

STRUCTURAL CONTRACTS AND LIABILITY CONCERNS ASSOCIATED WITH
BUILDING INFORMATION MODELING

by

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Abstract

Building Information Modeling (BIM) is altering the way that the construction industry is developing design documents by involving all members of the design team as well as the general contractor early in the design process. The members are encouraged to offer advice on the design and constructability on the project. However, not only is the design process changing, but the liability and responsibility of each team member is changing as well. The alteration in responsibility can severely impact structural engineers because of the level of responsibility already associated with their role in the design process. This report looks at the concerns industry leaders and legal professionals have with how BIM is altering the liability landscape, such as standard contracts, software interoperability, data misuse, intellectual property, loss of data, the legal status of the model, the standard of care, and design delegation. In addition to the liability concerns, this report examines the steps that industry leaders have taken to prevent any unnecessary additional liability from affecting structural engineers.

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Dedication

To my family: without their help and guidance this report would have never been possible.

1.0 Introduction

The construction industry has been experiencing productivity losses since the mid 1960's (O'Connor). In a study done by the US Department of Commerce, non-farming productivity has increased by over 100%, while construction industry productivity has *decreased* by 25%. The changes in productivity for the construction and non-farm productivity from 1964 to 2003 are shown in Figure 1 in which both construction productivity and non-farm productivity are equal to 100% in 1964. The construction and non-farm labor productivity index is measured by "constant contract dollars of new construction work per hourly work hour" (Teicholtz, Ph.D.). This means that construction projects have a required substantially more work hours per dollar of the contract. Essentially, this is saying that the construction industry has not applied labor saving ideas and techniques that other industries have been applying for the past 40 years (Teicholtz, Ph.D.). In his article "Productivity and Innovation in the Construction Industry: A Case for Building Information Modeling," O'Connor suggests the decrease in the productivity of the construction industry has been directly related to fears of liability and risk during the design and construction process among other causes such as new safety standards. The decrease in productivity of the construction industry has forced industry leaders to change the way they do business at alternate design and construction practices which increase the construction industry's productivity. This led to the introduction of Integrated Project Delivery (IPD). IPD encourages collaboration among the owner, architect, engineer, general contractor, fabricators and subcontractors early in the design process which allows the design team to catch errors earlier in the design process, which prevents having to make design changes during construction. The introduction of IPD was integral to the success of Building Information Modeling (BIM) technology because both BIM and IPD encourage collaborative design amongst the entire design team to assist in preventing avoidable mistakes.

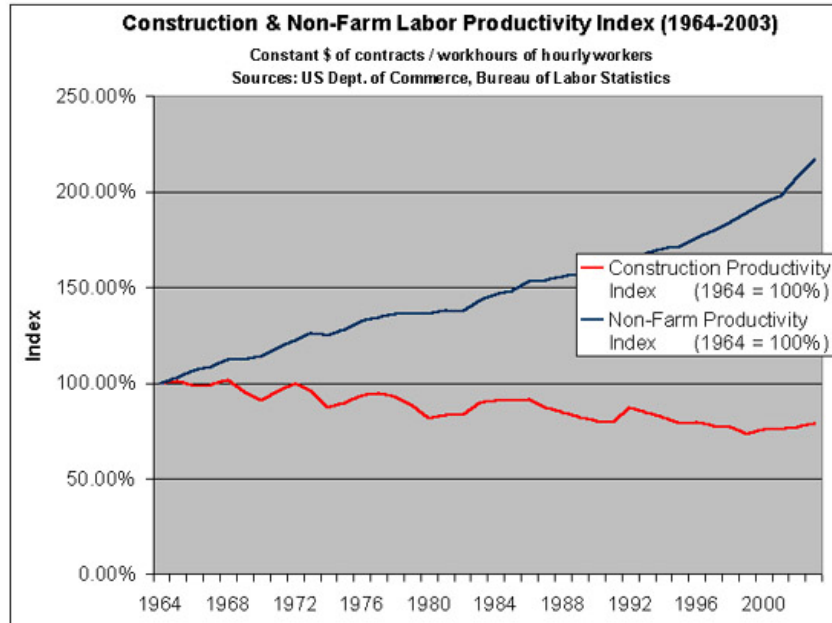


Figure 1 - Construction & Non-Farm Labor Productivity Index (Teicholtz, Ph.D.)

BIM was introduced to the construction industry approximately 10 years ago. Since then, owners, architects, general contractors and engineers have used it primarily for larger projects from data centers, convention centers to commercial high rise buildings, but recently even in smaller projects such as retail outlets (**McGraw-Hill**). A 2008 study done by McGraw-Hill surveyed hundreds of owners, architects, civil, structural, and MEP engineers, and general contractors with the “goal of to determine knowledgeable users’ perceptions of BIM adoption, implementation, value and impact within their firms” (**McGraw-Hill**). The survey found that “architectural, structural, mechanical and plumbing elements – in that order – are the most likely to be modeled when using BIM.” Structural systems, specifically reinforcing and steel details, were reported to be the most common modeling element used in BIM among engineers, with 49% of the participants reporting the structural systems “most frequent” modeled ones. In addition, the study found that “...the larger and more experienced an engineering firm is, the more likely it is to see these elements modeled on BIM projects” (**McGraw-Hill**). With the integration of different engineering discipline collaboration BIM has created an alternative way for the industry to operate, which could help solve the growing issue of construction productivity. This is especially true with the integration of IPD. Choosing an IPD contract structure without the use of BIM is very difficult. Either IPD or BIM could be used

independently of each other; however, the contract format of IPD is ideally standardized for using BIM and the two are intended to be used together.

This new construction process and technology has led to many questions regarding the liability and risk incurred by the parties that use it, which partially explains the decrease in the construction industry's productivity. The liability concerns have led precautions during a project that lengthen the construction process, which decreases the productivity. With the advancement in technology that BIM has provided it does not come without some legal concerns. Legal issues such as software interoperability, data misuse, intellectual property, loss of data, legal status of the model, the standard of care, and design delegation. This report examines the challenges that structural engineers encounter when they use IPD and BIM.

Professional engineers follow the Engineer's Creed as a way to give them guidance during their career on how to conduct themselves. The National Society of Professional Engineers' Code of Ethics Fundamental Canons state that "engineers, in the fulfillment of their professional duties shall:

Hold paramount the safety, health, and welfare of the public.

Perform services only in areas of their competence.

Issue public statements only in an objective and truthful manner.

Act for each employer or client as faithful agents or trustees.

Avoid deceptive acts.

Conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession. (NSPE-3).

With the use of BIM technology, engineers are responsible for knowing the risks, as well as the rewards for incorporating BIM into their projects. The introduction of new technology challenges the familiarity of an engineer with the software, which could affect the health and safety of others, as well as the engineer's job security and reputation, if careful practices are not taken to advance the users knowledge in the technology. Knowledge of the risks and common mistakes made by engineering professionals enables engineers to avoid serious mistakes later.

As NSPE Code of Ethics continues to state in Section 9.E:

Engineers shall continue their professional development throughout their careers and should keep current in their specialty fields by engaging in professional

practice, participating in continuing education courses, reading in the technical literature, and attending professional meetings and seminars (**NSPE-3**).

Section 9.E dictates that engineers remain current about new codes to perfect their technical expertise in structural engineering. Just as it is important to remain current about new codes, it is equally important to remain current about new technology that can make an engineering professional much more valuable in the profession by being more productive. In this particular case, that new technology is BIM and the benefits that this technology provides. In addition to understanding BIM, structural engineers must understand how the technology changes their liability. This report discusses how liability varies in different contract structures for Design-Build, Design-Bid-Build, and Integrated Project Delivery as related to the structural engineering process of a project.

2.0 Building Information Modeling

The application of computer assisted virtual design, known as BIM, is becoming more widespread in the construction industry (**McGraw-Hill**). BIM has the ability to depict buildings in a three-dimensional virtual format, which enables engineers to visualize the building structures that are more complicated, such as free form structures like the Rock & Roll Hall of Fame. The virtual nature of the technology has helped the structural engineer work with complex shapes with greater ease. This is why BIM has become popular, especially among professionals in structural engineering (**Hurtado, and O'Connor**).

The greatest challenge to fully understanding the impact of BIM is realizing that it not only encompasses new software that incorporates the computerized virtual model, but also changes the traditional process in which the project is completed. In fact the National Institute of Building Sciences defines BIM as follows:

A Building Information Model, or BIM, utilizes cutting edge digital technology to establish a computable representation of all physical and functional characteristics of a facility and its related project/life-cycle information, and is intended to be a repository of information for the facility owner/operator to use and maintain throughout the life-cycle of the facility (**Ashcroft**).

BIM uses data rich elements within the model that include but are not limited to the members' lengths, widths, physical properties, types of the connection to surrounding components, manufacturing locations and model part numbers (**Hurtado, and O'Connor**). All of this information can help the structural engineer design connections on complex structures. With the ability to virtually see a complex connection and all of the steel members incorporated in the connection will provide the structural engineer with the assistance that he or she might need to design an effective connection in a more efficient amount of time.

However, the introduction of BIM and its widespread use have created new legal challenges and liability issues. As Hurtado and O'Connor (2008) wrote:

It is not surprising that the legal community is struggling to assist in developing meaningful contract terms relating to the use of this technology, given the speed with which it has appeared on the construction scene, the lack of industry standards about what BIM is and does, disagreements about the process best used to generate model design and what deliverables should be derived from the completed model.

Since 2008, many new developments have taken place improving the use of BIM in construction projects. These improvements include new contract standard addendums such as the ConsensusDOCS Building Information Modeling Addendum titled ConsensusDOCS 301 or the American Institute of Architects (AIA) Building Information Modeling Protocol Exhibit, or E202. These two documents accomplish the same goal of outlining a detailed BIM execution plan that breaks down the design process that is used while applying BIM, the description of the model design level per contract, and clarifies and assigns additional risk that arises when BIM technology is used. This document defines controls for establishing the extent to which party members can use and rely on the information contained in the model protecting the structural engineer from the fabricator or general contractor from relying upon the model instead of the contract documents (**Hurtado, and O'Connor**).

3.0 Contract Document Process

Four significant reasons organizations such as the American Institute of Architects (AIA), the Association of General Contractors (AGC), the American Institute of Steel Constructors

(AISC) and the Engineers Joint Contract Documents Committee (EJCDC) provide standard contract documents for members of the construction industry exist.

First, the contract certifies a general business model by recommending a consistent operational framework that will work within the industry (**Ashcroft**). Construction projects extend across the nation, often employing construction firms from various states and are subject to various laws. Construction law in each state differs, which can cause confusion among construction party members if they happened to be from different states. A good example of this would be a mechanics lien. A mechanics lien is an insurance-like remedy that protects any construction party member from not being paid by allowing unpaid party members to file a grievance or a lien, which will enable them to acquire security against the property up to the value of the grievance. This also entitles the parties to legally file suit against members who did not directly contract for the work (for example, a subcontractor against a property owner). An example of varying state laws would be the amount of time allowed to a party member is entitled to file a mechanics lien. For instance, the statute of limitations, which limits the time allowed for filing the lien can vary depending on the state. For example, in Washington, the statute of limitations on such liens is 3 years; in Louisiana the statute of limitations is 10 years (**Wolfe**). Thus, the law in Louisiana protects against any unpaid monetary debts from the contract for an additional 7 years. Such a detail could easily be overlooked by the various parties in the construction team when a contract is developed. A standardized contract can protect against these mistakes, which can result in litigation after the project has been completed.

Second, standardized contracts provide a “consensus allocation of risks and an integrated relationship between the risks assumed, compensation, dispute resolution, and insurance” (**Ashcroft**). By using a standard contract, the structural engineer is knowledgeable and comfortable with the risk allocation procedure for each project contract. This also allows the structural engineer to gain familiarity on what to expect with contracts for similar scale projects. Custom agreements, unless drafted by experienced professionals, can lead to many mistakes and overlook many potentially contentious issues. For example, in the case *New Athens Generating Company vs Bechtel Power Corporation*, New Athens was the plaintiff arguing against the excessive liquidated damages that the company had agreed to in the contract. New Athens was asked to build a \$533 million power plant. The parties agreed to liquidated damages of \$149,000 per day for any unexcused delay in the completion of the project. The substantial completion of

the project was completed over 200 days late; this meant the liquidated damages amounted to \$26.9 million. When the issue was taken to court, the judge upheld the contract and New Athens was forced to pay the damages (**NSPE, “NSPE Lawsuit”**). In this case, New Athens Generating Company failed to provide any excuse for the excessive delay of the project causing the company to pay out \$26.9 million in damages to Betchel Power Corporation existed. Standard contract documents and/or experienced legal professionals can provide additional legal foresight in situations such as these to protect all of the parties involved.

Third, the additional cost for generating a customized agreement would be added to the project cost and could reduce the profitability of the project (**Ashcroft**). Lawyer costs can add up quickly. According Joe Knopp P.A., an experienced lawyer can cost as much as \$1000/hour. Such a cost is a function of how specialized the contract needs to be for a project. Contracts that are more unique take longer to develop, thus increasing costs. Expect the contract to cost “between \$500 and \$2,500” (**Knopp**). Such additional costs limit the amount of money left for the rest of the project. On the other hand, according to the AIA website AIA.org, the standard contracts developed by AIA will cost as much as \$25.

Finally, standard documents alleviate the pressure of documenting and preparing the roles and responsibilities of members of the project (**Ashcroft**). By using a standardized contract consistently, construction party members will better learn their roles and responsibilities per contract. The experience gained by consistently using the standard contracts among construction party members will allow for a more fluid work environment because of less confusion among the professionals.

The EJCDC provide contract documents are created and peer reviewed by experienced industry experts, which helps reduce conflicts and litigation among parties. These documents are balanced and fair provisions for the parties involved and are user-friendly, and that are easily customizable (**NSPE, “Contract”**). This group provides contract documents to all members of a construction team. The committee is made up of members from “NSPE's Professional Engineers in Private Practice, the American Counsel of Engineering Companies, the American Society of Civil Engineers, and the Associated General Contractors and involves the participation of more than 15 other professional engineering design, construction, owner, legal, and risk management organizations” (**NSPE, “Contract”**).

In addition to summarizing various contract standards, this chapter takes a comparison of two different steel structures and follows a steel member through the design process ultimately through installation. This comparison is done to see the difference in the process depending on the standard contract structure used in the design process. The steel member comparison will be between an arbitrary complex steel structure, such as a sports stadium, and a simple steel structure, such as a warehouse. It is assumed in this comparison that the foundation is already in place and the only structural elements left for design are the steel members.

3.1 Design-Bid-Build Standard Contract

Design-bid-build is considered the traditional method when designing and constructing buildings. In a design-bid-build project delivery method, an owner will hire an architect to design and develop a schematic design. After the owners approve of the design, the architect will assemble a team consisting of a structural engineer, civil engineer, electrical engineer, mechanical engineer, landscape architect, etc. This team will work on the schematics and design development for the project. Bids can go out at this time just to get a rough estimate of the project cost, but a general contractor that bids during this time is not guaranteed the final contract. Once the schematics and design development are approved by the owner the construction documents are completed. The construction documents are signed and sealed by the engineers and architect. The signed and sealed construction documents will then go out for bid to the general contractors (**Brookwood Group**). This process is a very systematic because of liability separation amongst every design team member that must be followed for liability concerns. A variety of contract methods are available to owners to choose from, including design-build, but design-bid-build is still preferred by many owners because of its precise separation of responsibility and liability among the construction parties (**Brookwood Group**). This is especially true in the public sector, which demands the specific liability assurances this method provides (**Brookwood Group**).

As mentioned above, industry officials have developed standard contract documents for design-bid-build. One example of an industry provided standard contract is the contract that was developed by the Engineering Joint Contract Documents Committee (EJCDC), the EJCDC A-990. Typically, when established owners and developers use the A-990, alterations can and will be made according to their own personal preferences in their project; this is not uncommon for

any of the standard contract documents. What makes the design-bid-build design and construction process different from IPD is the linearity of the risk and liability of the process. All design decisions are completed by each discipline, which protects each party from any risk that may be incurred by another design team member. Although following this linear systematic method clearly separates liability to each individual discipline, it also increases the project design and development stages. In this method, the owner will hire an architect (or engineer for infrastructure works). Once an architect has been hired, the architect will develop the building drawings. During this process, engineers are hired by the architect and have a contract with the architect for their design work. Once the architect's building design concept is complete and the owner has signed off, work to develop the contract documents begins. Once the contract drawings are complete, bids from general contractors are submitted to the owner within a specific time period. The owner will then determine the winning general contractor based on qualities such as lowest bid or experience with the type of project. Once a bid is accepted, the winning general contractor will establish a contract directly with the owner. General contractor separate their contracts for the engineer and architect for liability purposes (**Brookwood Group**). Figure 2 indicates the leadership breakdown including the project manager role. Figure 3 indicates the leadership breakdown for an alternative way of Design-Bid-Build without a project manager role, which is assumed by the general contractor. In the figures the arrows represent who reports to whom (for example the engineers still report to the architect because of their contract). However, the architect will report to the project manager. The dashed lines indicate those with whom the owner has a contract. The project manager position can be hired directly by the owner or can be employed by the general contractor.

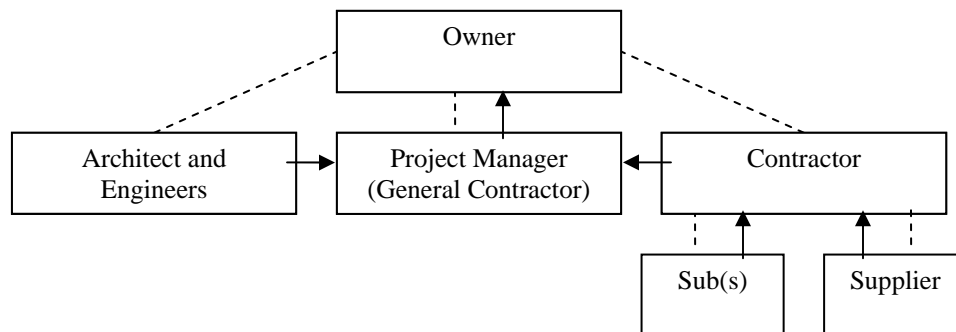


Figure 2 - Design-Bid-Build Leadership Format (w/ Project Manager)

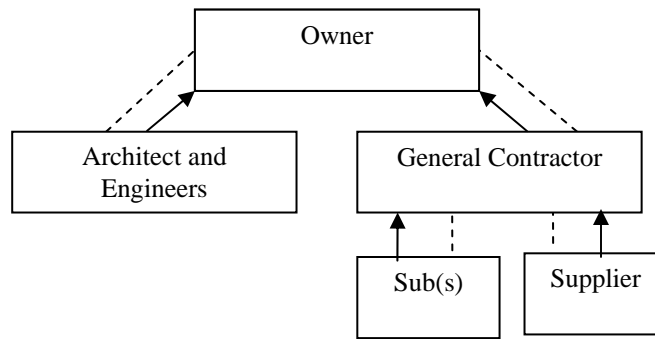


Figure 3 - Design-Bid-Build Leadership Format (w/o Project Manager)

The advantage of traditional agreements, such as design-bid-build, is that since this form of design method has been used for such a long time, the risk allocation has been clearly defined among the various parties in the contracts for the owner. The design-bid-build contract structure does not allow for waivers to be included within the contract. A waiver is when the signee willfully relinquishes entitled individual rights. No waivers are ever established between any of parties because of the direct liability that each party accepts. Since the roles for each party are clearly defined, this contract structure holds each party completely responsible for errors and omissions up to the maximum the law can require. The law would be upheld until the expiration of the statute of limitations. From a construction perspective, an example of a breach of contract would be a mechanical, electrical or structural failure in the project. Each party could be individually or collectively responsible for the failure. As noted previously, the statutes of limitations differ for each state, and they can range from 3 to 15 years. In the state of Kansas, the law states that any claims must be handled within 5 years after substantial completion of the project. After the statute of limitations has expired, the general contractor, architect and/or engineer are no longer held liable for any mechanical, electrical or structural failures (definitions.uslegal.com).

In the design-bid-build contract agreement between the construction parties and owner, all parties are required to obtain design and construction insurance coverage (**Ballobin**). The coverage can vary depending on the project size. As the size of the project increases, so will the need for a higher insurance premium. This insures that plaintiffs can receive monetary awards in cases of judgments in their favor. As with any other construction project, the structural engineer will need to obtain individual professional liability insurance to protect against any claims that may be brought against the structural engineer (**Ballobin**).

The Design-Bid-Build Standard Contract is ideal for a smaller, simpler structure, such as the warehouse. Using Design-Bid-Build in a complex structure, such as the sports stadium, will add additional cost and time to the project because of the slower design process that is incurred when using this standard contract. For example, in the Design-Bid-Build standard contract the location of the steel member will be determined by the engineer with coordination with the architect and other engineering disciplines, with general structural details for the beam such as end conditions, pinned or fixed and dimensions of grid members and spacing of beams. This is the stage that a BIM model would be developed to the current design level. When using the BIM Addendum E202, this would be a Level of Development of 100. This would allow for an approximate estimation of the size and location of the members to find any errors (conflicts with other disciplines) in the design. Once the architect has completed the schematic and design development plans, the structural engineer starts for load calculations and member sizing, producing construction documents which are coordinated with the final architectural and other engineering disciplines' construction documents. The structural engineer will determine the member forces based on the plans provided by the architect. Depending on the state regulations, during the design document phase the structural engineer will either completely design the steel connections for the member or rely on the steel fabricator to develop the steel connections based on the end reactions given on the construction documents. Once the shop drawings are approved by the engineer-of-record for the steel and the connections, these members are fabricated, and sent to the project site and for placement (erection). This process allows each party member to work separately, eliminating most responsibility and liability concerns should a problem arise. The engineer relies on the architect for the architectural plans and other engineering disciplines' plans, while the steel fabricator will rely on the plans provided by the contractor for fabrication, which are generally the structural construction documents for the project that contain steel. During construction, the general contractor typically uses the architectural and engineering contract documents (plans and specification), while the steel erector will construct the steel based on the steel fabricator's shop drawings and erection drawings for more instruction on the assembly of the structure.

3.2 Design-Build Standard Contracts

The main difference between Design-Bid-Build and Design-Build is the contract setup. With Design-build, the owner hires one entity to be responsible for both the construction and design of the project (**Kunkel**). This single source is responsible for the development of the design documents and total construction of the project. If the design-builder, this being either the general contractor, architect or engineer, does not have the capabilities to complete the project “in-house,” then the design-builder is responsible for hiring any other parties (**Kunkel**). For instance, if the general contractor is the design-builder, then the general contractor is responsible for hiring the architect and engineer, the design team, to produce the necessary contract documents (design drawings and specifications). This method reduces the chances of disputes between the design team and the general contractor because the party acting as the design-builder hires the other parties based on the confidence that they will have a good working relationship. However, if a problem does develop, the design-builder has the option of terminating the subcontractor or the design team and hiring another party to complete the work (**Saltz**).

An additional benefit of Design-Build is that technical specifications only need to be produced for required material and equipment. Since the general contractor and designer are working on the same team, the protective language, error and omissions, used in traditional Design-Bid-Build contract is not necessary (**Fredrickson**).

The AIA A141-2004 is an example of a standard contract provided by the American Institute of Architects for Design-Build project delivery. This contract standard is set up to use a single entity to determine what the owner wants and then take full responsibility of designing and constructing the building. The single entity can be an engineer, architect or general contractor, but for most projects the single entity is the general contractor. Either way, the single entity subcontracts out any work that it is not qualified to perform. For example, the design-builder will determine what the owner wants and then hire the architect to develop the design drawings. The architect will then hire the structural engineer, civil engineer, electrical engineer, mechanical engineer, etc to work on the schematics and the design development. Due to the contract structure, owners no longer have a direct relationship with architects and trust the design-builder to communicate all the requirements to the architect. Thus, owners must trust the

design-builders and their competence to complete the project to their satisfaction (**Saltz**). Figure 4 shows a contract and leadership breakdown for the design-build process when the engineer is in a contract with architect, while Figure 5 shows the contract breakdown when the engineer is in contract with the design-builder or general contractor. The dashed lines represent the parties' contract agreement breakdown, as well as, represent the leadership and responsibility breakdown from the top down.

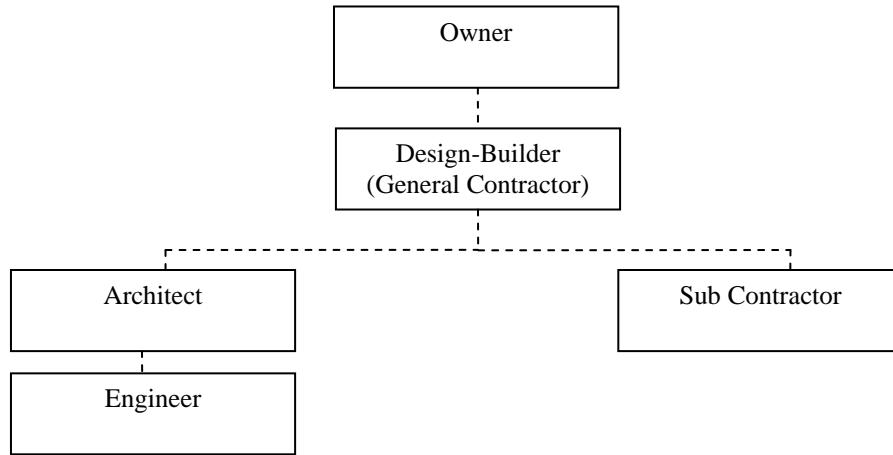


Figure 4 - Design-Build Leadership Format (w/ Architect in contract with Engineer)

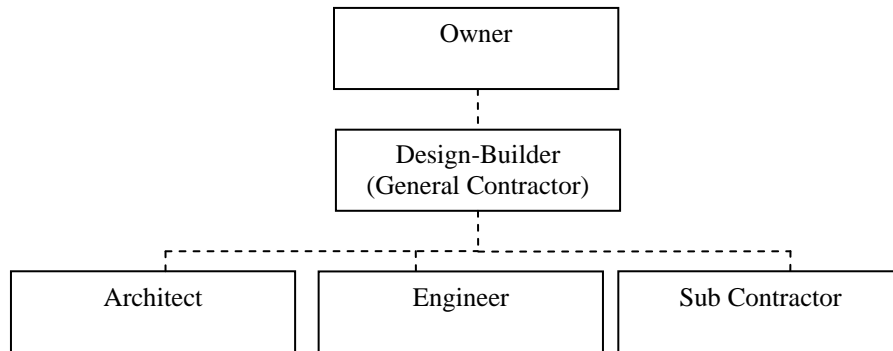


Figure 5 - Design-Build Leadership Format (w/ Gen Contractor in contract with Engineer)

The AIA A141-2004 provides a contract between the owner and the design-builder. In addition to the owner's contract, this contract standard also provides the contract for the design-builder and the engineer. An additional contract between the design-builder and the general contractor is available if needed; however, the general contractor typically assumes the role as design-builder (**Saltz**). The contract provides the opportunity for the owner to choose one of three payment structures: 1) Stipulated Sum, 2) Cost of the Work plus Design-Builder's Fee, and 3) Cost of the Work plus Design-Builder's Fee plus Guaranteed Maximum Price (**Saltz**). Under the stipulated sum agreement, the total project cost is determined prior to the start of construction. This allows the owner to hire the general contractor without receiving a precise cost breakdown of the project; however, any of the budget not spent will result as additional profit for the general contractor ("www.businessdictionary.com").

Since the owner only deals with the design-builder, the design-builder becomes responsible for coordinating and developing the project according to the owner's requests. The design-builder must completely understand what the owner desires in the project so that the owner's ideas can be relayed to the design professional. Per contract, the owner must provide "Project Criteria" to the design-builder, which is a set of specifications and information concerning what the owner wants included in the building, so that the design-builder can provide sufficient information to the design professional (**Saltz**). Also included in the Project Criteria are the owner's Schedule of Values. According to Saltz, the Schedule of Values "is a compilation of the values of the various phases of the work." This gives the owner evaluation criteria whenever a phase of the project has been completed and the design-builder is requesting payment (**Saltz**). Finally, this portion of the contract provides the contractual agreement that the general contractor will not proceed with work until the design build documents, which include all the contract documents with the exemption of the designer's documents, have been reviewed and approved (**Saltz**).

As mentioned above, in the case that the general contractor is the design-builder, the general contractor may subcontract out the development of the design documents to qualified design professionals. In turn, the design professionals may subcontract some of the design work also. In this case, the general contractor and owner must protect themselves from errors and omissions committed by the design professionals. In fact, the agreement requires that the owner receive a waiver of responsibility for any and all errors and omissions in the project committed

by the design-builder, the architect, the engineer, the general contractors or anyone directly associated with the project. The design-builder's errors and omissions insurance will not, however, cover the liability typically associated with the design professionals. Only a design professional is eligible for that type of insurance. Design-builders can protect themselves by requesting that design professionals provide a waiver for covering all work done by them, thus protecting design builders against errors and omissions that cause defects attributed to the subcontracted design professionals (**Saltz**). Saltz also notes that, "design professionals often do not carry substantial amounts of errors and omissions insurance and are willing to increase their coverage only if the additional premium is paid by the party which it contracts." The design-builder will typically pick up this extra cost, especially if the design-builder is able to pass it off to the owner, for the additional protection that it provides.

The DB Standard Contract can be used for simpler or larger more complex structures. The collaborative nature of the design process, which allows the general contractor to provide input on constructability, makes this process available for either type of projects. In DB standard contracts, the architect will consult with the general contractor, who typically acts as the design builder. The architect will collaborate with the general contractor on anything from the owner's design requirements to the constructability in the architect's design. At this point, the architect, general contractor, and other engineering disciplines would develop a BIM model checking for errors (coordination issues between disciplines and the owner's requirements) in the design. Using the AIA E202 BIM Addendum this model would project to be a Level of Development of around 200 or 300. This allows for some detail in the model, but not a completely accurate model. Similar to that of DBB, once the plans are completed by the architect, the finished plans will be sent to the structural engineer for load calculations and member sizing. The structural engineer will determine the member forces based on the plans provided by the architect. The DB standard contract does not bring any additional liability that will affect the structural engineer during the construction document phase since the collaboration was done between the architect and general contractor. The member will be sent out to the project site once the steel members and the connections are designed by either the structural engineer or the steel fabricator based on end reactions given on the construction documents. This process allows the general contractor and architect to collaborate early in the design process and for other design party member to work separately, which allows separation of the responsibility and liability of each design team

member. The engineer relies on the plans provided by the architect which worked in collaboration with the general contractor, while the steel fabricator will rely on the plans provided by the engineer for fabrication of the steel. During construction, the general contractor will have the plans prepared by the architect and engineer, while the steel erector will can rely on the steel fabricator's plans for more instruction on the assembly of the structure.

3.3 Integrated Project Delivery Standard Contracts

Design-bid-build clearly defines the purpose and responsibility of each party involved in the construction process. The contract structure clearly separates each party's role and responsibility on the project, which protects each individual party from another project team member's mistakes. In contrast, when all the parties begin to offer input on the project design from the beginning, the specific roles that were defined in the design-bid-build process begin to become blended. From a legal standpoint, the roles of the engineer, architect and general contractor are no longer clearly defined as they are in Design-Bid-Build. With IPD all of the parties are invited to contribute their expertise during the design phase of the construction process. The design phase will take longer, however it is more cost effective to find design mistakes before construction starts rather than making design changes during construction, especially in large complex projects. This integration of all design team members leads to a blurring of the traditional professional liability. This still makes design firms alter their business practices and insurance agencies to alter their professional insurance coverage. Although all the design team members are providing input during the design phase, the structural engineer is still required to stamp the contract documents and will be ultimately responsible for what is on the documents. As insurers study the use of BIM, structural engineers should eventually see discounts to encourage design professionals to take advantage of the "consistency, coordination, and clash detection advantages of BIM" because it will eliminate some of the errors during the design phase that are not caught until construction commences (**Mow, and Naylor**). This can be especially beneficial on large projects because as the project becomes more complex and the user gets more familiar with BIM software, the structural engineer should become more efficient with the software, thus making the design process much quicker.

Figure 4 provides a visual idea of how all the party members would interact to contribute into completing the project. In the figure, the dashed lines represent how the design team

collaborates and shares responsibility of completing the project. All the arrows represent their contribution to the project.

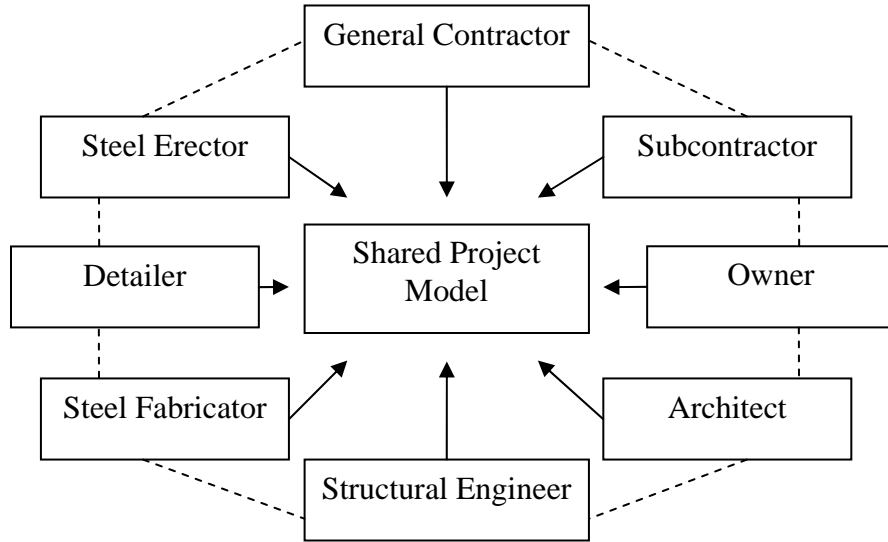


Figure 6 - Shared Model Project Concept

In 2007, as BIM and IPD continued to grow in popularity, the construction industry introduced a new set of contract standards. These standards were introduced to give engineers, architects, general contractors and owners a base set of legal contracts that could be applied when (IPD) is used for their projects. The AIA introduced A195/B195/A295 and C195, while the Associated General Contractors of America (AGC) and several other construction organizations introduced ConsensusDOCS 300. In addition, AIA and ConsensusDOCS issued addendums for the use of BIM in projects. AIA Document E202-2008, BIM Protocol Exhibit, is available for use in traditional project delivery (Design-Bid-Build or Design-Build) as well as IPD. ConsensusDOCS 301, BIM Addendum, is designed to be used with any project delivery method (**Mow, and Naylor**). Neither document is a stand-alone document but is used as an addendum to a variety of project delivery standard contracts. However, the AIA document was primarily written to support the IPD contract standards (**AIA**). In contrast, ConsensusDOCS was written for “the 301 BIM Addendum to be of value, it is not necessary for the Parties to agree to mutually shared cost-saving bonus arrangements for all Participants.” These kind of saving plans can be seen in ConsensusDOCS 300 tri-party agreement.

3.3.1 AIA A195/B195/A295

The AIA A195/B195/A295 standards are called transitional agreements. Transitional agreements allow for the easiest transition from design-bid-build standards or traditional standards to the IPD standards because of their similarity to the traditional agreements. In this contract structure, the architect acts as the project consultant to the owner to assist in finding a suitable general contractor or project manager. Once a guaranteed maximum price has been determined with the general contractor the design planning will begin (**Ballobin**). Unlike what happens with the C195 and the ConsensusDOCS 300, a limited liability company and a three-party contract are not developed. This contract structure allows for the owner to have an individual contract with each of the design professionals and the general contractor. Again, this is why the AIA A195/B195/A295 contract standards are called transitional agreements because of their direct similarities to design-bid-build contract standards. This allows a simple transition from a traditional method (design-bid-build) to a new contract and design format like IPD. The breakdown of the management and contract agreements for the AIA A195/B195/A295 is shown in Figure 5. The owner has a direct contract with the architect and general contractor. This allows for a collaborative team effort among those 3 party members throughout the design and construction phases of the project. The structural engineer is under contract with the architect, similar to what would be anticipated in a traditional agreement.

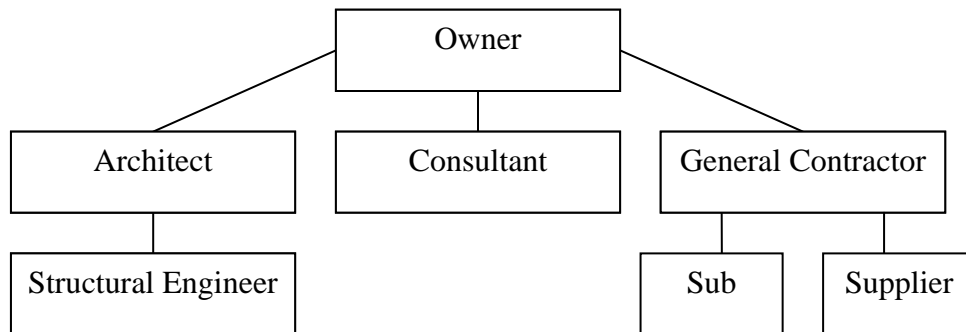


Figure 7 - AIA A195/B195/A295 Leadership Format

In transitional agreements, the risk allocation for each party is written out in the agreements with the owner. Each party has an individual agreement with the owner that defines specific responsibilities for the project; however, some of the responsibilities are broader than others. For instance, Ballobin offers this example: "...the contractor is to provide the owner and architect with recommendations on constructability during the design phases. Due the

collaborative nature of the IPD, the contract will be providing services earlier than in traditional delivery methods.” This reallocates liability to the general contractor and the architect. In this case, the only reallocated risk that the general contractor would assume would be the construction costs exceeding the guaranteed maximum price (GMP) of the project. This means that the sole liability can still be associated with the designer or the general contractor, depending on the construction phase of the project. For instance, a design mistake in the early phases of design would still put sole responsibility on the engineer and/or architect. A failure in construction in the later phases would result in sole responsibility being assigned to the general contractor. Consequently, most of the risk allocation does not change from what is expected in traditional agreements, except for the GMP agreement between the general contractor and the owner because of the early involvement from the general contractor. If the general contractor went over the GMP, then the contractor would be liable for covering the additional construction costs.

The A195/B195/A295 contract standards use three specific types of waivers. The first is a waiver for the statute of limitations; this waiver limits the amount of time allowed for making claims among the owner, architect, engineer and general contractor to 10 years (**Ballobin**). This is considered a private statute of limitations, which, under contract, would supersede any state regulations that has a statute of limitations that would exceed 10 years (**Knopp**). This is done because the statutes of limitations in different states vary. For instance, Kentucky has a statute of limitations of 15 years for contract disputes, but under this agreement party members would only be able to file claims for breach of contract for 10 years (**Thomson Reuters**). However, in the circumstance that a state has a statute of limitations that is shorter than 10 years, the state law will *supersede* the contract. For instance, in Arkansas the statute of limitations is 5 years for contract disputes; thus, the plaintiff would only be able to file a claim for 5 years after substantial completion, instead of the 10 years specified by the contract (**Thomson Reuters**). The second waiver concerns claims made by the various parties against each other for consequential damages. Consequential damages result not from a specific act, but are damages incurred by a failure of an act (**Knopp**). For example, an engineer not finishing a project design causing a delay in construction for the general contractor could lead to a consequential damage if the design delay resulted in a penalty for the project not having been completed on time. If the penalty for unsuccessful completion of the project on time is enforced, then the general

contractor has a case for consequential damages against the engineer. However, in this agreement all the parties waive this claim because all parties are involved in the project from the beginning and work collaboratively to complete the project. Finally, in most AIA standard agreements a waiver exists for subrogation for damages. Subrogation is the collection of damages from the insurer of the damaged party from the party at fault's insurer (**Thomson Rueters**). Under subrogation, an insurer has the right to seek monetary damages equivalent to the cost of the claim. The insurer will seek the damages from the party at fault's insurance company and the party members are legally bound to assist the insurer in retrieving that money (**Thomas Rueters**). The parties, however, agree to waive the right of subrogation for damages covered by property insurance applicable to work and the project. Once again, this is enforced because the parties work collaboratively during all phases of the design and construction process.

As mentioned before, the AIA A195/B195/A295 contract standards are close in structure and formality to the traditional contract standards, such as the EJCDC A-990. This makes for an easy transition for the purchasing of insurance policies. In the transitional agreement, all the parties are still required to obtain typical design and construction insurance coverage. The only difference is that the general contractor will be responsible for obtaining professional liability insurance and errors & omissions insurance because of his or her increased involvement in the design phase. This is a precautionary measure in case of errors in the design model raising this parties exposure to liability.

This IPD contract standard is considered a transitional agreement because the contract provides an easy transition from DB and DBB agreements. According to the AIA, traditional agreements are capable of handling BIM, however BIM is most commonly applied to IPD design process. IPD encourages all team members to participate in collaboration early in the design process. In this case, the owner, architect, general contractor, engineer, fabricator and a variety of subcontractors will work together on design and coordination of the project. In this standard contract, each party member still works individually on the project with separation of responsibility, similarly found in the DBB standard contracts, with the exception of the three waivers listed above. Once preliminary plans have been developed by each of the design team, construction on the data model will commence. Using the AIA E202 BIM Addendum as a reference, this model would be able to be design to a Level of Development of 500. This would provide the most accurate model, complete with specific detail such as steel member size,

location and weight. The early collaboration amongst the design team members effectively alters their early design responsibility. The members assume the risk of additional liability brought on by the data model such as data translation/interoperability, data misuse, legal status of model, and standard of care which are all discussed in greater detail in Chapter 4. During the data model coordination phase, the architect will still provide plans to the structural engineer for beam location. At this point, the structural engineer will be able to include that information into structural analysis software, such as Risa-3D, for analysis of a complex building, such as the sports stadium. Incorporating Risa-3D into the design process is not essential for simpler buildings, such as the warehouse. The structural analysis of the building can still be done by hand calculations without any consequence because the data of the structural members, such as depth and weight, can be added into the data model later. Once the model is complete, it is the responsibility of the architect and engineer to complete the required 2-Dimensional drawings (contract documents) for the project construction team. The fabricator can use the completed data model in manufacturing the proper steel and can also give the model to the steel erectors for use in the field. The data model is legally allowed to provide assistance to the fabricator and erector based on the American Institute of Steel Construction's Cod of Standard Practice for Steel Buildings and Bridges.

3.3.2 AIA C195

The AIA C195 standard requires that the owner, design firms and construction firms form a limited liability company (LLC). In this company, a governance board is created that manages daily business affairs. The governance board will be made up of an odd number of members. The non-owner members are allowed to appoint at least one representative; however, the owner must be represented by members numbering more than one number than the total of non-owner members. For example, if the total number of the governance board is seven, the engineer, architect and general contractor will each appoint one representative, while the owner will appoint four. The board members establish a project management team that is responsible for the design, planning and construction of the project. Other non-team members can be brought in, but they serve only as advisors and are not part of the voting team (**Ballobin**). A breakdown of the company is shown in Figure 6 below.

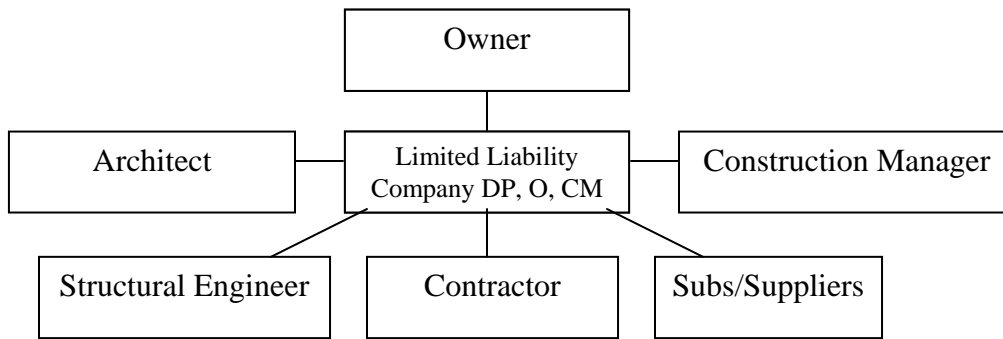


Figure 8 - AIA C195 Leadership Format

Of particular interest in the C195 standard format is the way incentive programs for both owner and non-owner members are set up. Two types of incentive programs are typically offered. The first type awards some of the savings if the actual cost of the project comes in under the projected cost. The company would pay the portion of the savings to the non-members according to the allotted values determined from Article 5 of the AIA C195. The other incentive program is a goal achievement program. To establish such a program an amendment is added to the contract detailing the project goals. A table is created stating the goal and achievement requirements with a pre-determined dollar amount also included. The monetary distribution to the non-owner team members is also pre-determined during contract negotiations. However, Ballobin also states “if a project goal is not achieved, the target cost shall be decreased in an amount equal to the goal achievement compensation that was not awarded by the company and the agreement will be amended as necessary.” Since all parties benefit from collaboration, the incentive program really helps encourage team members to work together out through the entire project.

When the company is formed, a risk matrix is used to determine the amount of risk that will be allocated to the particular project. The risk matrix takes into account planning, designing, constructing, and commissioning. The matrix will then be used in assigning each party its responsibility for managing each risk. Essentially, the risk will be allocated to the team member that is best suited to handle such risks. The risk matrix is not included in the contract, member agreements, or agreements with non members. The matrix is simply used as a guide to assign risk. Also, if a particular party fails to manage risk properly, each member is liable due to the waiver of claims signed by the members.

Unlike what occurs in the typical design and construction process, the standard does not allow claims to be brought against members of the LLC. Since all members are members of the LLC, the waiver of claims must be done in a contractually specific way. First, all company members must waive claims in the contract against the company and the members. This waiver was designed to encourage design and construction efforts to be more collaborative. Second, the owner must waive all claims in the contract against other company members. This creates a unified LLC that includes the owner, architect, engineer, and general contractor. Although no party is able to file a claim against another, the owner, architect, engineer and general contractor are still required to obtain design and construction insurance coverage. This is because currently no insurance coverage exists yet that can manage the loss for the company or party members as an LLC (**Ballobin**). Insurance companies are still uncomfortable with offering insurance due to the natural “speculative risk and moral hazard” (**Ballobin**) that this form of contract creates.

This IPD standard contract develops a limited liability company (LLC) to encourage collaboration through the entire team. All of the design team members, which consist of the owner, architect, general contractor, structural engineer, steel fabricator and any subcontractors, must join the LLC. The design team works together to lay out preliminary plans for project. All members are consulted because of their expertise in their field. Once preliminary plans have been developed by each of the design members, construction on the data model will commence. Once again, using the AIA E202 BIM Addendum as a reference, this model would be able to be design to a Level of Development of 500. This would provide the most accurate model, complete with specific detail such as steel member size, location and weight. The early collaboration alters their design responsibility each assuming new responsibility because of their corporation in the LLC. A risk matrix determines how the risk will be managed in the LLC. Essentially, the risk matrix will assign the risk to the party that is capable of handling said risk. Collaboration between the team will determine the location of the beam in the project. However, it is still the responsibility of the structural engineer to determine the capacity and size of the beam. The structural engineer will be able to include that information into structural analysis software or solve for the beam size by hand, the process which the steel member size is determined is based on the complexity of the project. Once the model is complete with the proper steel member size, it is the responsibility of the architect and engineer to complete the required 2-Dimensional drawings for the project construction team. The fabricator can use the

completed data model in manufacturing the proper steel and can also give the model to the steel erectors for use in the field.

3.3.3 ConsensusDOCS 300

In the ConsensusDOCS 300 standard a management group is formed. It is the primary decision maker for the project. The management group is made up of the owner, engineer, architect and general contractor, as well as, any needed additional members, such as subcontractors or fabricators. A diagram of the management group is shown below in Figure 4. According to Ballobin, the group is “responsible for reviewing the owner’s programs and setting project goals.” This encourages collaboration, mainly because all major design and construction decisions need to be made by consensus. Any decisions that cannot be made by a consensus of the group will result in the owner making the ultimate decision. During the design phase, the team will meet frequently; the frequency will be determined by contract. During this time the team will discuss site collaboration, building materials, systems, and equipment. Design consultants and subcontractors are supposed to be selected early in the design phase, so that they can be integrated as early as possible into the design team (**Ballobin**).

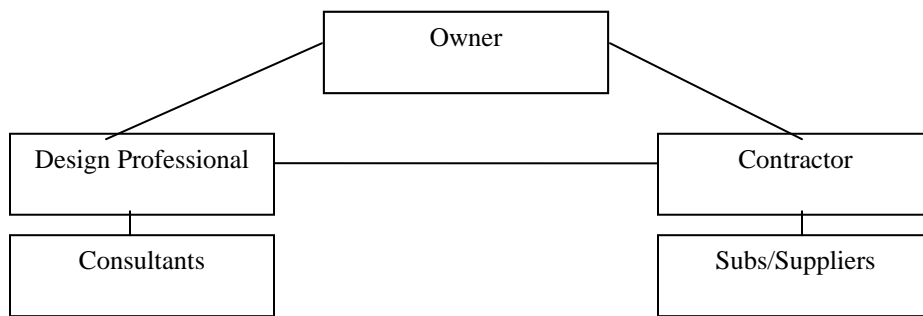


Figure 9 - ConsensusDOCS 300 Management Group Layout

As will the C195, an incentive program can be established by the management group to support the integrated project delivery. This would be an incentive-laden program that will reward team members for exceeding project goals set by the management team and for meeting scheduled deadlines. Specific details in the incentive program will be added as an amendment to the contract agreement. The program will be funded by the savings generated from the collaborative work, which reduces the overall cost of the project (**Ballobin**).

This standard agreement allows the team to choose from two risk allocation approaches. The first option is to waive all claims among group members against each other that arise from a mutual decision from the management group. The group agrees to waive all claims that arise from non-negligent act. However, the waivers do not apply to acts or omissions that are construed as willful misconduct (**Ballobin**). The second risk allocation approach more closely resembles that in the traditional standard. This approach allocates responsibility to every party, as would be expected in a traditional contract, although the decisions are still made collaboratively. This method would require the architect and engineer to have an aggregate limitation on their liability to the owner, general contractor or anyone else who may make a claim based on project errors. In this case, the general contractor must also have an aggregate limitation that is equivalent to that of the designers. However, each of the previous limits of liability established by the designer and general contractor can be exceeded if losses are reimbursed by an insurance policy or a professional liability policy. Several other stipulations within this agreement should be noted. In section 12.9 of the agreement, the architect and/or the engineer is required to coordinate and be liable for any services provided by a design consultant. What this section essentially means is that even though the management group has approved the design consultant and the consultant's work, the engineer and/or the architect is still liable for all of consultant's services. A similar agreement for the general contractor exists in section 13.1.2, which states that the general contractor is responsible for any acts and omissions from the subcontractor. The final section that should be noted is section 13.9.1, which assigns responsibility of safety during the construction process to the owner, architect, engineer and general contractor. However, the general contractor will be responsible for safety measures and programming (**Ballobin**). This differs from more traditional contracts, under which the general contractor takes all of the responsibility for safety during construction (**Ballobin**).

The various liability waivers depend upon which risk allocation approach that the management group chooses. In the first scenario discussed above, all the claims made by the management group will be waived. However, in the second scenario, none of the claims will be waived. The choice is up to the management group; both scenarios have plenty of advantages and disadvantages. However, all parties waive consequential damages, regardless of whether the group chooses to waive the claims or impose them (**Ballobin**).

Once again, insurance requirements depend on which risk allocation method the management group chooses to use. If the group chooses that all claims should be waived, the needed insurance is similar to what is needed under the AIA C195. This means negligence would be inconsequential because claims would be waived and shared. However, standard insurance is still required for the engineer, architect, general contractor and owner. If the management group chooses not to waive the claims, the insurance structure will be similar to what is required under AIA A195/B195/A295. In this method, all parties will be responsible for their own designs which will require similar insurance as the traditional methods. This requires the parties to obtain professional liability and commercial general liability insurance. However, as noted before, the designer and general contractor will agree upon an aggregate limitation that will limit the liability of both parties (**Ballobin**).

ConsensusDOCS 300 allows the design team to select the risk allotment to the group. The design team can select to keep all claims intact or waive all claims to each design team member, which makes similar to either the AIA A195/B195/A295 or AIA C195, respectfully. At this point, the design process follows the same process as the AIA A195/B195/A295 and the AIA C195.

3.3.4 BIM Addendums: AIA E202-2008 & ConsensusDOCS 301

As discussed previously, AIA E202-2008 and ConsensusDOCS 301 simply provide an addendum for project delivery standard contracts when BIM technology is used in a project. Mow and Naylor state that “this document is integrated by reference in and is an exhibit to the governing Owner-Architect and Owner-Contractor agreements.” These contract addendums provide important protections for projects that use BIM at any point in the project. These protections include defining the standard of care, protecting copyrights and granting licenses (**Mow, and Naylor**). The addendums provide a variety of protections, but the AIA and ConsensusDOCS provide them in two different ways.

One of the main differences between the addendums is how the two documents lay out the development of the model and the reliance the design team places on that model (**Mow, and Naylor**). E202-2008 establishes a procedure for the design team to follow depending on the model’s level of development (LOD). LOD refers to the completeness of the model at certain stages of the project (**Mow, and Naylor**). The document establishes the model information for

five levels of development and each level of use at each development stage (**AIA**). Mow and Naylor state that “the spectrum runs from LOD 100, which requires ‘overall building massing indicative of area, height, volume, location and orientation,’ to LOD 500, which requires modeling of “constructed assemblies actual and accurate in terms of size, shape, location, quantity, and orientation.” To help assist the design professional in determining the LOD, the E202-2008 provides a model element table with listings of certain model elements. The table not only helps the design professional determine the LOD of each model, but “helps clarify model ownership, sets forth BIM standards and file formats, and provides the scope of responsibility for model management from the beginning to the end of the project” (**AIA**).

The main reason behind describing each level of development within the addendum is that to limit the level of reliance of the model within the contract to protect structural engineers from outside designers relying too much on the model (**Mow, and Naylor**). In addition, the contract protects the author (designer) should the designer complete the model past the LOD determined in the contract. Section 4.1.2 of the addendum states, “Model Users and subsequent Model Element Authors may rely on the accuracy and completeness of a model element consistent only with the content required for a LOD identified in [the model element table]” (**AIA**). Section 4.1.3 of the addendum protects the model element author “from and against all claims arising from or related to subsequent Model Element Author’s and Model User’s modification to, or unauthorized use of, the Model Element Author’s content” (**AIA**). The rationale for Section 4 of the addendum is that the designer should be protected from any modifications from outside sources not previously determined in the level of development list provided in the agreement. Thus, any alterations to the model from an outside source will be held liable if any of the changes cause a failure. The purpose of this portion of the contract is to protect the structural engineer if the model is over designed or even under designed per requirements in the contract. Any alterations will need to be done by the structural engineer and if alterations to the model are done by an outside source, that source is now liable for any discrepancies.

In contrast to the E202-2008, ConsensusDOCS 301 determines the development of the model in separate stages. Those stages are: model, design model, full design model, construction model, and project model (**Mow, and Naylor**). ConsensusDOCS defines the design model as a continuation of what should be expected in a two-dimensional construction document. The

greatest difference between ConsensusDOCS and AIA is that ConsensusDOCS allows the designer to determine the level of execution. The plan should include, among other things, the models to be created, the content of those models and the required level of completion at certain stages in design, a schedule for updating the models, the file formats that will be used on the project, and specific measures for interoperability (**Mow, and Naylor**). Another important feature of ConsensusDOCS is that the design team can determine the level of accuracy in the design model and issue that level per contract. Mow and Naylor state that “project participants can specify that they make no representation as to dimensional accuracy so that the model is to be used for reference only, that dimensions are accurate to the extent the BIM execution plans require, or that dimensions are accurate and take precedence over dimensions in the two-dimensional drawings.” However, Mow and Naylor continue to state that “allowing dimensions in the model to take precedence over two-dimension drawings is ill-advised, as the model is not a stamped and signed document subject to regulatory review.” This portion of the agreement limits the reliance a party member can place on the model. The accuracy of that model depends on the level of accuracy selected by the design team in the contract. The contract also imposes a duty on all project participants to report any errors, inconsistencies or omissions in the model (**ConsensusDOCS**).

Another important difference between ConsensusDOCS and AIA concerns the management of the model. According to AIA E202-2008 Section 2.4.1, the “Architect will manage the Model from the inception of the Project.” To manage the model properly, the architect must select “protocols for storage and access, collecting and archiving models, performing class detection, and maintaining archives” (**Mow, and Naylor**). ConsensusDOCS allows the owner to appoint one or more information managers. An information manager could be any member of the project team or an outsider brought in by the owner. The information manager has to protect and provide access to the model for the project participants and essentially manage the information of the model for the project (**Mow, and Naylor**).

4.0 Liability Concerns

4.1 Contract Documents

In 1918, in *United States v Spearin*, 248 US 132, 136 (1918), the United States Supreme Court found that the general contractor had built to the specifications of the owner's designers. The *Spearin* court case determined that "the one who provides the plans and specifications for a construction project warrants that those plans and specifications are free from defect" (**Ashcroft**). The court found that the general contractor is required to build according to the design plans and specifications and "will not be responsible for the consequences of defects in the plans and specifications" (**Ballobin**). Further, the court determined once the plans became a stamped design document created by a design professional, the document immediately invoked an implied warranty that "described the character, dimensions, and locations of items that were to be constructed" (**Ballobin**). The purpose of the IPD and BIM is to incorporate general contractors in the design phases so that general contractors are able to provide their input on design and constructability issues. However, the general contractor's early involvement in the project could result in an invalid implied warranty that the *Spearin* Doctrine provides, thus leaving the general contractor partially responsible for design defects.

The *Spearin* Doctrine has been tested in a variety of ways when contracts combine design and performance specifications. The courts have allowed general contractors, who offered input early in the design process, to apply implied warranty theory if plans and specifications that are authored by someone else "are defective to the degree that adherence to them results in an article that fails to satisfy a stated performance specification" (**RJ Crowley**). However, in cases in which the general contractor should have recognized the potential for a design defect, the courts have found that the contract assumed the risk for defect and that no implied warranty exists.

Although no cases currently exist that specifically question whether the *Spearin* Doctrine is affected by BIM collaboration, similar cases can provide assistance in determining the solution. In *Austin Co vs United States*, a general contractor entered into a contract "to design, manufacture, test and deliver an innovative, novel digital data recording system" (**Ashcroft**). In this case, the contract already included detailed design specifications, but the general contractor ultimately determined that it would be impossible to complete the project with the specifications provided. The general contractor was forced to alter the design and still could not execute the

contract. The court denied the potential to claim impossibility, stating that since the general contractor used his own designs, he warranted the ability to successfully complete the project with the alternative specifications (**Ashcroft**). This could be applied to a general contractor and a design team's relationship because this was a case in which a general contractor provided additional information. Based on cases like this, Ashcroft suggests "it seems clear from analogous cases that extensive general contractor and subcontractor involvement may sharply curtail implied warranties."

4.2 Technological Legal Concerns of Interest with BIM

When BIM is used as a CAD modeling software by a party and kept by the same party and used in a traditional contract setup, then no inherent legal concerns for anyone on the construction team occur. However, once BIM is used to its full potential as a 4D design tool, lawyers will become concerned with the operational structure and use of BIM. BIM is a collaborative network that enables the owner, design professionals and the general contractor to share information and requires all of the team members associated with the project to divulge information early in the design process. This means that all building information and a complete set of design documents are stored together and interconnected. One of the benefits of having all the information stored together is one of the BIM software's more highly touted capabilities, which are its clash detection abilities. The design team has the ability to develop detailed designs that include the structural layout, mechanical, electrical, plumbing systems and the building skin. This assists the structural engineer in determining any potential coordination problems in the design. This enables real-time coordination of information in every view (**Goldberg**) and allows the architect and engineer to make corrections to his or her model with little effort, before any of the project construction begins. Instead of trying to determine discrepancies with a light table overlay and 2D plan sets supplied by each party, all of the design party members' information is included in the model and a clash detection program highlights each of the overlapping elements within the model (**Hurtado, and O'Connor**). For example, if the design calls for a complex steel beam and column connection the 3D model will assist the general contractor and the steel erector in construction the connection. Consequently, this can lead to fewer construction management issues and will decrease the number of Request for Information sent to the structural engineer (**Goupil**). Figure 10 below, shows a steel connection

found in the Washington Nationals' Ballpark. This is an example of what a 3D digital project model and what the actual steel connection would look like. This picture helps visualize the 3D model and understand how it can be beneficial to the design and construction team when assembling and designing steel connections.



Figure 10 - Example of BIM Technology (AECBytes)

However, this concept is relatively new in the construction industry. This new technology and method gives the structural engineer and the whole construction industry an alternative way of looking at the design and construction process. BIM reallocates risk and liability to all parties, which creates a gray area in contract negotiations and risk allocation discussions. The previous way that the contract format and insurance coverage were handled in traditional agreements no longer pertains to when BIM's software and process are used as the primary design team structure. The following sections examine some of the principle concerns of engineers and lawyers when BIM technology is used in the construction industry.

4.2.1 Data Translation/Interoperability

Structural engineers use various tools when they design and analyze structures. These tools include, but are not limited, to calculations, construction drawings and analysis models. However, with respect to BIM, the structural engineer's analysis model is the most important tool because this is what can be imported into the BIM software. Structural engineers like every other party member have their own tools that help complete the design and construction process. However, BIM software allows structural engineers to use the architect's design model and the material fabricators shop drawings and information to formulate an accurate model. The motivation for BIM technology is that each of the party members' information can be compiled into a useful model that can pay dividends to all party members. All the information that is

collected is presented in a single model with the intention that all the information fits seamlessly. Unfortunately, that is not always the case.

Currently, software companies like to provide direct information links to specific companies' software. This direct link will allow the software to exchange information necessary for the model. For instance, a wide variety of analysis tools exist that structural engineers can use to complete design analyses for models. However, if design teams are using Autodesk's Revit software, structural engineers will only be able to use ETABS, RISA-3D and ROBOT Millennium to complete their analysis (**Verley**). This is because these programs have a direct link with Revit software and can exchange the information without the risk of losing the information. This prevents customers from using a competitors' software. However, engineers can choose from an abundance of available software to do their analyses. The problem arises when a structural engineer uses software that is not compatible with or linked to the BIM software being used on a project. When any member of the design team uses software that is not capable of being directly linked to the BIM software, the party members must use software integration. This is especially helpful on large projects in which it would be much easier and cost effective to integrate the project rather than moving all parties involved on a project to one platform (**Laiserin 63-92**). Building data models are being developed that will create a platform on which companies can base their software. This allows for universal communication among *all* analysis software for BIM use. In the United States, this movement is being called National BIM Standards (NBIMS). The purpose of the movement is to allow designers to communicate their electronic model data with other designers' data in the various engineering fields, even though all parties might not have the same brand of software (**Laiserin 63-92**). The two main building product data models are the Industry Information Classes (IFC), which specializes in building planning, design, construction and management, and the other is CIMsteel Integration Standard Version 2 (CIS/2), which is for structural engineering and fabrication. The two standards are the only public and internationally known standards available today (**Laiserin 63-92**). IFC is much more integrated throughout the entire design process and IFC can transfer specific entities such as structural elements, structural analysis extensions, architectural designs, electrical elements, HVAC elements and building control elements. Since IFC provides a wider variety of capabilities than CIS/2, many believe that "the IFC data model is likely to become the

international standard for data exchange and integration within the building construction industries” (**Laiserin 63-92**).

In addition, the General Services Administration (GSA) has also adopted IFC for code checking and design review. The GSA is responsible for constructing and maintaining all of the United States government buildings, which makes this administration the largest holder of property in the United States. The GSA is a government agency that developed the National 3D-4D-BIM Program. The primary goal of this program is to “promote value-added digital visualization, simulation and optimization technologies to increase quality and efficiency” (**U.S. General Services Administration 2008**) within the construction industry. As of 2007, the GSA has also made the commitment to require any public building projects that will need approval from the Office of the Chief Architect to use BIM at some point during the project (**U.S. General Services Administration 2008**). This endorsement from the GSA, is bound to make IFC have an even greater impact on construction teams and processes.

Despite the developments of IFC data models, however, problems with interoperability still exist. Software is still available that does not work under the IFC Standards. If current data information is not in an IFC data model, it must be translated into one. However, a translator might not transfer all information from the original model, which is a serious problem. Also, Ashcroft notes, “some translators cannot ‘round trip’, i.e. move data from one platform to another and then return it to the original platform after it has been modified” (**Ashcroft**). Essentially, if design software is not perfectly linked together through IFC data models, the design team takes a tremendous risk that differences will be created in the models. This will cause discrepancies between the original data model from which the information was taken and the new data model to which the information is being sent. This problem can lead to data loss, which can lead errors in the design. Errors that should have been caught, such as design conflicts, might not be noticed until well into the construction process.

If these errors are not fixed prior to construction, or even earlier legal problems can ensue. For example, in the case *M.A. Mortenson Co., Inc v Timberline Software Corp.*, a software error caused a general contractor’s bid for the Harborview Medical Center in Seattle to be \$1,950,000 too low. The court ruled in favor of the software company because Timberline Software Corp. had issued a disclaimer about using it for actual construction. The disclaimer was included in the software warranty, and the warranty was included in the contract. The

Washington Supreme Court found that the software company was not liable for the general contractor's mistake or any of its losses. Ashcroft further explains that, "if errors in BIM software cause economic loss to the user, the injured party has no realistic remedy. However, the user's liability to other parties is not similarly limited, causing a liability gap if the errors cause deficiencies in plans or other deliverables" (**Ashcroft**).

The industry has improved interoperability significantly; however, additional improvements in the interoperability are still needed before the system will be considered perfect. Much of the concern can be removed if the structural engineer still operates cautiously when translating information into one model. The structural engineer must make sure that model data is interchangeable with the analysis software and the BIM software to prevent errors in the model and very costly mistakes. Doug Green, a leader in the field for BIM, said that a new feature in BIM software called 'data log' will help with this problem. This log will document all the information inputted into the model, including information about alterations, additions, subtractions and the users of the model. This allows for documentation of any and all information that is inputted by the various design professionals while the model is being used. This tracking method will allow users to go back into the model and determine who is at fault if an error or a failure should occur during the project.

4.2.2 Data Misuse

BIM models can be created for a variety of different users. However, issues arise when a model is used for different purposes than for what it was initially intended or designed. According to Ashcroft, "currency, adequacy, and tolerances are three issues that need to be addressed when information in one model is used for another" (**Ashcroft**).

A structural engineer can use various modeling software to analyze a building model. However, my knowledge extends only to the use of Risa-3D structural modeling software, so that is the only software I reference in this report. In Risa-3D, the model is often generalized; no need exists for specific detail to be put into the model, such as how many bolts or types of welds are in a connection. In reality, none of the steel connections are included in the original Risa-3D model. Structural engineers need to know how the model will act in terms of rotation, displacement and force dispersion at the connection, but they do not need to know much else. The connection calculations are performed outside of the modeling software and are typically

completed by the steel fabricator. This raises the question as to whether the structural engineer needs to thoroughly design a virtual structural model to be included into the design team's model. The structural model does not necessarily need to include all the details to be able to be in sync with the architectural model; the most important details would include the member size, depth and width, weight and cost. However, the fabrication model uses the loads provided by the structural analysis model, as well as, the structural details and specifications provided by the structural engineer to complete the steel connection fabrication. In summary, the structural engineer needs to use different design details for various members of the design team as well as various stages in the design process.

4.2.3 Intellectual Property

The motive for creating IPD and BIM is the need to be able to share information among the members of the design before the construction of building begins. However, the sharing of the information raises legal questions. For instance, because of the collaboration among all the parties, the ownership of the model could be questioned. In addition, design firms develop trade secrets that make their business models successful (**Ashcroft**). With all the information available in the model to all of the party members, that information could become public, thus causing design firms to lose valuable edges that have made them successful.

Design ownership issues are not new. Determination of whether the owner or the designer owns the documentation has been argued about for a long time. Mow and Naylor argue that construction drawings and now building information models are subject to copyright protection. Article 1, Section 8, Clause 8 of the United States Constitution is the Copyright Clause (**Mow, and Naylor**). This clause empowers the United States Congress to “promote the Progress of Science and useful Arts, by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries.” Essentially, authors, or in this case designers, have the right to own and protect their creations and have protection from others trying to copy, use or interfere with the owner's use of that document (**Mow, and Naylor**). Since all the parties have begun working more closely together, the ownership issue is being pushed to the forefront. However, the answer to questions about ownership depends on the way that designers are currently operating. The ownership of the design, therefore, needs to be clearly defined within the contract. AIA and ConsensusDOCS vary on this issue. The AIA

contract standards defend the architect-engineer's copyright of the model and do not give the owner an opportunity for ownership. On the other hand, in the ConsensusDocs standard contract between the owner and the architect-engineer, allows the owner and the design professional to decide who owns the documents. ConsensusDocs allows for various options for ownership, enabling designers to still claim ownership of individual portions of the design or the owner can claim ownership of the design. An alternative solution is to award ownership to the designers and have the designers issue a license to the owner for use (**Mow, and Naylor**). A license is permission to operate and use another's property, which without a license would be subject to legal action (**Mow, and Naylor**).

It should be noted, as the use of BIM technology expands, one of its key capabilities is the ability to operate and manage the building through the BIM designed model. This will lead to more owners requiring ownership of the model once the project is finished. This can benefit the engineer, because training owners on how to use the model could generate additional post construction revenue (**Ashcroft**).

A firm's trade secrets can be very valuable, especially if the secrets have been proven to work successfully over long periods of time. This is why firms are very eager to withhold their tradecraft from competitors because it can give them an edge in the business. When trade secrets are used within a model that is viewed by several different firms, the best way to keep that information private is to use these secrets carefully (**Green**). BIM technology is modeled in such a way that a large portion of the work can be done without interacting with other firms. The real value comes when the model is put together so discrepancies can be seen by any of the concerned parties. This allows a firm to hide any trade secrets that others may be able to see and benefit from (**Green**). When the necessity arises, a stricter approach can be used. A confidentiality agreement can be used and be incorporated into the contract for the project (**Ashcroft**). However, as mentioned before, safeguards exist within the software to prevent such drastic measures.

4.2.4 Loss of Data

All digital data is subject to data loss. So this is a problem when BIM is used. The parties involved in sharing the data must take careful precautions when saving and storing the information. This is especially true when all of the design elements are transferred to one main

model. The model contains the design details and information belonging to several design professionals; thus the data in the model must be kept safe. So models will not crash, as well as, perform at a higher level, they are set up on their own computer server or systems. This provides the optimum computer operation when a file size as large as a BIM data model is used.

In addition, the virtual data model should be insured. This will protect the party member responsible in the case of severe data loss to the model against any liability and the financial hardships incurred by the party members that are directly affected by the loss of data (**Ashcroft**).

4.2.5 Legal Status of Model

Architects and engineers are required to seal or stamp construction documents as a way of reporting that they have used “responsible control” during the preparation and design of the drawings. In the past, responsible control has been achieved by supervising, reviewing and overseeing the document development by a design professional (**Mow, and Naylor**). The application of BIM in projects has generated a new way for information to be imported into a project by different sources, using the internet or the software itself. A concern arises when the model information from different disciplines is added to the model that could affect the structural elements of the building. All of this is done without the responsible control of the structural engineer, which could be in violation of state licensing laws and could create new legal issues concerning the use of BIM (**Mow, and Naylor**).

As recently as 2008, the National Council of Architectural Registration Boards expanded the definition of responsible control to help address this issue. The NCARB included the ability to identify “trusted sources” for which information can be acquired (**Mow, and Naylor**). The following is the new definition of responsible control as written in the NCARB’s Rules of Ethical Conduct in 2008:

That amount of control over and detailed professional knowledge of the content of technical submissions during their preparation as is ordinarily exercised by a registered architect applying the required professional standard of care, including but not limited to an architect’s integration of information manufacturers, suppliers, installers, the architect’s consultants, owners, general contractors, or other sources the architect reasonably trusts that is incidental to and intended to be

incorporated into the architect's technical submissions if the architect has coordinated and reviewed such information.

Although the definition applies to architects, the structural engineer can apply the definition. The structural engineer must still control what information is included and determine whether the information is valid.

Also, Appendix A of the American Institute of Steel Construction's Cod of Standard Practice for Steel Buildings and Bridges says that the model is considered a design drawing which is considered a contract document—for fabricators and erectors both. This vague statement creates uncertainty about the legal status of the other members of the design team. Currently, because of the complexities of integration of the model, the model is not considered part of a contract for any other portion of the design team. Actually, a model is considered a helpful design tool and nothing more. Currently, the 3D model will need to be developed and checked thoroughly. Once that is done, 2D drawings are developed for contract purposes and use in the field. This is done for a variety of reasons. First, the models are developed so integration of information from among the different parties can be checked, but some important construction details are left out of the end model that are crucial for construction, but not for integration. Second, although it may be easier for people who are familiar BIM and 3-D modeling to understand a model, the reality is that such models are still not considered a standard in the construction industry and 2D designs are the most common communication tool used in the industry. Third, permit agencies are not ready to review digital models due to the advanced technology that is incorporated into the model. Permit agencies still need to use 2D drawings to validate the design because of the level of uncertainty that still exists when BIM design tools are used. Finally, how the engineer or architect should sign off on a model is still being deliberated (**Ashcroft**). Since BIM aims to incorporate all the party elements into one massive model, the design details and specifications that each individual party member could stamp and seal cannot be separated. Consequently, the design team members cannot agree as to whether one professional should be responsible for stamping the model or all the professionals associated with the project should stamp the model.

The model is allowed to be used in the field, but it is used more as a reference than a fact. In no way can the model be relied upon for construction purposes. If the general contractor chooses to use the model provided, then the liability for the design is handed off to the general

contractor. Naturally, during the construction phase the general contractor will rarely use the model the team provides, but instead, the contractors generate their own models from the drawings that are provided by design teams.

According to Ashcroft, the model can be used two other ways within a contract. The model can be considered a “co-contract document,” which will allow both parties to use the model but not submit it to the permitting agencies. If this is the case, the contract will need to state how inconsistencies in the model will be handled by the design and construction team. The other choice is to use the model as an “inferential document.” This option allows for the provision of visualization of the 3D model, but questions must be answered by the 2D drawings **(Ashcroft)**.

The second option, which considers the model an inferential document is the most commonly used approach in the construction industry. The model will provide a new level of data that would not be available otherwise, such as clash detection, but it is still not considered a legal document. The model is only considered to be a reference for the design team and general contractor and is not contractually legal to use to further design or construct the project.

4.2.6 Standard of Care

Standard of care requires a structural engineer to put forth the same “degree of care, skill, and diligence as is reasonable required of others in the profession under the circumstances” **(Mow, and Naylor)**. This is the responsibility that the structural engineer owes to the general public and is protected under common law, which is law that exists with absence of contract, statute or regulation. The term ‘standard of care’ is known by structural engineers, but the term itself continues to evolve as technology advances, today the technology causing the evolution is BIM. Because of this evolution, the professional standard of care will continue to change for better or for worse.

As BIM is used more widely in the industry, the capabilities of the users must be expanded. The expectations of owners will continue to increase, further pushing design and model expectations **(Mow, and Naylor)**. A few years ago, mistakes and errors in design were expected. However, as the competence of engineers and use of BIM increases, coordination errors will become rarer. A structural engineer’s standard of care will have to adapt with the use of this technology. In addition, the same level of coordination and design will become expected

whether the design team is using BIM or not (**Mow, and Naylor**). Resolving design and conflict disputes once construction begins will no longer be acceptable (**Ashcroft**). Unfortunately, more liability claims could occur as client expectations increase if the design conflicts are not caught prior to the start of construction, often resulting in additional construction costs for the owner (**Mow, and Naylor**). This is all the more reason to invest in BIM technology early to prevent future conflicts among the design professionals.

4.2.7 Design Delegation

Design delegation among the parties can cause problems with respect to standard of care. BIM technology allows any of the project members to insert material and product information into the model. These project team members can be structural engineers, architects, subcontractors or fabricators. The latter two are not liable for the information that they insert into the model, but the former two are. So if information is inputted improperly or incorrectly, damage can be done to the model, especially if errors are not identified.

As I explained previously, BIM technology has an incredible ability to highlight coordination issues in a design. What's more, BIM will automatically correct the model when a fault is noted. The problem occurs when structural engineers or architects don't notice the problem, or even worse, that the model was altered without their knowledge. Since BIM technology is still in its infancy, legal precedents concerning BIM and design alterations do not yet exist. However, legal cases exist that relate to this subject and could be used as a reference to learn more about what could happen in event of a design mishap that occurred specifically as a consequence of BIM's unique features. For example, in the case of *Frankfort Digital Servs. vs Kistler*, a customer used bankruptcy software to file for a Chapter 7 bankruptcy. The software's manufacturer claimed it was an "expert system" that provided advice on bankruptcy and how to file in various jurisdictions. The Ninth Circuit of California law found that:

Frankfort's system touted its offering of legal advice and projected an aura of expertise concerning bankruptcy petitions; and, in that context, it offered personalized – albeit automated – counsel. Cf. *Landlords Prof'l Servs.*, 215 Cal. App. 3d at 1609. We find that because this was the conduct of a non-attorney, it constituted the unauthorized practice of the law (**Ashcroft**).

According to Ashcroft, “from a legal perspective, there is little difference between Frankfort’s bankruptcy software and advanced BIM tools.” However, a slight difference does exist, and this is the fact that the persons responsible of using the BIM technology are licensed professionals, while the person using the bankruptcy software was a layperson (**Ashcroft**).

It is the responsibility of a licensed structural engineer to be in charge of the design. An engineer usually accomplishes this by doing the work him or herself or by having the work done under his or her supervision. However, automatic changes to the model created by the design software or the information inserted by a fabricator or subcontractor could have not been supervised by a licensed engineer. Thus, the model provided to the client has the chance of not being completely prepared by a licensed engineer (**Ashcroft**).

Consequently, design professionals must practice good engineering judgment with sufficient standard of care when they use design technology to their benefit. Engineers are still responsible for their designs and even though the model is not considered a contractual document, however the model provides important insight about the model, such as, coordination issues and structural element information. Regardless, the model will still need to be prepared and overseen by a licensed professional. This technology has been developed to reduce the pressures on design engineers to help eliminate design issues that arise later in the construction process. However, proper care still needs to be taken to ensure the best possible product is being developed.

5.0 Conclusion

The new construction process enabled by the use of BIM has led to many questions regarding liability and risk for parties that use it. BIM cause legal concerns because of the concerns in software interoperability, data misuse, intellectual property, loss of data, the legal status of the model, the standard of care, design delegation, and standard contracts. Organizations such as the AIA and AGC provide standard contracts for Design-Bid-Build, Design-Build, and IPD. An addendum for BIM use can be added to any of these standard contracts. BIM is beginning to be used in all sizes of projects. However, I believe that the additional design and coordination time required for BIM has the most value on large projects rather than smaller projects. The complex coordination and scale of large projects warrant the

added time and value of BIM. However, the additional design time and cost for BIM on smaller projects is not necessary.

Industry leaders have been hard at work for several years trying to mitigate the liability concerns and developing creative solutions to solve the problems associated with the use of BIM. Many of the solutions to these problems are reflected in the way that the contracts are developed. The AIA 202-2008 and ConsensusDOCS 301, which are the BIM addendums for AIA and ConsensusDocs standard contracts, provide an additional contractual agreement for protection against additional liability issues that could arise from using BIM. Although there are several court cases that provide an example of the ramifications and penalties that will arise if BIM is not used properly, there are currently no court cases involving liability issues with BIM. Industry leaders have been hard at work preventing future risks, but time will tell whether or not the liability prevention tactics, such as standard contracts and BIM addendums, will provide the necessary liability safeguards for structural engineers.

Despite the concerns over the use of BIM, the process and software is still too valuable to overlook not to be used. Project cost savings, conflict resolution capabilities, and the increases in productivity that result from using BIM outweighs potential drawbacks. I believe BIM is the technology of the future and will become the popular choice for project delivery software in the near future. Consequently, we should begin investing time and resources into learning how to use BIM wisely.

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Glossary

IFC – “The Industry Foundation Classes was developed to create a large set of consistent data representations of building information for exchange between AEC software applications... IFC was designed as an extensible ‘framework model.’ That is, its initial developers intended it to provide broad general definitions of objects and data which more detailed and task-specific models supporting practical workflow exchanges could be defined” (**Laiserin 63-92**).

Subrogation – To substitute (one person) for another with reference to a claim or right (**Dictionary.com**)

Aggregate Limit - maximum dollar amount of coverage in force under a health insurance policy, a property damage policy, or a liability policy. This maximum can be on an occurrence basis, or for the life of the policy (**Dictionary.com**)

Consequential Damages - Consequential damages are those that are not a direct result of an act, but a consequence of the initial act. To be awarded consequential damages in a lawsuit, they must be a foreseeable result of an act. In a contractual situation, consequential damages resulting from the seller’s breach include any loss resulting from general or particular requirements and needs of which the seller at the time of contracting had reason to know and which could not reasonably be prevented by cover (obtaining a substitute) or otherwise. Many warranties seek to exclude or limit consequential damages, such as exclusion for loss of time, inconvenience, loss of use of the vehicle or commercial loss in car warranties (www.definitions.uslegal.com)

Incentive Program – A contract that may be of either a fixed price or cost reimbursement nature, with a special provision for adjustment of the fixed price or fee. It provides for a tentative target price and a maximum price or maximum fee, with price or fee adjustment after completion of the contract for the purpose of establishing a final price or fee based on the contractor's actual costs plus a sliding scale of profit or fee that varies inversely with the cost but which in no event shall permit the final price or fee to exceed the maximum price or fee stated in the contract. See also cost contract; fixed price type contract. ("**Dictionary of Military and Associated Terms**")



Peter Boos <peterboos86@gmail.com>

KSU Master Report - Peter Boos

3 messages

Peter Boos <peterboos86@gmail.com>
To: pteicholz@msn.com

Thu, Nov 11, 2010 at 9:34 AM

Dr. Teicholz,

My name is Peter Boos and I am a masters student at Kansas State University and I am doing my master report on Building Information Modeling and how the usage will affect the liability of the structural engineer. I am showing the changes in productivity in the construction industry to prove the necessity for BIM and a needed change in the construction process.

I wanted to contact to you and ask if I could use your graph from your article "Labor Productivity Declines in the Construction Industry: Causes and Remedies" in my report? It is the graph of the construction and non farm labor productivity index. The graph is perfect for my report because it shows the need for a new technology and construction process that will increase the productivity in construction industry.

Do I have your permission to use the graph?

Thanks,

Peter Boos

—

Peter Boos
College of Engineering | Senior
Kansas State University
Peboos@ksu.edu
Cell: (913) 461-9326

Paul Teicholz <pteicholz@msn.com>
To: Peter Boos <peterboos86@gmail.com>

Thu, Nov 11, 2010 at 10:41 AM

You certainly do. Please send a copy of your report.

Paul Teicholz

From: Peter Boos [mailto:peterboos86@gmail.com]
Sent: Thursday, November 11, 2010 10:35 AM
To: pteicholz@msn.com
Subject: KSU Master Report - Peter Boos

[Quoted text hidden]



Peter Boos <peterboos86@gmail.com>

Peter Boos - Image

3 messages

Peter Boos <peterboos86@gmail.com>

Thu, Dec 2, 2010 at 11:08 AM

To: lachmi@aecbytes.com

Cc: aecbytes@aecbytes.com

A copy of the image that I would like to use from your website is attached to this email.

Thanks.

Peter

--


Peter Boos

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Lachmi Khemlani <lachmi@aecbytes.com>

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To: Peter Boos <peterboos86@gmail.com>

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