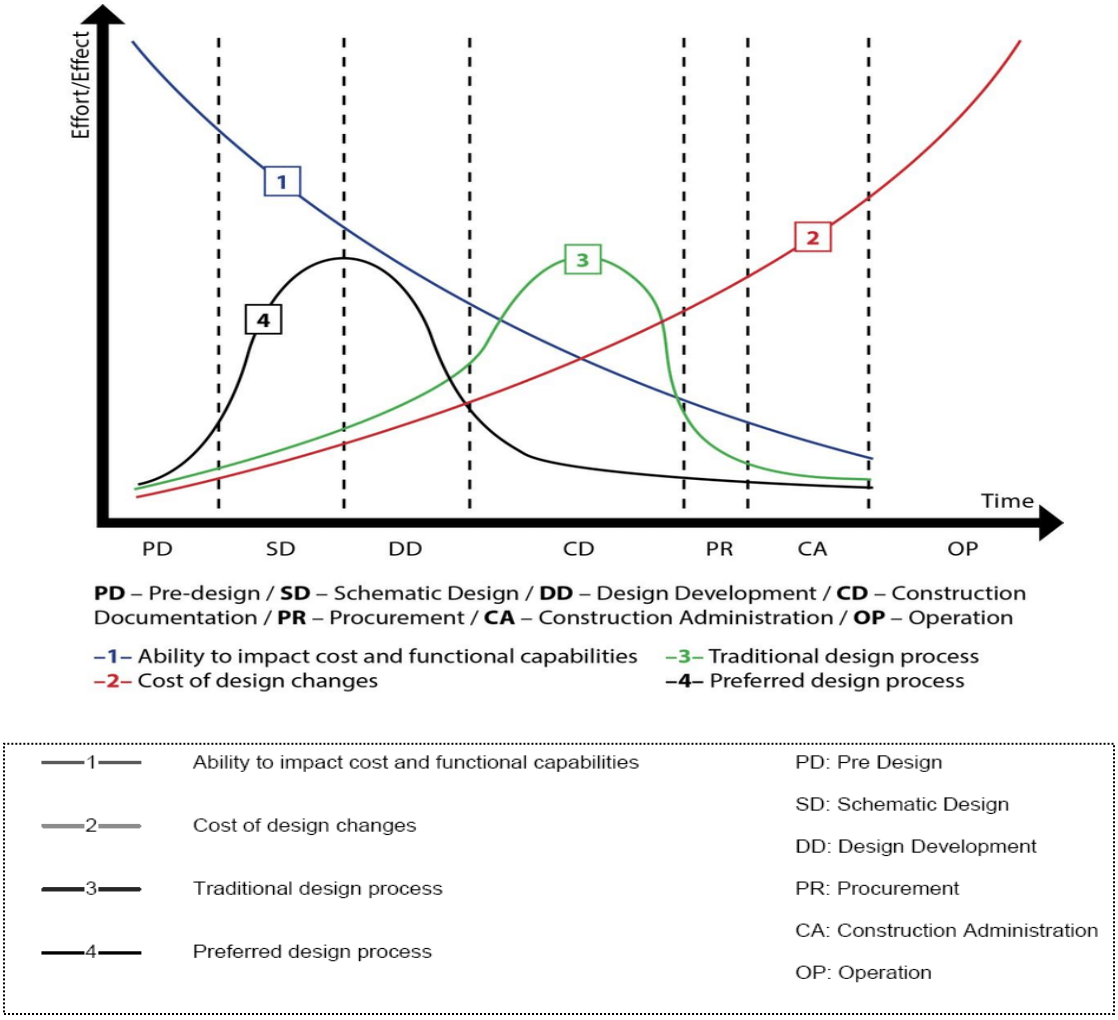

Figure 9. Value Added, Cost of Changes and Current Compensation Distribution for Design Services[1].

At the conceptual design phase a building information model provides checks for sitting, massing and a visual feel for fitting and locating the programmatic requirements within the building. At the detailed design phase BIM is used for the design and analysis of the building systems. Various design and modelling software can help in analysing a building‘s structure, temperature, lighting, acoustics and energy consumption. The information contained within a building information model not only aids in analysing a particular aspect of the design but can facilitate cross discipline design iterations to produce the most efficient design. Building information models can expedite the process of creating construction documents for the construction document phase. Placement and composition rules within a BIM software can help standardize and expedite the production of construction documents. During the final phases of design development the BIM aids in the integration of the design and construction. In a design-build delivery process it can expedite design iterations that help in developing a design favorable for a faster and more efficient construction process.

2.2.4 Construction Benefits to Contractors

A building information model offers many benefits to developers and contractors during the construction phase. A building information model can be used to reduce design errors by using clash detection. After the design phase and just prior to construction models containing construction details from various subcontractors can be merged to detect any conflicts between the various building systems such as clashes between MEP systems, and structure and MEP. BIM software that helps in clash detection not only facilitates automatic geometry clash detection but also allows semantic and rule based conflict analyses that allow for identifying interferences based on proximity and systems.

A building information model can assist in quantity take-off and cost estimation, Counts of building components, linear footages of pipes, areas of surfaces and volumes of spaces can be extracted from a model and associated with costs to produce project estimates. A building information model linked to a schedule can simulate the construction process. A time based simulation provides better insight into the construction sequence, detects time based interferences, help in better trade sequencing and improves site logistics by optimizing crane layouts, lay down areas, location of large equipment and office trailers.

A Building Information Model can also be integrated with cost and schedule control and other management functions. Building components in BIM can be provided with status as a property which can be then associated with colours to quickly be able to identify areas behind schedule. Objects in BIM can be used to quickly populate a procurement database.

Some applications (like 1st pricing) allow procurement within BIM applications, providing direct quotes to components such as doors and windows based on zip code. An accurate building information model can readily and accurately facilitate offsite fabrication. BIM can transfer geometrical, dimensional as well as finish information from a subcontractor‘s detailer directly to the fabricator, reducing the need to recreate the information and at the same time reducing errors during data transfer. BIM can also be used for onsite verification, guidance and tracking of construction activities. Laser scanning technologies that report into a BIM tool can help verify locations of building systems for critical pours. Dimensions from a BIM tool can be used to guide machines that excavate and grade earthwork.

2.2.5 Building Information Modelling Benefits for Subcontractors and Fabricators

The benefits of BIM for Subcontractors and fabricators include:

- Enhanced marketing and rendering through visual images and automated estimating
- Reduced cycle times for detailed design and production
- Elimination of all design coordination errors
- Rendering through visual images
- Automated estimating
- Reduced cycle time for detailed design and production
- Elimination of almost all design coordination errors
- Lower engineering and detailing costs
- Data to drive automated manufacturing technologies
- Improved preassembly and pre fabrication.

2.2.6 Challenges of Implementing BIM in the Construction Industry

The implementation of BIM practices highlights a number of benefits to all members of a project team; nonetheless, current practices within the AEC industry are not formatted to facilitate integration between the distinct project phases (design, construction, and facility management). Introduction of a collaborative based technology such as BIM therefore will warrant a shift from the predominantly segmented nature of the AEC industry towards a more integrated approach.

The challenges of implementing BIM in the construction industry include organization, economical, and legal issues.

Due to the predominantly segmented nature of the AEC industry, in implementing BIM practices contractors will have to take on a more collaborative role during the design phase and in facilitating transition into the operation and maintenance of the project. Moreover, making the transition from two-Dimensional based practices to a BIM based process will require investment in software, hardware, and staff training, as well as restructuring the firm’s business such that the BIM process is tracked, modified as necessary, and implemented successfully. BIM practices involve implementation of a new ideology in terms of performing routine actions and not simply performing these routine actions in a new way.

Contractors also incur an economic cost associated with the implementation of BIM processes. The initial investment in implementing BIM practices includes the acquisition of BIM based software and the necessary hardware to properly operate it, as well as the necessary training to enable project team members to properly implement the technology. Another cost associated with BIM implementation is development of the building information model. If the design firm does not provide the contractor with a model, the contractor will have to incur the cost of developing. Furthermore, the model developed by the architect might not include the necessary information for the contractor to benefit from the model; as such a new model will have to be developed. These added costs incurred by the contractor in implementing building information modelling will consequently find their way into a contractor’s overhead cost and into the project estimate. The added overhead cost can potentially be the difference between being awarded a contract and losing it.

2.3 Claims in Construction Projects

There is no unique definition of claims in construction projects, but it has many definitions as follows; researchers defines construction claim as a request by a construction contractor for compensation over and above the agreed-upon contract amount for additional work or damages resulting from event that were not included in the initial contract[92]–[98]. As result of the whole definitions, the claim can be define a compensate request by the contractor or owner for an extension of time or additional cost as a result of a cause led to an increase in the cost of work and need more time to complete, or as a result of damage by the other party.

2.3.1 Causes of Construction Claims

Many researches study the causes happened in construction projects which lead to claims , as a result of that, construction projects suffering from behind schedule and overrun budget. Depending on these research causes of claims can be classified into four groups as following[93], [99]–[116].

1- Causes related to owners.
2- Causes related to engineers (consultants).
3- Causes related to contractors.
4- Causes related to others parties.

2.3.2 Causes of construction claim related to owner

In Construction industries, there are many issues related to owner can cause claims as a result of that such as following:

1. Change and Variation order: Changes are abroad topic. Claims in construction project included any situation where the owner directs the contractor to perform work that is different from work defined in the contract. Variations are common in all types of construction projects.
2. Construction projects can cause substantial adjustment to the contract duration, total direct cost and indirect cost.
3. Delay caused by owner: Delays in construction project are routine and causes huge losses of resources, and aggravation are an everyday occurrence
4. Delay by owner comes as a result of conditions of an existing facility, which should provide like proper site access, or facility that are made as a part of the contract work that differ in their location, sometimes when the owner directly responsible to provide materials, equipment’s, furnished and other items,

where delivered late or defective, the possibility to submit claim by contractor will arise.

5. Oral changes order :Oral changes order considered as a part of changes that happened in construction projects, while written changes order has gone through an approval process, which too long or in case the time is inadequate, the contractor may proceed with only a verbal changes order. The oral changes order have to be written in formal to save rights of projects parties, as well as prevent to develop for dispute.
6. Owner Attitude: Contractors ordinarily expect to perform their works efficiently and high productivity without owner interference, in case owner interference in all events, the claim of interference will increase according to that.
7. Termination of contract: During the project construction, some causes may be happened that lead to terminate the contract which lead to a conflict on owner or contractor directly.
8. Suspension of Works: Suspension of works is an owner's direction that the work may be stopped on part or for the whole contract. The duration must be reasonable length and suspension must be valid causes. The right of suspension is unilateral, the contractor can't initiate a work suspension, and however the contractor can hart stop, curtail or alter his operations in the face of massive changes on the premise of damage mitigation.
9. Bad Coordination and Communication between Parts: Most of the disputes, as a several researches established, are due to lack of communication and coordination interface management in the design phase. These lacks lead to difficult access of working area and conflicts in the requirements of various parts during constructions. Improve coordination in construction projects especially those with relatively long period, cooperation among owner, designer, consultants, contractor and suppliers, lead to projects with least conflicts, improved costs and schedule. It is beneficial for parts to have more complete understanding of the other parts.
10. Planning Error :The time is beginning from idea's creation of project through decision to pursue a project until completion project take a several years, during that period of time many factors can influence the owner's decision on what they wants, need, and can afford as a final product, the owner could require addition parking, different offices configuration, different information technology capability, or different quality finishes that previously chosen.

2.3.3Causes of construction claim related to Engineer (Consultant)

As owner in construction industries, engineer decision or his work can cause a claim like following;

1. Estimation Error: Engineer estimates the quantity of works for construction project items and puts it in Bill of Quantity (BOQ), so any error will be happened in estimation of works will lead to disruption in construction phase.
2. Scheduling Error: Engineer makes a project schedule according to estimated duration of works, say that the schedule may be updated in order to monitor the time and work in construction project. Depending on that, any error in schedule will lead to confusing and disruption in construction projects and may raise the claims.
3. Specification and drawings Inconsistencies: Specifications are written documents that describe in detail the requirements for products, materials, and workmanship upon which the construction project is based. While drawings are the principal part that set of construction documents show lines and text for the purpose of providing information about the project.
   A complete set of construction documents contain drawings and specifications that prepared in professional manner with effective communication. Sometimes the drawings ask for one product but the specification calls for another, this situation is very common on construction projects where the drawings are assigned to different consultants, each one of them is acting on their own without any kind of direction from a team leader, that leave the contractor with difficult task of assuming and quoting on one article.
4. Design Error or Omission: The design stage is relatively short compared to the duration of project as all, but it has a large impact on the project, some studies have related that more than half of the construction projects overrun on both budget and time at completion and these problems largely occur due to design changes, scope changes, omission, and correction in design. Incomplete design occurs when a designer fails to identify the project scope to the level sufficient to allow the contractor to adequate and execute the work.
5. Poorly Written Contract: The contractor construct a project with detailed plans and specification provided in contract documents, so any weakness in written contract will produce confusion and disruption to contractor, while the contractor can't deviate from the specification prepared by the owner unless know about defects or oversight. Poorly written contract lead to errors in omission, contract drawings, specification or the contract language.
6. Unreasonable Supervision Attitude: Sometimes Engineer (Consultant) requires a standard of workmanship or work process not as required by contract or in excess of standard industry practice. In this case if the contractor feels that it is being held to an incorrect or exceptional standard, that lead him to review the contract, specification and codes related to that works, as well as analysis of the workmanship required by consultant and compare it with current standard practice accepted for such work.Professional experience and judgment is an important factor for completion of building project successfully.

2.3.4 Causes of construction claim related to Contractor

Causes of claims that related to contractor can be taken in both sides, for contractor or for owner base on case of claim itself. Causes of claims related to contractor can be classified as following;

1. Variation in Quantity: Sometimes within construction process, the amount of quantity works may differ from which are shown in drawings, confusing that,

causes by this different in quantities resolving in contract documents in a certain clauses, it is rarely happened claims in construction projects.

2. Subcontracting Problems: It is stated that lack of coordination between contractor and subcontractor will lead to delay work activities. In many cases in construction projects, problems between contractor and subcontractor like delay in payments, reflected directly on process of work that consider as a default to owner, who may claim for compensate this default.
3. Delay caused by Contractor: Process of work on a construction project is composed of complex and interrelated activities; therefore a delay in any activity may create confusion for others, in addition to affect the ongoing process of the next activities. Delays in the delivery of the project lead to the loss of the owner like revenues to run the project, which may not be compensated by delay penalties which not exceed 5% of total cost of project and 10% in special contract in building projects in Jordan.
4. Not Well Organized Contractor: Contractor organization need for essential communication links between different levels of the organization in contractor firm, therefore miscommunication will lead to disruption of contractor as will, lead to delay and overrun of construction project.
5. Contractor Financial Problem: Financial difficulty is defined as getting into a situation where a respondent's credit is adversely impacted, such as not paying bills. Contractor financial difficulties are defined as the contractor not having sufficient funds to carry out the construction works. So owner have a contractual rights to claim damage against the contractor associated with failure to pay for labours, materials, or equipment's utilized in the project due to problems in contractor financial condition.
6. Bad Quality of Contractor Works: Defective works are commonly in construction projects, so the owners have the right to claim against contractor for repair the defective works, or compensate the decreasing in project value due to bad quality.
7. Accidents (Bad Safety Implementation): Accidents occur in building sites. Occasionally, the damaged materials or the fabric of buildings which are occurred by negligence or mistakes during construction, so that in the most cases the owner or contractor has insurance policies that cover this damage, taking in consideration that claims happened due to this reason is rarely.
8. Poor Management and Administration of Construction: Effective management and administration on construction site by contractor is very important to ensure the project to be completed on time, will stop confusion occurring within construction process. Poor site management may occur when contractors do not have enough experience and suffer from a lack of knowledge in managing the project team.
9. Acceleration of Work: Acceleration of work is normally happened in construction project, when delay occurs and completion date not modified to match this delay. The contractor must increase work's rate productivity to recover this delay. In case, contractor cause this delay the cost of acceleration work is non-compensable, but if owner cause a delay or request to expedite works for earlier completion, contractor has a right for compensable time and money.
10. Changes in Material, Labor, and Machinery Costs: Construction process took a long time until to finish project, so changes in cost of material, labor and machinery can occur at any time of construction.

2.3.5 Causes of construction claim related to others

In many project some of claims that happened do not related to owner, engineer or contractor, but happened as a result of event by other parts such as;

1. Low Price of Contract Due to High Competition: It is argue the following "The sluggish global economy has created an environment in which construction firms are forced to bid project at or below minimum profit level". In addition in case decreasing the numbers of construction projects which lead to increase the competition between contractors, so the contractors bid low price to get a project and depend on claim may happened to increase their profit.
2. Subsurface Problems: The assumption on the soil condition or other issue regarding the construction of the project can be different from the actual condition in the site. Underground works design based on subsurface investigations conducted by or for the designer, the results may or may not be made available to the contractor, but the resulting design and anticipated conditions are implied within the contract, so any changes in these implied or stated underground conditions can result in changing conditions.
3. The Effect of High Inflation: Nowadays, inflation is considered as one of the most factors which is affecting global economy, construction projects as all things in life influenced by inflation, but the claims regarding inflation still so rare.
4. Government Regulations :Local government may have specific regulations that should be followed, government regulations affect construction projects directly, for example in some cases transportation authority's specified a certain hours for trucks to pass, or prevent casting concrete in certain time of day.
5. Climate, Earth quick and Volcanoes :Coverage of the weather conditions are varied from contract to others, but as all in Jordan, the Ministry of Public Works and Housing issue a compensate time for delay occurs by weather, depend on that, the claims because of weather is rarely as well as earth quick and volcanoes.
6. Fossils: Fossils have important value for countries; it reflects the historical records for the life in that location, so when we start a construction project, the most essential thing is to check that there are no fossils in project's location. On other hand, fossils found in any construction project causes stop of works as well as disruption in work which lead finally to construction claims by contractor to compensate delay, but it is rarely happened.
7. Delay by Authorization: In some cases authorization issue temporary regulations or instructions that can cause delay in construction process or stop it, in this case contractor request to compensate for this damage.
8. Major Force: Strikes are considering as a major force events,

because under typical construction contracts, labors are treated as situations that are beyond the control of both parties. Strike entitles the contractor to time extension but rarely give the contractor entitlement to additional compensation. War is considered as major force, but it is rarely happened or considering that not recently in Jordan.

2.3.6 Claims Classifications

A significant number of research papers try to identify the main types of construction claims in construction projects over the worlds, as a conclusion, the following are the main types of construction claims.

1. Contract Ambiguity Claims (Contractual claims): Contract Ambiguity claims refer to incomplete and inadequate understanding clause of contract forms and conditions; in addition, it is a logical result of poorly written contract and ambiguity on some clauses.
2. Delay Claims :In construction, delay claims often happen in all construction projects even by contractor or owner, delay means the time overrun beyond the completion date of the project. To the owner, delay means loss of revenue, while to the Contractor means higher direct, indirect, and impact costs. Moreover, it is simply defined delay as a project slipping over the planned schedule. Type of Delay in construction projects can be divided into three categories: direct delay .concurrent delay and serial delay.
3. Acceleration Claims: Acceleration claims refer to accelerate works which can take many forms such as working longer shift, increase equipment's and labor, as well as performing various tasks concurrently. The difficult aspect of establishing acceleration claims may determine the reasons and compensability of acceleration efforts. The requirements to accelerate works may originate from three sources. Contractor Direct Acceleration, Owner Direct Acceleration and Constructive Acceleration.
4. Changes Claims: Changing in construction is normally happened in all projects by adding or deleting some items in contract, modified of works, or changing material... etc., changing is a result of changing owner scope to meet his needs (requirements) or discovery of design error, this changing can be written or orally ordered, however time of changing considered as a very important thing.
5. Extra Work Claims :Extra work claims refer to owner's ordered to contractor for doing some works – often after construction – as a part of his responsibility (scope), but not included in original contract, while contractor performance work should be as mentioned by the contract documents, however the contractor believes that he is performing extra works.
6. Different Measurements Pricing Claims :At final stage of construction conflict between owner and contractor may be happened due to disagreement of measurements which lead to claims, these claims included the differences in pricing of some items like material.
7. Different Site Conditions Claims: During the construction process contractor may face subsurface or hidden condition which are unanticipated and have major impact on project cost as well as completion date, so we can define different site condition claims as changes in physical aspects of the project or its site which differ materially from that shown in contract documents.
8. Damage Claims: Damage claims may be happened due to act of the owner or safety related problems, but it is rare to happen, because in construction projects contractor has total responsibility for the site.
9. Negligence Claims: Negligence is that claims fall below standard established by the law for protection of others against unreasonable risk of harm, which can arise from action or inaction, which is essentially a failure to do something required by contract, however negligence include a failure of a part to warn another part about defect, potential loss or danger.
10. Inefficient and Disruption Claims: Disruption between parts in construction project happened when performing contract work in different and less efficient that originally planned. Often contractor bids a project with cost for work based on assumption concerning construction procedures, level of manpower and material, in addition sequence of work activities, so any discrepancy from these factors will cause increasing in the cost required to perform the contract works. While inefficient claims related to substantiated incremental cost incurred due to losses in productivity construction, however the most successful method to counting losses in efficiency by comparing the productivity in normal period of the project to productivity in disruption period of the project.
11. Termination Claims: In case the owner terminates one part due to default, may be suffer from damage related to the delay and increase cost associated with having a different part to complete the work.
12. Quantum Meruit Claims: Quantum Meriut is Latin; it means pay after check the quantity, This type of claims considered as one of the common types of construction claims which happened due to alleged breaches or change to construction contract, however it based on the theory that the contractor should be compensated for its work to prevent "unjust enrichment" of the other part receiving the benefit of work. It attempts to quantify the increased unreimbursed value of the project occurring from the contractor additional efforts that are caused by the owner.

    There is different between quantum merit claims and claims related to the changes or extra works, where claims refer to right of contractor for recover the cost of changes or extra works imposed by owner, while the quantum merit claims is based on an implied right to be reimbursed for work performed.
13. Owner Claims for defective Work and Delay :Sometimes owner may be suffer from direct damage of the action of several parts in construction process, such a delay, defective or incomplete work, and third part claim, which giving rise to owner claim. In addition, the action of the part may be given another part to raise a claim against the owner like delay in return shop drawing from engineer who gives contractor right to construction claim against owner.

2.4 Impacts of BIM and Claims on Construction Projects

Claims arise in construction projects for many different reasons such as, contract ambiguity, delay in construction process, changes, extra works and others. Claims may involve numerous issues resulting from the owner, engineer, designer and contractor that affect construction process and lead to disruption and confusion between all parts. Early notice of claims has the advantage of enable the parts in early stage of project to minimize and avoid the impact of potential claims, which at the end of projects lead to increase project time and/or cost.

Many researches study the impact of claims on construction projects, and found that the effect of claims are different from project to another, based on some criteria like nature of project. It is identified that half of claims happened in the construction projects in Canada constitute additional cost of the origin contract value by more than 30%, in addition to about one third of claims amounted at least 60% of the origin contract value[95], [102], [117]–[120].

In the other side there is strong awareness in the region of BIM and its value to the construction industry. Seventy-nine per cent of the initial survey respondents indicated awareness of and/or exposure to Building Information Modelling. Within the BIM users respondents there was strong recognition of the real value of BIM (Figure 10) shows the benefits to BIM users. This level of recognition was fairly consistent across all company types, indicating general agreement on the perceived benefits of BIM by all respondents[121], [122].

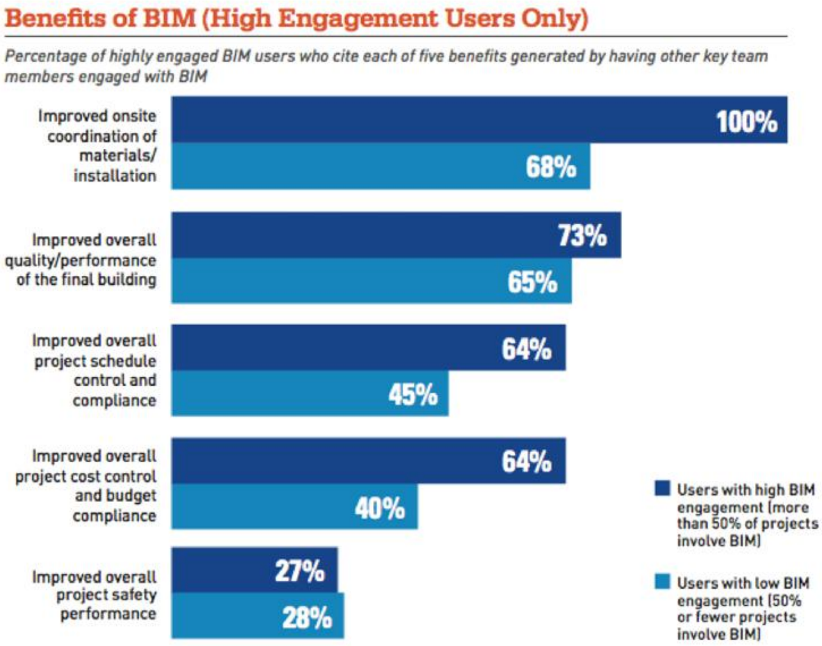

Figure 10. Benefits to BIM users [2]

The common evaluation of BIM savings is based on how many changes were eliminated and therefore extra costs avoided. The actual amount is not known, Following are samples of proclaimed savings:

• Estimated returns of 2 to 1 and approximately 10% labor savings.

• Design firms experienced 50% productivity gains by half of Revit users .

• Labor productivity 15% to 30% better than industry standards.

• Engineers had 47% decreases in labor hours needed to design and manage projects .

McGraw Hill Construction issued a report entitled “Building Information Modeling (BIM): Transforming design and Construction to Achieve Greater Industry Productivity “on December 2008, presenting the impact of using BIM in the construction industry in the US. This report, which is produced in collaboration with 23 construction industry organizations ;including 15 associations and the U.S. Army Corps of Engineers ; is based on extensive interviews with hundreds of owners, architects, civil, structural, and MEP engineers, construction managers, general contractors and trade contractors who are currently using BIM.

- 62% of BIM users use BIM in more than 30% of its projects in 2009
- 82% of experts believe that use BIM has a very positive effect on the productivity of the company
- 72% of BIM users say that BIM had an impact on their internal project processes.
- 20% project cost savings
- 25% faster delivery.
- 35% improved safety record
- 30% increased productivity

The Stanford University Centre for Integrated Facilities Engineering studied 32 major projects that utilized BIM and found the following benefits.

- Up to 40% elimination of unbudgeted change
- Cost estimation accuracy within 3%
- Up to 80% reduction in time taken to generate a cost estimate
- A savings of up to 10% of the contract value through clash detections
- Up to 7% reduction in project time

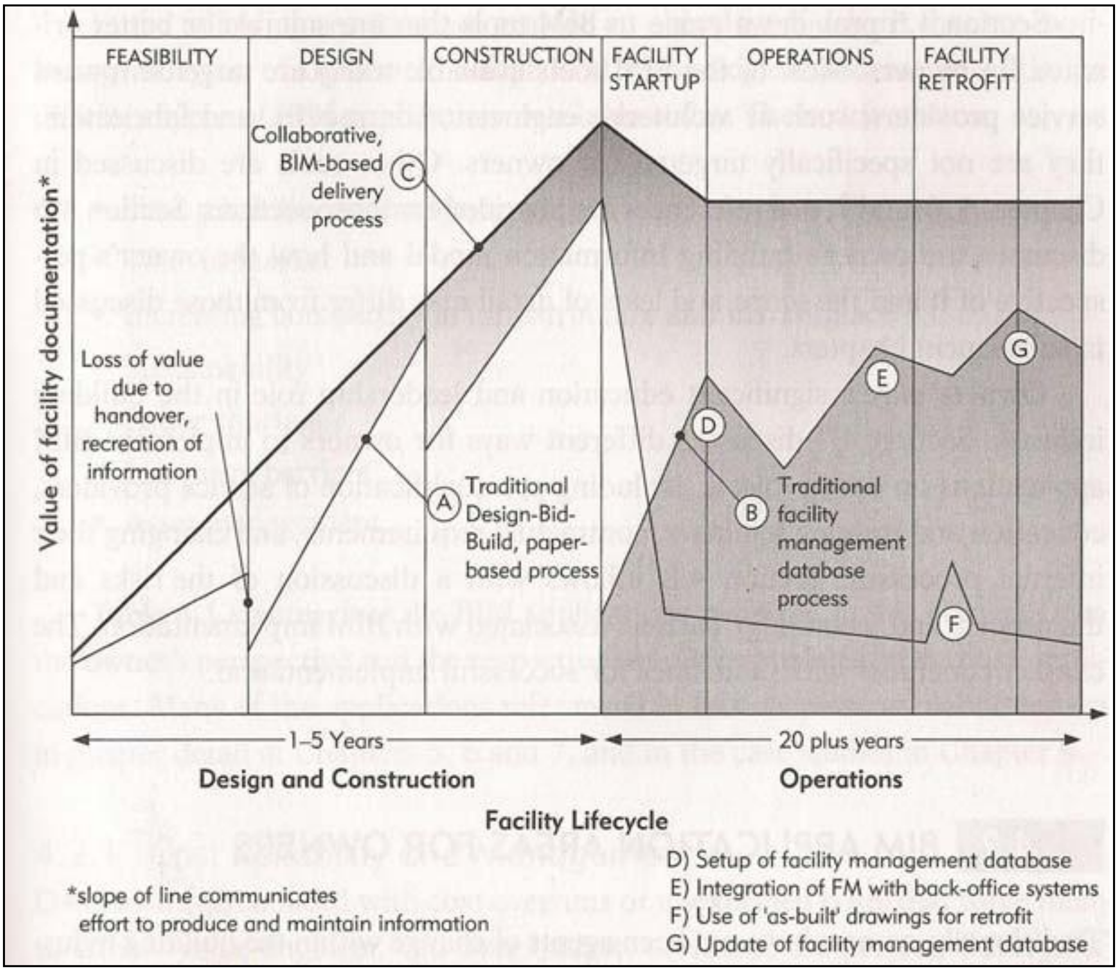

Figure 11. Illustration of information loss at process phases [1].

Smith proposes that one way to improve this loss of value is to have reliable information on the building. This not only improves the construction and operations of structures, but also allows better deconstruction and reuse of raw material. Drawings used by contractors are pictorial in nature, but facility operators use an alphanumeric system for running the building. There are arguments that the BIM data interoperability issue could be solved by using open source for developing software. This requires a modular design for independent and concurrent work where the information can be exchanged easily because it is in smaller pieces.

IV. CONCLUSION

This paper has evaluated the use of BIM in claims management associated to the traditional
methods, to establish the effect of BIM on evading and/or reducing construction claims. To
accomplish the aim of this research. BIM application in construction projects has great influence on reducing and/or avoidingconstruction claims. The paper intended to define a framework of preemptive effects and reactiveschedules to claims. This mechanism helps protect projects against claims and in case oftheir happening.The paper has also reviewed the local and worldwide trends of disagreement value and length. These preliminaryfacts underlined the economic and social implications of construction claims. In the analysispart, the paper pointed out how BIM improves data and information management, cuts costsand reduces time taken to manage claims. Critically the paper has addressedbriefly how BIMsolves major problems and challenges in claim management.

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