The Integration of Building Information Modeling (BIM) Into Civil Engineering Curricula

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ABSTRACT

Building Information Modeling (BIM) is an emerging technology used in the Architecture/Engineering/Construction (AEC) industry. The proliferation of BIM usage across the industry has been swift and prolific. Academia has lagged behind the adoption rate of the industry by not producing enough students with BIM exposure. Thus, the question is whether civil engineering curricula should provide an understanding of BIM technology to students entering the design and construction profession. The immediate objective of this research is to determine if it is important to provide exposure of BIM to undergraduate or graduate students in the civil engineering curricula and if so to what extent and how. Should all civil engineering students be exposed or just a subset (e.g. students interested in structural engineering)? What level of exposure and understanding is optimal for civil engineering students as they enter the profession? The capability of BIM technology has continued to increase over the past few years and it is anticipated that the capability of BIM software will continue to increase as the technology gains adoption in the AEC industry.

To ensure that a BIM course would be valuable for civil engineering students, the current adoption of BIM in curricula at several universities has been examined along with a survey of members of the Structural Engineers Association of South Carolina and interviews with civil engineering professionals. Several options are feasible for CE programs; however, some of these are more beneficial for the student and their level of
understanding at various junctures in their studies. BIM exposure can occur at many different levels of a curriculum, including freshman level courses, replacing current engineering graphics courses, at the upper-class level of the curriculum, or as a graduate level course. While this study was originally focused on possible improvements to the civil engineering program at Clemson University, the findings are likely relevant to a large number of existing civil engineering programs. Utilizing the understanding of BIM and the needs of the profession acquired during this research, recommendations are made with respect to the introduction of BIM concepts into a typical civil engineering curriculum.
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CHAPTER ONE
INTRODUCTION

Building Information Modeling (BIM) is creating a significant change in the process typically encountered during the design and construction of a new building. A BIM model is a digital representation of the physical and functional characteristics of a building. Using these characteristics, the model is a resource of shared knowledge beginning from the initial design of the building through its entire lifecycle (NIBS 2011a).

In the typical design-bid-build process, the work progression is very linear, creating a slow, inefficient approach for the overall design (Ballard and Koskela 1998). Furthermore, once the initial design is completed, there are typically several Requests for Information (RFI) in the field due to a lack of coordination between architects, engineers, and contractors during the design.

Although rooted in a three-dimensional (3-D) model, BIM is much more akin to a process that extends across the entire lifespan of a building. Utilizing BIM, each trade can access the model earlier in the design process and input their respective design to gain a better perspective on potential problems in the field. With an accurate model and collaboration, a substantial amount of money can be saved because of the reduction of on-site problems as well as a quicker design process leading to a better end product.

The benefits of BIM extend far beyond an increased efficiency during the construction process. Mr. Jim Jacobi stated the time spent creating a model is approximately the same
as the amount of time spent during the traditional drafting process (Jacobi 2011). Eventually, the same quality construction drawings can be completed in less time than normal using a BIM model, with a more detailed model being created in the same timeframe as traditional drawings. Analytical models can be linked with the BIM model to conduct analysis of the structural system, report the efficiency levels of the HVAC model, and many other capabilities that have not even been utilized yet.

There are even some extended capabilities that are still in their infancy but could become very important tools. With a completed model, the following can benefit from the capabilities of BIM: facilities management, renovations, and post-disaster analysis.

A simulation of facility operation can also be created in conjunction with the addition of time to a BIM model. A prescribed maintenance schedule can be created for the expected lifespan of a building. If the schedule is carried out as expected, the operation of a building should be extended with less emergency maintenance issues. If the occupancy of a building changes during its lifespan, a BIM model can also be used to reanalyze the current structural system with the new loads to ensure that the system is adequate for a change in occupancy.

A BIM model can potentially be used to improve the process of post-disaster analysis. If a building is ever damaged during its lifecycle, the BIM model can be used to compare the as-built condition with the post-disaster condition. Currently, model viewing is
available on several smartphone operating systems; therefore, the model can be viewed during inspections. For example, identifying the severity of a crack in drywall can be easier because of the knowledge of the structural system within the building. Likewise, if excessive deflection is present after an event, the model can be tweaked to recreate the scenario to try and gain a better understanding of what may have caused permanent deformation. Improving the efficiency of post-disaster analyses will allow for more inspections to be made in a shorter period of time. Once the damage is analyzed, a new quantity take-off can be produced to replace the damaged components of the building. Cost estimating can also be used in conjunction with this quantity take-off to give a more accurate assessment of the cost of repairs.

1.1: Project Description

It is expected that the use of BIM will continue to grow in the AEC industry (Azhar et al. 2010); therefore, should civil engineering students be introduced to the principles of BIM and the capabilities of BIM software packages? The goal of this research is to investigate whether or not BIM should be integrated into a civil engineering curriculum, and if so, how should it be implemented? Literature Review, the results of surveys, and interviews were used to determine the need for BIM in a curriculum as well as the expectations of employers. Some universities have begun to introduce BIM into their curricula, therefore, the methods used for these courses were examined to try and find a method that will not only teach students the principles of BIM, but also how to utilize the extended capabilities associate with the BIM. Options were then developed to try and create an appropriate way to introduce BIM to these students to prepare them for what will be
experienced in practice. From the options, recommendations were chosen that best fits the current curriculum offered at Clemson University and likely at other universities.

1.2: Objectives

If a BIM course was proven to be needed, there are several important factors that need to be identified before making a recommendation. First, the level of expertise expected by employers has to be examined within a BIM software package. This factor has a major impact on whether or not BIM can be introduced as a module within an existing class, or should it be introduced in a new class that has a specific focus. Next, the inclusion of other disciplines to facilitate the collaboration aspect of BIM has to be identified. The core purpose of the course also has to be determined. Should a BIM oriented class focus more on the underlying principles and capabilities or should it be software package specific and introduce students to only what is available within that package as well as how to use that package?

1.3: Outline of Thesis

The first section of Chapter 2 is a literature review of information related to this research project. In this Chapter, Building Information Modeling is introduced by describing the underlying principles of what is different between a BIM model and the typical graphic model generated by each of the respective disciplines. In addition, the reader is familiarized with the fundamental capabilities of BIM and acquainted with several current and potential extended capabilities. Next, a review of several civil engineering curricula is discussed with a focus on how engineering graphics courses are deployed as
well as how technical electives are utilized. The introduction of BIM at several other universities around the world is also reviewed with special attention being applied to how and when these courses are offered.

Chapter 3 is a summary of the outreach to professionals utilizing interviews and a survey. Individuals were selected for interviews to gain an idea of how BIM is being used by engineering and construction companies as well as how these engineers believed a BIM course should be offered. A survey was distributed at the 2011 Annual Conference of the Structural Engineers Association of South Carolina. The survey was used to find out approximately how many structural engineering firms are using BIM for their projects and what capabilities are most commonly used. The results of the interviews and surveys were used in the development of options and recommendations for the incorporation of BIM into a civil engineering curriculum.

Chapter 4 presents the options that were created utilizing the information found in Chapters 2 and 3. Each of the options is presented with the modules that will be used in the courses as well as when the course will be offered during the curriculum. A recommendation is made to Clemson University from the options presented. The recommendation is made to try and create a course that will advance the student’s knowledge and be useful once the student enters the profession. The recommendation should be applicable at most universities because of the similar nature of curricula within civil engineering. In addition, a few impediments to implementation are presented.
CHAPTER TWO
LITERATURE REVIEW

BIM usage in the Architecture/Engineering/Construction (AEC) industry has continued to grow at an impressive rate over the past several years. Between 2006 and 2007, the number of AutoDesk REVIT licenses doubled worldwide from 100,000 to 200,000 (Crumpton et al. 2008). At the time, approximately 500,000 AutoDesk AutoCAD licenses were in use. To imply that BIM will render AutoCAD outdated in the near future would be inaccurate, but the data definitely show the importance of BIM to the AEC industry.

Understanding what is included in BIM is a key component in knowing why BIM has become an important tool in the industry. The construction industry experiences approximately $600 billion in losses each year due to non-value added effort or waste (NIBS 2007). Examples of this include: ordering an incorrect amount of materials needed for the job, incorrect installation due to the misunderstanding of construction documents, and idle time waiting for Requests-for-Information. BIM is improving productivity and reducing waste in the construction industry considerably. The increasing number of companies that use BIM is causing universities to examine their curricula to create a system that has their students properly prepared for the industry after graduation. There have been several implementations of BIM classes in civil engineering curricula around the world (Barison and Santos 2010b).
2.1: General Building Information Modeling

The critical element that distinguishes BIM is that it is not simply a software package, but a process that begins at design and continues through the lifecycle of a building. The functionality of a BIM model does not end at the creation of a 3-D model. It is important to note, BIM software packages should not be looked at as the latest edition of CAD. BIM is fundamentally different than CAD because it enables the user to extend beyond just the model by including additional parameters, whereas, CAD provides a simple graphical representation of the building (Sacks and Barak 2010). Construction documents created without the use of BIM software are individually drawn views of the building including plan views, elevations, and sections. Once a satisfactory model is created, BIM software packages allow the user to create these views at a significantly faster rate as well as allow the user to have increased confidence in the accuracy and consistency of said drawings. If the model is modified after views are created, the software package will update the previous drawings to reflect the changes made. By doing this, the chance of drawings not being up-to-date is reduced considerably.

The deficiency of proper collaboration is one of the most problematic portions of the construction process. Figure 2.1 illustrates the normal bid process, which has a very linear progression of information exchange between the parties involved with the construction process.
Figure 2.1: Traditional Design-Bid-Build Process

Figure 2.2 illustrates the change in information sharing when a BIM model is involved. The owner is able to be more involved with the design process because they can visualize the space better, allowing them to change it as needed. Moreover, each of the disciplines can become more involved in the design process much earlier than the traditional process, allowing for fewer problems and less design time.
The failure to effectively communicate is a major contributor to many of the problems experienced during construction. These problems could be more easily avoided if there are suitable lines of communication among the architect, engineer and/or contractor. BIM creates an environment where each of these areas are collaborating more often and earlier in the process. With the increase in the exchanging of information, fewer problems are encountered during the construction process. According to Kymell, (2008) the fundamental concept that should be taught and learned is collaboration.

The Stanford University Center for Integrated Facilities Engineering studied 32 major projects that utilized BIM and found the following benefits (Azhar et al. 2010):
- Up to 40% elimination of unbudgeted change
- Cost estimation accuracy within 3%
- Up to 80% reduction in time taken to generate a cost estimate
- A savings of up to 10% of the contract value through clash detections
- Up to 7% reduction in project time

Figure 2.3 illustrates the advantages of using an integrated design process. Changes can be made with less expense and effort early on. The early integration of disciplines allows for problems to be discovered sooner, therefore, it is less difficult and more cost efficient to solve the problem. Integrated and traditional design processes have similar time requirements; however, the integrated design process shifts the design to a much earlier period during project.

Figure 2.3: The Benefits of the Integrated Design Process (Pressman 2007)
The level of detail required in a model is entirely dependent upon the use of the model. A satisfactory level of detail for a structural detailer will be completely different than that of a Mechanical/Electrical/Plumbing (MEP) contractor. For example, an MEP contractor will only need enough detail on a slab to understand the shape, but a structural detailer will be inputting the location of reinforcement across the slab. Once an accurate model is created, the dexterity of BIM is actually realized. Improved visualization, construction document creation, clash detection, and many other functions can be performed to improve the construction process and the quality of the building. Each of these capabilities will be discussed in detail in subsequent sections.

2.1.1: Parametric Objects & Databases

BIM software packages use parametric objects to model the different components of the building being designed. A parametric object is more than just an extruded representation, which is what traditional graphic programs utilize. The parameters associated with these objects envelope all of the details associated with that particular constituent, thereby creating an “intelligent” object. For example, these parameters include the height of a wall as well as the beginning and end points of the wall. Inside of a BIM model, a wall recognizes that it ends at an adjoining wall. Therefore, if the wall needs to be resized, the affixed wall resizes concurrently so that the change only needs to be made to one of the walls. Figure 2.4 shows the changes made when the structural system is changed using a parametric object. The non-structural components have changed to accommodate the thicker slab and deeper member, without any extra work from the operator.
Depending on the detail of the model, additional database inputs might include cost, delivery time, scheduled assembly time, unit weights, R-values, and who the subcontractor is. These details can later be used in tasks such as quantity takeoffs, cost estimation, and scheduling. Quantity and material takeoffs can be made more accurately using a BIM model because all of the required information including material types and quantities is stored in the databases. In addition, cost estimation and scheduling is more accurate as well because the required data is also stored in the databases. The increased accuracy of these will make creating a “lean” construction environment easier to obtain and meet the goals of being sustainable.

2.1.2: Improved Visualization & Construction Document Creation

Improved visualization is the most conspicuous advantage when creating a BIM model. Owners are able to more easily understand the design of their building when viewing a
BIM model. After models from each of the disciplines are combined, a program can be used to “walk-through” the building as if it were just built. This allows the client to ensure that the environment created by the designer is satisfactory and will meet their needs. Figure 2.5 depicts the increased visualization encountered when using a BIM software package.

Figure 2.5: Illustration of the Improved Visualization Experienced using BIM (Meadowlands Stadium, NJ) (Image Created by Thornton Thomasetti) ((McGraw-Hill Construction 2009))

Improved visualization can lead to fewer problems during construction. The trade crews will be able to view the model so that they can step through the construction process as
well as identify the “finished” look of the building. Using this feature will allow these workers to anticipate difficult areas of fabrication as well as anticipate where problems may occur. The owner will be able to visualize potential future upgrade possibilities for their building. Renters will also be able to envision whether or not a space will fit their needs by utilizing the improved visualization capabilities associated with BIM software packages.

The creation of construction documents is significantly faster when employing a BIM model. After the model is created, very little user input is required to create documents such as elevations, sections, and floor plans. Once the drawing is created, annotations to meet the designer’s needs are added similar to the typical drawing process. A BIM model also handles revisions very well. If a change is made to the model, each previously created view reflects the change automatically. This feature not only saves time and money, it also decreases the chances of missed revisions on different drawings, therefore, leading to fewer problems in the field.

2.1.3: Construction & Time

Time can be added to a model as an additional dimension. By adding time to a model, studies over across a time period can be conducted. Once the fourth dimension is added, several important facets of construction and the lifespan of the building can be examined.

By creating a construction sequence by utilizing the fourth dimension of time in BIM, money can be saved by allowing the constructor to layer the delivery schedules of the
material as well as create an environment where the layout of the construction yard can be designed to increase efficiency. The construction sequence can be used for “just-in-time” training of construction workers to display possible limitations or easier methods for installation. Material layouts can also be created for greater efficiency in the construction area. This will allow materials to be placed in a manner that they will not affect the prescribed sequence until needed. In addition, the positioning of a crane could be contemplated to reduce the number of moves during the construction process to decrease downtime on the job while the crane is moving. Figure 2.6 demonstrates the use of examining the positioning of a crane within a BIM software package.

Figure 2.6: Construction of a High-rise Building Using a Crane (Image Created by Mortenson Construction) (McGraw-Hill Construction 2009)
BIM models might also revolutionize the permit process for construction (Words & Images 2009). Permit offices will need to create an analysis tool that will be able to examine the BIM model and determine whether a permit will be issued based on the details of the model. This feature will decrease the time waiting for permits significantly. The same analysis might also be able to check for building code compliance. This will make building inspections easier by creating a list of possible trouble points within the design.

2.1.4: Clash Detection

Clash detection is also another heavily utilized function once a BIM model has been created. Traditional drawing methods have each of the disciplines produce their own drawings independent of each other. A BIM model, on the other hand, helps reduce clashes by bringing all of the various models of each discipline together earlier in the design process. Once each of the models is present, clash detection is performed to find where elements might run into each other or where code compliance may not be present.

Figure 2.7 exemplifies a complex system of piping and HVAC systems along with the structure where clash detection use in a BIM software package would be useful to help prevent problems during construction.
2.1.5: Sustainability

BIM is making it easier for designers to address sustainability issues as well. There is an increasing trend of buildings becoming Leadership in Energy and Environmental Design (LEED) certified (Ahn and Pearce 2007), and BIM offers several tools that allow the designer to create a more sustainable building. Energy simulation is an available tool that examines the building’s energy performance. This allows the designer to look at the expected energy usage and efficiency losses of the current design of the building. Heating and cooling needs will be more easily calculated using energy simulation. Daylighting analysis examines the annual daylight availability of the building as well as calculates the energy use of automated lighting controls. This creates a scenario for the
designer to inspect how the orientation of the building and geometry will affect the natural lighting that the occupants experience. Thermal performance can also be checked using a BIM model. Investigating the thermal performance can include several aspects including: solar shading and penetration, HVAC systems, natural ventilation, and mixed-mode systems (Words & Images 2009). Deconstructability can also be considered when using a BIM model. Using the databases previously discussed, the materials used during construction will be known for the life cycle of the building. This will allow for the building to be constructed with recyclability and sustainability in mind.

2.1.6: National BIM Standard

Standards are an important factor to the success of any new technology. The presence of these standards indicates industry supervision and will make ensure that concepts are global rather than software specific. The National Institute of Building Sciences (NIBS) released the first version of the National BIM Standard-United States (NBIMS) in 2007. The purpose of these standards is to solve problems associated with ineffective exchange of information amongst the parties associated with the building process. The NBIMS strives to cover all business transactions during all phases of the facility lifecycle (NIBS 2011b). The NBIMS covers information exchange concepts, information exchange content, and further development of standards.

The Information Exchange Concepts chapter in the NBIMS examines the theory and exemplifies the information exchange of BIM models. The purpose of the information exchange concepts chapter is to lay the groundwork for creating a coordinated, industry-
wide BIM language and data structure. Subsections include: “Introduction to Exchange Concepts”, “Data Models and the Role of Interoperability” and “Storing and Sharing Information,” respectively. The second subsection of the Information Exchange Concepts chapter describes how BIM information will be stored in project settings as well as comparing and contrasting integration and interoperability. The third subsection of the Information Exchange Concepts chapter examines the conceptual need for a shared repository for lifecycle information and presents an approach that can be used by information exchanges.

The fourth chapter of the NBIMS, entitled Information Exchange Content, examines the requirements for creating a true, informative BIM Model. Utilizing the guidelines provided, models will be created and be able to be shared because of uniformity across the industry. “BIM Minimum,” defines the quantity and quality required for a defined BIM. This section is one of the most important sections when considering the relative infancy of BIM modeling. By creating a defined minimum, the overall quality of the model is ensured if the minimum requirements are met. “Capability Maturity Model,” expands on the previous subsection by further defining a BIM and informs of a plan to improve the capability to produce a mature BIM (National Institute of Building Sciences (NIBS) 2007).
2.2: Current Civil Engineering Curricula & Methods for BIM Integration

2.2.1: A Nationwide Survey of Current Civil Engineering Curricula
Russell and Stouffer (2005) conducted a nationwide survey of 90 Accreditation Board for Engineering and Technology (ABET) accredited civil engineering programs to gain an understanding of what the students of today are learning during their undergraduate career. The average curriculum found during this survey should not be considered the model curriculum (Russell and Stouffer 2005). The typical progression of classes is engineering science fundamentals, civil engineering fundamentals, and civil engineering specialties. After these areas are covered, the student moves on to design courses, further technical specialization, and then real world experience through cooperative education or in their first few years of practice. Forty-four of the programs required a graphics related course. These courses consisted of engineering graphics, graphic communications, or drafting style classes. Ninety-three percent of the surveyed programs required at least one technical elective course, while fifty-five percent of the programs required at least four technical electives. A BIM course could be used fill the requirements of a technical elective.

2.2.2: An Overview of Current BIM Teaching Strategies
Barison and Santos (2010a), identified 103 schools that have introduced BIM into the curriculum. There is currently no consensus on how BIM should be taught, because it is still unclear. This is because most of the experiences are very recent. Excluding the Georgia Institute of Technology (Georgia Tech), which has been researching BIM since
the 1990s, most of the schools that have integrated BIM into their curriculum have done so since 2003 (Barison and Santos 2010a). Georgia Tech offers most BIM related courses through the College of Architecture and focus heavily on development of BIM software for specific sectors in the industry. The academic BIM experiences have been subdivided into three categories for by Barison and Santos: discipline course (90%), multidisciplinary course (7%), and distance collaboration (3%). The BIM courses have been administered by being integrated into the base curriculum, as an elective, or in conjunction with another course such as an Architectural Design Studio. Their analysis indicated that most of the civil engineering, architectural engineering, and construction management programs introduced BIM in a BIM-specific course (Barison and Santos 2010a).

2.2.3: Review and Analysis of Current Strategies for Planning a BIM Curriculum

Introducing BIM to students is more complex than just adding a new course to the curriculum, because BIM has the potential to be involved in the entire program (Barison and Santos 2010b). The introduction of BIM to the student should correspond to their intellectual maturity based on their previously completed courses (Denzer and Hedges 2008). For classes in the first two years of the curriculum, modeling and model analysis should be the main focus, whereas, courses in the last two years should focus on teamwork and dealing with problems through collaboration.

In general, the design curriculum of universities has changed very little over the past 40 years (Heintz 2010). Moreover, it is the duty of the university to ensure that these
students are prepared. The continued adoption of BIM in the construction industry may require a change to create graduates that will be able to use the software (Crumpton et al. 2008) and understand BIM principles. Larger firms will employ BIM specialists and technicians. However, many small firms will expect the engineer to be capable of identifying problems and making changes within a BIM software package.

Each program must determine how to teach the technology including how to manage the information given and needed for a proper BIM model as well as how to fit BIM into a curriculum and its hour requirements. A BIM curriculum should include concepts that are based on the tools of BIM, how to manage a BIM model, case studies, common problems, and how to implement BIM (Barison and Santos 2010b). Sacks and Barak (2010) have stated that if students have a solid understanding of BIM concepts, they will be capable of using any other tool given to them.

Table 2.1 has been modified from its original form to show universities that have offered a BIM course in a civil engineering program. While this list is not all-inclusive, it is clear that the majority of the universities that have adopted BIM in their curricula have done so in the latter stages of students’ undergraduate careers, whereas, typical CAD classes are taught early. This would indicate that the use of CAD is viewed as a basic skill, whereas, BIM is treated as a more difficult subject or specialty (Sacks and Barak 2010).
Table 2.1: Universities with BIM Courses  
(Adapted from Barison and Santos 2010)

<table>
<thead>
<tr>
<th>University</th>
<th>Author(s)</th>
<th>Program</th>
<th>BIM Course</th>
</tr>
</thead>
<tbody>
<tr>
<td>Israel Institute of Technology</td>
<td>Sacks and Barak</td>
<td>Civil Engineering (CE)</td>
<td>Communicating Engineering Information</td>
</tr>
<tr>
<td>California State University</td>
<td>Kymmell</td>
<td>CM</td>
<td>BIM I, II</td>
</tr>
<tr>
<td>USC</td>
<td>Becerik-Gerber</td>
<td>Engineering &amp; CM</td>
<td>Building Information Management</td>
</tr>
<tr>
<td>Texas State University</td>
<td>Mulva and Tisdel</td>
<td>Architectural Engineering</td>
<td>Design Studio I and II</td>
</tr>
<tr>
<td>George Mason University</td>
<td>George Mason University</td>
<td>Civil, Environ., Infrastructure Eng.</td>
<td>Building Information Modeling</td>
</tr>
<tr>
<td>University of Washington</td>
<td>University of Washington</td>
<td>CM</td>
<td>Advanced Project Management Concepts</td>
</tr>
<tr>
<td>California State University</td>
<td>Kymmell</td>
<td>CM</td>
<td>BIM III</td>
</tr>
<tr>
<td>Purdue University</td>
<td>Schmelter and Cory</td>
<td>Computer Graphic Technology</td>
<td>Commercial Construction BIM Course</td>
</tr>
<tr>
<td>Norwegian U. of Sc. &amp; Tech.</td>
<td>Hjelseth</td>
<td>Structural Engineering</td>
<td>Design of Buildings and Infrastructure</td>
</tr>
<tr>
<td>Cal Poly</td>
<td>Korman and Simonian</td>
<td>CM and CE</td>
<td>MEP Coordination Studio-Laboratory</td>
</tr>
<tr>
<td>Cal Poly</td>
<td>Dong</td>
<td>Arch, CM, and CE</td>
<td>Int. Design Studio and Int. Bldg. Envelopes</td>
</tr>
<tr>
<td>Virginia Tech</td>
<td>Ku</td>
<td>CM, Building Construction, Arch.</td>
<td>Several BIM Courses</td>
</tr>
<tr>
<td>Texas A&amp;M University</td>
<td>Texas A&amp;M University</td>
<td>Arch, CM</td>
<td>Integrated Design Studio</td>
</tr>
<tr>
<td>Penn State University</td>
<td>Poerschke et al.</td>
<td>Arch, CE</td>
<td>Integrated Design Studio</td>
</tr>
<tr>
<td>Georgia Tech</td>
<td>Georgia Tech</td>
<td>Graduate Courses</td>
<td>Building Information Modeling: Case Studies</td>
</tr>
<tr>
<td>California State University</td>
<td>Kymmell</td>
<td>CM</td>
<td>Building Information Modeling IV</td>
</tr>
<tr>
<td>University of North Texas</td>
<td>Arnold</td>
<td>Construction Engineering Tech.</td>
<td>Senior Design Class</td>
</tr>
</tbody>
</table>

2.2.4: BIM Integrated into a Freshman Year Civil Engineering Class

At the Israel Institute of Technology, BIM principles were introduced in a class entitled “Communicating Engineering Information.” Sacks and Barak (2010) produced a case
study detailing the class and how it was received by students. This class did not focus exclusively on BIM; however, it was the basis for a large portion of the course.

The key to this course is that instead of focusing on a certain software package, it concentrated on the underlying principles of BIM. The staff decided to present BIM to the undergraduate students as an essential basic communication skill that should be required for civil engineers as opposed to a specialty subject. Teaching BIM this way has shifted the traditional method of instructing on a particular skill independently to teaching a conceptual approach to engineering communication. By utilizing this approach, BIM is viewed as a human activity that encompasses a change in the construction process rather than a thing or type of software (Eastman et al. 2008).

The course contained five major modules of content: general introduction, engineering graphics, BIM concepts, the language of engineering drawings, and BIM training. The introduction module included an overview of engineering graphics and BIM as well as an introduction to building structures and their commonly used nomenclature. The engineering graphics module taught the basics including orthographic projections, cut sections, and isometric views using sketching. The next module, BIM concepts, introduced the students to the essentials of computer graphics, solid modeling, and object-oriented modeling. The language of engineering graphics was then taught to ensure the students understood the symbolic language that is typically used in structural
and construction documents. BIM training was used to introduce the students to the capabilities of BIM software.

2.2.5: Introduction of BIM into the Curriculum at Worcester Polytechnic Institute

Salazar et al (2006) has written a report on the way BIM has been implemented into the curriculum at Worcester Polytechnic Institute (WPI). The introduction of BIM into the curriculum helps the students be better prepared to practice engineering after graduation. The addition of BIM has benefited the students by helping to develop a more complete understanding of the building and its components as well as letting the students acquire an advanced skill.

BIM has been gradually added to the curriculum at WPI and has made its way into graduate, undergraduate, and Major and Interactive Qualifying Projects. In 2003, Autodesk Revit was used for a term project in a graduate class entitled “Information Technology in the Integration of Civil Engineering.” The class was reoffered in 2004 and 2006, with BIM still being used to develop the term project. However, lectures were also dedicated to the use of BIM by guest speakers. Throughout the term project, students completed training modules in the use of the software as needed. The training modules were a combination of web-based training with lab sessions in class.

Also, beginning in 2003, a 1-week module was introduced a predominantly freshman and sophomore level civil engineering course entitled “Civil Engineering and Computer Fundamentals.” This module focused on the introduction of Autodesk Revit to the
students. Furthermore, the same module has been taught at the end of an AutoCAD course. The module consisted of two lectures, three assignments, a learning style assessment test, and a final quiz. The module has also been beneficially linked to a second module taught by a different instructor.

Salazar (2006) feels as if the addition of BIM to these courses was advantageous and properly prepared their students for entry-level employment in the AEC industry. Conclusions drawn from the inclusion of BIM were: the software can be considered “user-friendly,” BIM software is a powerful tool for avoiding design errors, the use of BIM software increased the students’ understanding the concepts of a building, and using BIM software made it easier for students to comprehend some technical components of a building.

2.2.6: Collaborative Learning Environment

BIM creates a much greater need for more collaboration between architects, engineers, and construction managers at an earlier stage in the design process. Using BIM, users from several different disciplines are able to create and share information concerning the project in a common database (Eastman et al. 2008).

Richards and Clevenger (2011) created a course that focused on using BIM to create an interoperable learning environment combining structural engineering and construction management students. At Colorado State University, the faculty and students created teaching modules that allowed students to experience BIM in an interdisciplinary
fashion. The modules consisted of two parts: a demonstration video describing the information available in a BIM model and how to access it and a self-guided learning assessment that allowed students to use a real-life BIM.

Employing BIM in these modules was able to teach the students about the interrelation of information across building process. Traditionally, in the classroom setting, the different disciplines do not do an adequate job of concentrating on the information exchange required for the construction process to be considered successful. In addition, the improved visualization provided by using BIM allowed the students to gain a greater understanding of how the building system is developed. These teaching modules allowed the student to further their knowledge of their own discipline, as well as gain a better understanding of how to exchange their own findings with the other disciplines. The collaboration style of this course has allowed students to experience some additional tools of BIM that they would not normally be involved with because it falls outside their area of expertise.

2.3 Conclusion

BIM is becoming an important tool in the AEC industry because of its wide range of capabilities and contributions to reducing costs during design and construction. The continued adoption of BIM in the industry means that civil engineering programs need to introduce students to a technology that is likely to be used by the student in practice. There have been several different attempts at integrating BIM into curricula ranging from an introductory course for freshman, collaborative learning environments, and adding a
BIM module into an existing course. These courses focused on the tools of BIM, collaboration techniques, and how to model using a software package.
CHAPTER THREE
THE NEED FOR BIM EXPOSURE IN A CIVIL ENGINEERING CURRICULUM

If BIM should be introduced into the curriculum, it is important that the method utilized will adequately prepare a student for what will be experienced in the profession. In order to gauge the usage of BIM in the industry and expectations concerning adding BIM to the curriculum, a survey was distributed to members of the Structural Engineers Association of South Carolina. In addition, several interviews were conducted to receive more detailed responses.

3.1: Survey of the Structural Engineers Association of South Carolina

A survey, found in Appendix A, was sent out to members of the Structural Engineers Association of South Carolina. The purpose of this survey was to try find out more about BIM usage in the state as well as try to gain some perspective on how structural engineering professionals perceive the presence of BIM in a civil engineering curriculum. Twenty people responded to the survey, with all of the respondents having been in the industry for more than six years. Members of the Structural Engineers Association of South Carolina come from many different firms, so the responses give a representation of small and large firms. However, the level of experience using BIM these respondents have is unknown; therefore some respondents may have a better understanding of what BIM is capable of.
Of the twenty respondents, nine have used BIM at their current or former employer. Four of the people that have used BIM replied that they were required by the architect to create a model. Fifty-five percent of the respondents that have used BIM said they were formally trained on how to use BIM, with each of them being trained by utilizing a short course. However, the depth of these courses is not known. Sixty-six percent of these respondents felt that a BIM focused class would be beneficial for students, but only forty-four percent felt that it should be a requirement in a civil engineering curriculum. Seventy-eight percent of the respondents that had used BIM felt that BIM knowledge would make someone a more attractive candidate to potential employers, whereas, eighty-one percent of those that had never used BIM felt that it would make a candidate more attractive. Of the respondents that had not used BIM, only thirty-six percent felt that it would be a beneficial addition to their company. Table 3.2 shows a full summary of the results from the survey.
Table 3.2: Summary of Survey Results

<table>
<thead>
<tr>
<th>Questions for respondents whose employer has used BIM</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does your current employer use BIM or has a past employer?</td>
<td>Yes 45%  No 55%</td>
</tr>
<tr>
<td>Your company only uses BIM modeling when required by the architect?</td>
<td>Yes 44.4%  No 55.6%</td>
</tr>
<tr>
<td>Were you formally trained on the principles of BIM?</td>
<td>Yes 55.5%  No 44.5%</td>
</tr>
<tr>
<td>A class about BIM in a school's curriculum would be beneficial to students.</td>
<td>Agree/Strongly Agree 66.6%  Neutral 11.1%  Disagree/Strongly Disagree 22.2%</td>
</tr>
<tr>
<td>Having BIM knowledge would make someone a more attractive candidate to employers.</td>
<td>Agree/Strongly Agree 77.8%  Neutral 0.0%  Disagree/Strongly Disagree 22.2%</td>
</tr>
<tr>
<td>If a BIM class was offered, you would suggest students take it.</td>
<td>Agree/Strongly Agree 77.8%  Neutral 11.1%  Disagree/Strongly Disagree 11.1%</td>
</tr>
<tr>
<td>A class on BIM should be a requirement for students in a Civil Engineering curriculum.</td>
<td>Agree/Strongly Agree 44.4%  Neutral 33.3%  Disagree/Strongly Disagree 22.2%</td>
</tr>
</tbody>
</table>

Questions for respondents whose employer has not used BIM

<table>
<thead>
<tr>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you feel like BIM usage would be a beneficial additional at your company?</td>
</tr>
<tr>
<td>Having BIM knowledge would make someone a more attractive candidate to employers.</td>
</tr>
</tbody>
</table>

The responses to the survey indicate that these professionals feel that the integration of BIM into a curriculum would be beneficial to students. The majority of respondents believe that BIM knowledge makes a candidate more attractive to employers, therefore, universities should begin to introduce BIM into their curriculums so that their students are being prepared for what they will experience in the AEC industry. More than 75% of the respondents with BIM experience feel that a student should take a BIM class if it is offered. This indicates that these professionals feel that BIM is an important tool and is something that the student should take advantage of a course.
3.2: Interviews

The interviewees were chosen to get a broad look at various sized structural engineering and construction firms. Table 3.1, identifies the people that interviewed, what company they work for, and the demographic represented.

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Company</th>
<th>Demographic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jim Jacobi</td>
<td>PE, CIO, Principal</td>
<td>Walter P. Moore</td>
<td>International Structural Engineering (SE) Firm</td>
</tr>
<tr>
<td>Scott Sprouse</td>
<td>PE</td>
<td>Bailey and Son Engineering</td>
<td>Typical SC SE Firm</td>
</tr>
<tr>
<td>Brian Pietras</td>
<td>PE</td>
<td>Rickborn &amp; Associates</td>
<td>Small SC SE Firm</td>
</tr>
<tr>
<td>Terrell Parrish</td>
<td>PE, Project Manager</td>
<td>CMC Cary Engineering</td>
<td>Typical SC SE Firm, Focused on Steel Structures</td>
</tr>
<tr>
<td>David Impson</td>
<td>PE, Vice President</td>
<td>Britt Peters &amp; Associates</td>
<td>Typical SC SE Firm</td>
</tr>
<tr>
<td>Katie Spearman</td>
<td>EIT, Preconstruction Engineer</td>
<td>Balfour Beatty</td>
<td>Large Construction Firm</td>
</tr>
<tr>
<td>Chad Thelin</td>
<td>Process Manager</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eric Cleveland</td>
<td>Process Manager</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chris Smith</td>
<td>PE</td>
<td>Jacobs Engineering</td>
<td>Large Multi-Discipline Firm</td>
</tr>
</tbody>
</table>

The interviews were conducted to gain more insight on what was discovered from review of the survey results and the literature review. Notes from these interviews can be found in Appendix C. During the interviews, professionals communicated their beliefs on things such as whether or not a BIM course should be offered, when it should be offered, and what should be included in a course were found. Additionally, more was found out about how these firms are utilizing BIM and some of the problems they are encountering. During the interviews, several responses that were repeated amongst interviewees include:
- A BIM focused course should be an option for students.
- The course would ideally be generic and able to focus on the principles of BIM.
- Students should also have a working knowledge of the leading BIM software package, currently Autodesk Revit.
- Collaboration and appropriate use of the advanced visualization techniques were two of the most mentioned capabilities that should be included in a BIM course.
- BIM experience is not currently a requirement for new hires, but it looks like it may be in the future.
- Currently, a short introduction to BIM and then plenty of on-the-job training are the most used training solutions for employees that are learning BIM.
- There is not very much confidence when sharing models between analytical models and BIM models.

From the above responses, firms would like to see students obtain a working knowledge of BIM software packages. At some point in the future, BIM experience might even become a requirement when hiring a new employee. Collaboration between the disciplines was mentioned as one of the key components to BIM, so it should definitely be focused on in a course. Knowledge of how to share models between analytical and BIM models would also be a valuable skill in the profession.

There were also several unique responses of note. Balfour Beatty mentioned during the interview that they would be willing to become involved with introducing BIM at Clemson University. At Bailey and Son, the level of detail of models is being limited by the BIM experience of the operator and budget issues. Mr. Jacobi believes that a BIM course would best serve the students if offered at a junior or senior level. Furthermore, he recognizes that one of the challenges that will be encountered will be fitting additional
class hours into an already tight graduation hour requirements. This view concurs with what was discussed in the survey of civil engineering curricula by Russell and Stouffer (2005).

It was also brought up that an engineer typically designs rather than spend time drafting; however this is not always the case. Currently, the trend for large firms is to have a CAD specific group with dedicated trained technicians, but this is not always the case at smaller firms. The engineer is still expected to understand how to utilize AutoCAD to provide advanced details on drawings. It is anticipated that a similar situation will happen with BIM, so the engineer must have experience and knowledge of BIM to complete the work expected of them.

The interviews indicate that the integration of BIM into a curriculum should happen. The responses specify that a BIM course should offer students the chance to collaborate with other disciplines, gain a working knowledge of Autodesk Revit, and learn how to take advantage of the added visualization encountered when using BIM. Teaching the student how to coordinate models between analytical software and BIM modeling software would also be beneficial to the student. Receiving training on BIM will make these students more attractive candidates to employers because it will reduce the amount of training required to bring the student to speed once they start their career.
3.3 Conclusion

The survey and interviews both indicate that the need for BIM in a civil engineering curriculum is present. BIM knowledge makes a candidate more attractive to a potential employer; therefore, it would be beneficial for programs to add BIM into the curriculum so that the students are better prepared for the profession. Additionally, experience using BIM may soon be a requirement for new hires as well. Interview responses indicate that a BIM course should focus on the general principles of BIM, while also introducing the student to leading software package, currently Autodesk Revit. Collaboration techniques for sharing information between disciplines should also be included in a BIM-specific course.
CHAPTER FOUR
OPTIONS AND RECOMMENDATIONS FOR INTEGRATING
BIM INTO A CIVIL ENGINEERING CURRICULUM

With 77% of survey respondents with BIM experience and all of the interviewees stating that a BIM class should be offered, it is clear that there is a need for a BIM focused course in a civil engineering curriculum. Integrating BIM into a curriculum is a difficult task. There are several factors that need to be considered when deciding how the students should be exposed to BIM. These factors include: when to offer the class in the civil engineering curriculum, how much exposure to software packages should be included, how to effectively utilize and expose students to interoperability between disciplines, and what to include in a BIM-oriented course?

After reviewing each of these factors, four options are being presented to create a course(s) that will not only introduce students to BIM, but try to implement the underlying principles that drive BIM. If a class is created, it is important that it meet the expectations of professionals in the AEC industry. The first option creates a class to be taken during the student’s freshman year that will focus on BIM principles, basic modeling skills, visualization techniques, and how to effectively communicate engineering communication. This course would closely resemble the class offered at Technion Institute of Technology discussed earlier. The second option offers two alternatives to alter the current Engineering Graphics, EG 210, which is offered during the first semester of the student’s sophomore year. The two alternatives for this are
splitting the students based on their emphases or adding a third hour to the course and offering a BIM concepts module to all students in the course. The third option would create a discipline specific course that would offer credit for both upper-level undergraduates and graduate students. An example of this would be a class that would be taught as a continuation of the “Structural Loads and Systems” course currently offered in the same capacity to further prepare the students for a career in structural design. The fourth option would add BIM to the Capstone Design project and shift the current setup into a two-semester course that encourages interoperability between the disciplines of civil engineering.

4.1: First Option: Introduction Early in a Curriculum

This option would create a class at the freshman level that would closely resemble the course offered at the Technion Institute of Technology discussed earlier in Chapter 2. The course would focus on improving the student’s ability to effectively communicate engineering information. The class would feature four modules during the semester:

- Engineering Graphics – Teaching students the basics of engineering graphics including views, line styles and types, and projections.
- BIM Concepts – Teaching the basics of BIM including parametric objects, modeling, and computer graphics.
- Engineering Drawing – Teaching the student how to properly communicate the drawing utilizing dimensioning, symbols, annotation, and title blocks.
- BIM Training – Teaching the student how to create a basic building utilizing the capabilities of a BIM software package.
This option would not fit well into the curriculum at Clemson University. Currently, the first year is devoted to exposing students to the various disciplines of engineering. BIM does cross over to other disciplines of engineering, but the percentage of students in these disciplines that will work in the AEC industry are not small enough to warrant adding the class for all disciplines. This course would force students to choose at such an early stage in their academic career that it could eventually become a hindrance to have taken the incorrect course for their chosen major.

4.2: Second Option: Altering the Current Engineering Graphics Course

In the current syllabus for EG 210, which is an AutoCAD focused course, the main course goals are defined as preparing students for the expectations of future engineering courses and to provide students with a solid foundation of basic engineering drawing skills. With the advent of BIM in the AEC industry, certain students are not prepared for what they will experience once they enter the profession. Currently, the class provides adequate exposure into the drawing skills required for each sub-discipline in civil engineering.

4.2.1: Splitting Students Based on Emphases

One option would be to split the engineering graphics course based on a student’s anticipated sub-discipline. The structural engineering students and construction engineering students would be in a section that would focus on building graphics utilizing a BIM software package as well an introduction to the principles of BIM. Students that
are in other sub-disciplines would continue learning from the current EG 210 course syllabus.

4.2.2: Addition of One Credit Hour to Include BIM in Current Syllabus

The other option would be to add one credit hour onto the current engineering graphics course to include BIM in the syllabus. This option would introduce all students to the concepts of BIM while also still teaching the student to AutoCAD. In this course, the students would be introduced to basic BIM concepts such as capabilities and what information can be pulled from a completed model. Modeling in a software package would not be a focus for this option.

This course would not be an ideal fit for Clemson University. At this point during the curriculum, the student will have chosen civil engineering as their major. However, there are still a few drawbacks to offering BIM this early. The student’s knowledge of building systems and construction processes will be minimal, therefore, they will not be able to make the connection between BIM principles and how a building is put together. Furthermore, it is unclear whether or not the student will carry enough knowledge into their later courses to make use of BIM in their assignments. However, if the course is used in conjunction with later options, it could provide a general understanding for use later.
4.3: Third Option: Discipline Specific Course with BIM

The third option is to create a course that will be discipline specific with BIM included. Creating a course like this will allow the instructor to independently decide how integrated BIM will be in the syllabus. Using this model, disciplines such as structural engineering, site design, and construction management can host their own class and dictate what exactly will be included. Below is an example of a structural engineering specific class that would complement the needs of Clemson University. The course would be entitled “Computer Modeling Techniques for Structures.”

This option would create a technical elective to be ideally taught in the first semester of the student’s senior year prior to taking the one-semester senior capstone design course. The “Structural Loads and Systems” course (CE 408) would be a strongly recommended prerequisite for this course so that the student would adequately understand a building’s structural system. The objective of this course is to increase students’ knowledge of how to accurately model a structure utilizing both analytical programs and a BIM software package to prepare them for what will be experienced after graduation. This class would be a three-hour course that would feature four modules:

- **SAP/ETABS** – This module would be used to introduce the student to structural analysis software packages created by Computers & Structures, Inc. (CSi). Modeling techniques for commonly occurring situations in the real world would be covered.

- **RAM Structural Systems** – This module would be used to introduce the student to structural design software packages created by Bentley. The student will learn
how to model a building’s structural system and then analyze it to withstand loading scenarios learned in Structural Loads & Systems.

- **BIM** – This module would be used to introduce the student to the principles of BIM as well as learn how to model a building’s structural system in Autodesk Revit.

- **Integration of Analytical and BIM Models** – This module would be used to introduce the student to the difficulties typically encountered when transferring models between analytical and BIM models and how to overcome them.

The biggest advantage to this course, or any discipline specific course, would be the ease of implementation within the curriculum at Clemson University. Necessary coordination between faculty members would be minimal if the class is taught by two faculty members, one for the analytical modeling module and one for the BIM modeling module. However, the class could easily be taught by one faculty member if they had knowledge in both structural modeling and BIM modeling. Currently, there is not a modeling class at Clemson University; therefore by adding a modeling class, structural engineering students will be better prepared for what they will encounter in practice. This course would be available to both undergraduates and graduates as a 400/600 level course, which would be beneficial to students that did not complete their undergraduate coursework at Clemson University.

The biggest disadvantage for this option is the lack of inclusion of collaboration between disciplines. In order for students in other disciplines in civil engineering to gain experience with and knowledge of BIM, several other courses such as the scheduling and estimating classes taught at Clemson University would have to be altered to include 4-D
modeling and quantity takeoffs, respectively. Furthermore, the difficulty in promoting collaboration between these classes would be extremely difficult because it would cause these classes to be taught during the same semester each time for the greatest benefit.

Figure 4.1 illustrates the prescribed path for structural engineering students if the third option is implemented: After completing the Computer Modeling course and design courses such as Steel and Reinforced Concrete Design, the structural engineering student will be prepared to be the Structures Representative of their Capstone Design Project team. Once the undergraduate curriculum is finished, the student will be able to apply skills learned during the Computer Modeling course to assignments during their graduate curriculum.

Figure 4.1: Optimum Course Path for Students when the Third Option is Implemented
4.4: Fourth Option: Create an Addition to Capstone Design Project

The fourth option is to alter the Capstone Design project to include BIM. The addition of BIM into a Capstone Design project will potentially create a more realistic execution of what will be experienced in the profession. Capstone Design projects are already typically team based, so the collaboration aspect of BIM is easily introduced. Below is an example of the proposed addition of BIM into the Capstone Design project for civil engineering students at Clemson University.

This option would revamp the Capstone Design Project at Clemson University. Currently, the students participate in the design project in their last semester as an undergraduate with team members designing a building, doing site work, creating a construction schedule and estimate, and performing a hydrological study of the site. This option would extend Capstone’s time requirement to two semesters. The hour allotment would remain at three hours for the second semester, with the first semester also being worth three credit hours. The overall goal and final deliverable would be similar; however, the road to the final project delivery would change significantly.

The first semester (Capstone 1) will feature three modules of instruction for students:

- Civil Engineering Communication – This module will replace or augment Technical Writing (Engl 314) and will prepare students for how to effectively communicate their work using memos, presentations, and technical reports. This module could be taught by a faculty member from the English department, or a Professional Engineer (PE) that is a member of the faculty that has experience communicating their technical information.
• Software Use for Project Delivery – This module will be used to teach each discipline the software that will be used during the design process. Each student will be introduced to the principles of BIM, and then they will split into “breakout” groups to learn their individual software packages. For the structures students, RAM Structural Systems and Autodesk Revit for structural system modeling will be taught. For the construction management students, Microsoft Project and Autodesk Revit for quantity takeoffs and 4-D modeling will be taught. For the site work and transportation students, Autodesk Civil 3D will be used, which can easily have a Revit model imported in for a comprehensive view of the site with the building. The hydrology students will learn how to use HydroCAD and Autodesk Revit so that the hydrological studies can be performed for the site and modeled once the site and building models are finished.

• Creation of Conceptual Design for Project – This module will be where students begin to use the skills learned in previous modules of the class to produce a conceptual design for the project. The deliverable will consist of mostly finished architectural floor plans where code requirements have been considered.

The second semester (Capstone 2) will begin with students commencing work on their preliminary designs and finishing with a full project delivery at the end of the semester. By utilizing two semesters for the design process, the designs can be more refined for a more realistic view into the design process. Each discipline will be expected to have a more comprehensive design finished at the end of the second semester because of the added time.

This biggest advantage of this option stems from the inherent collaboration required for a successful project delivery. Each of the disciplines will be directly involved with creating or utilizing a BIM model for the completion of the project. Interoperability between the disciplines was consistently mentioned during the interviews performed as one of the most important tools associated with utilizing BIM. In addition, creating a two
semester design project will allow the students to experience a much more in depth design process.

The biggest disadvantage of this option stems from the increased demand on faculty. The number of faculty that would be required for this project to successfully happen would increase. Each faculty member would have to create their own expectations for their discipline’s team members as well as work in conjunction with the other faculty members’ disciplines.

Figure 4.2 illustrates the expected path of students if the fourth option is implemented: The students will be forming an initial BIM model as well as learning the software associated with their discipline during the first semester with refinement and final design occurring during the second semester.
4.6: Recommendation for Integrating BIM into the Civil Engineering Curriculum at Clemson University

Civil engineering students who plan to work in an area where BIM is being used should be exposed to the technology to gain an idea of how it is used as well as a working knowledge of what is required to complete a model. Attaching BIM to a discipline specific course and altering the Capstone Design project to include BIM are both options that will meet this objective. The ideal situation would be offering courses across the curriculum to have students gain a more comprehensive understanding of the uses of BIM. This setup would give the students a general understanding of BIM, as well as introduce the BIM requirements of their discipline, and give them the opportunity to use
that knowledge in a collaboration environment that mimics industry. Moreover, if only one option is feasible, then the student is still being exposed to BIM in some capacity.

The first option would be difficult to implement because the student’s schedules during their freshman year are full. The courses these students are taking at this point in the curriculum are critical, therefore, it would be detrimental to try and replace one of the fundamental courses. The second option would not be ideal because the student would still be missing a fundamental understanding of buildings, which would prevent them from being able to take advantage of the more advanced capabilities associated with BIM.

If only one option is to be introduced at Clemson University, the best solution for students would be integrating BIM into the curriculum would be the fourth option presented above. The addition of BIM into a Capstone Design environment would satisfy the expectations presented by the interviewees including the collaboration of disciplines, giving students a working knowledge of Autodesk Revit, and exposing the student to the other principles of BIM. Extending the Capstone Design Project to include BIM has several benefits for the students. Several of the most important capabilities and abilities of BIM will be illustrated in the new course set-up such as the importance of early integration of each discipline, increased visualization techniques associated with the project, and the addition of 4-D modeling. The student will also gain a greater
understanding of the scope of work required during the design and construction phases of a new project.

Introducing the new Capstone Design Project set-up will help create a student with a higher understanding of what is expected in the real world. It is anticipated that after finishing the two semester sequence, students will be well versed in how to communicate their technical information, create analytical models in their respective discipline, and possess a better apprehension of what is required for a final project delivery. It is important that Clemson University takes the appropriate measures to ensure that the students here are provided with an education that will help them develop into professional engineers. Clemson University has the chance to stay at the forefront of civil engineering education by adding BIM; however, if action is not taken quickly, the Department might very well fall behind the curve. The interviewees from Balfour Beatty were very adamant that this would be the case in the very near future.

The third option would also be beneficial to Clemson University because it would still be offering an integration of BIM into the curriculum. If changing the Capstone Design Project is not a viable solution immediately, the introduction of a discipline specific course would hopefully set a precedent and potentially motivate other disciplines to follow suit and start a course that will introduce students to the benefits of using BIM within their disciplines.
4.6: Potential Impediments for Successful Implementation

The following is a list of problems that may arise during the implementation of an option:

- For the extended Capstone option, a student not continuing to the second semester of the course would create a problem for a team because of the increase in workload. (Option 4)

- Will a typical student’s laptop be able to handle the computational requirements of a detailed model? If not, will computers with BIM software licenses be provided in a lab environment? Currently, software providers are administering licenses for students to load BIM software packages on their own personal machines. (All Options)

- How much of a disadvantage will a student experience if they are off-schedule and take the BIM course before completing a course that would lay the groundwork for being successful in the BIM course such as “Structural Loads and Systems” for the structures specific modeling course? (Option 3)

- AutoCAD experience is still heavily requested by professionals, how much of a disadvantage will be created for students that only have Revit experience with little to no interaction with AutoCAD? (Option 2)
CHAPTER FIVE

CONCLUSION

The purpose of this study is to develop a recommendation for Clemson University’s civil engineering department on how BIM should be introduced to students. To achieve this goal, a literature review, a survey, and interviews were conducted to find out how much BIM is actually being used in the professional world and determine the need for BIM integration in a civil engineering curriculum. A few universities have already begun to offer courses about BIM using varying methodologies. These courses were examined and used in conjunction with the responses from professionals to try and synthesize a course that adequately covers BIM and its capabilities.

Integrating BIM across an entire curriculum, or any combination of the presented options, would present the most beneficial opportunity for students to prepare themselves for what they will experience in the profession. However, if only one option were available to introduce students to BIM, the recommendation would be the addition of BIM into the Capstone Design Project.

The second semester’s schedule will remain largely unchanged, other than the conceptual design being completed in the first semester. The first semester will offer the students three major modules of learning. These modules will focus on improving the student’s ability to communicate engineering information, teaching the students the software associated with their discipline, and completing a conceptual design for the project.
BIM’s principles will be introduced to all of the students during the second module, but the structural engineering and construction management students will learn how to utilize a BIM software package for their tasks.

It is critical that schools begin to offer BIM training to their students. Academia has fallen a great distance behind the professional world concerning the use of BIM. Students attend school to properly prepare themselves for what they will experience once they enter the work force. As BIM use continues to increase, these firms will begin to look at BIM experience as a requirement, similar to that of AutoCAD currently.

5.1: Future Action

If any of these courses are implemented, an assessment program must also be put in place to ensure that the course is preparing students for what the student will experience in practice. The purpose of this assessment will be to find out if the original implementation is on target, should anything within the class be adjusted, and is the material still relevant. A course covering a quickly evolving technology needs to be monitored closely to ensure that the material being taught is not out of date or inaccurate because of changing capabilities. For this assessment, the instructor, stakeholders, and students all need to be contacted for their opinion on the course. The success of the project delivery should also be assessed because of the significant change Capstone will experience with the advent of BIM.
REFERENCES


Zarzycki, A. (2010). "BIM as Design Exploration Tool in Architecture.".
APPENDICES
PROFESSIONAL ENGINEER SURVEY
(6+ years since graduation)

The following survey should take less than 3 minutes to complete. Building Information Modeling (BIM) is becoming an important tool in the AEC industry of late. The Clemson University Civil Engineering Department is trying to gauge the amount of usage in order to determine if BIM should be integrated into the curriculum. Please take a few minutes to help us potentially create a class that could be beneficial to your company down the road. If you have any problems during the survey or would like more information, please contact Jason Cooksey at 864-504-4598 or jcookse@g.clemson.edu.

PLEASE RETURN THE SURVEY BY FRIDAY, SEPT. 23, 2011, BY EITHER SCANNING AND E-MAILING TO JASON COOKSEY OR BY FAXING THE COMPLETED SURVEY TO 864-656-2670.

Number of Civil/Structural Engineers at your company:

College Degree Received From: 

If you wouldn’t mind us contacting you for more information, please leave your mailing and e-mail addresses below:

Your Name (optional):  
Company Name (optional):  
Mailing Address (optional):  

E-Mail Address (optional):  

Would you like to receive the results from the survey?  
○ Yes  
○ No

Does your current or former employer use BIM?  
○ Yes  
○ No
If yes, please proceed to Question 1. If no, please proceed to Question 15. Please mark the answers in the bubble.

1. Who develops the BIM model at your company?
   - Structural Engineer or EIT
   - CAD Technician
   - Other, Please Specify: ________________________________

2. Who updates the BIM model at your company?
   - Structural Engineer or EIT
   - CAD Technician
   - Other, Please Specify: ________________________________

3. Does your company only uses BIM modeling when required by the architect?
   - Yes
   - No

4. What BIM software have you used or are currently using? (Mark all that apply.)
   - Autodesk Revit Structure
   - Bentley Structural Modeler
   - Bentley RAM, STAAD and ProSteel
   - Tekla Structures
   - CypeCAD
   - Other, Please Specify: ________________________________

5. What structural design software did/do you use in conjunction with your BIM software? (Mark all that apply.)
   - SAP2000/ETABS
   - RAM Structural System
   - STAAD-Pro
   - Other, Please Specify: ________________________________
6. What capabilities of BIM did/do you utilize? (Mark all that apply.)
   ○ Clash Detection  ○ Estimating
   ○ Project Visualization  ○ Design
   ○ Other, Please Specify: ___________________________________

7. What percentage of projects has your company used BIM for in the last year?
   ○ 0 – 25%  ○ 51 – 75%
   ○ 26 – 50%  ○ 76 – 100%

8. Using BIM has increased productivity at your company.
   ○ Strongly Agree
   ○ Agree
   ○ Neutral
   ○ Disagree
   ○ Strongly Disagree

9. Using BIM reduced the amount of problems experienced during the following:
<table>
<thead>
<tr>
<th>Design</th>
<th>Plan Review</th>
<th>Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Agree</td>
<td>Strongly Agree</td>
<td>Strongly Agree</td>
</tr>
<tr>
<td>Agree</td>
<td>Agree</td>
<td>Agree</td>
</tr>
<tr>
<td>Neutral</td>
<td>Neutral</td>
<td>Neutral</td>
</tr>
<tr>
<td>Disagree</td>
<td>Disagree</td>
<td>Disagree</td>
</tr>
<tr>
<td>Strongly Disagree</td>
<td>Strongly Disagree</td>
<td>Strongly Disagree</td>
</tr>
</tbody>
</table>

10. Were you formally trained on the principles of BIM?
    ○ Yes
        If yes, how: ___________________________________
    ○ No
11. A class about BIM in a school’s curriculum would be beneficial to new graduates.
   - Strongly Agree
   - Agree
   - Neutral
   - Disagree
   - Strongly Disagree

12. If a BIM class was offered, would you suggest students take it.
   - Yes
   - No

13. Having BIM knowledge would make someone a more attractive candidate to employers.
   - Strongly Agree
   - Agree
   - Neutral
   - Disagree
   - Strongly Disagree

14. A class on BIM should be a requirement for students in the CE curriculum.
   - Strongly Agree
   - Agree
   - Neutral
   - Disagree
   - Strongly Disagree

STOP, YOU HAVE REACHED THE END OF THE SURVEY, THANK YOU FOR PARTICIPATING.
15. Do you feel like BIM usage would be a beneficial addition to your company?
   ○ Strongly Agree
   ○ Agree
   ○ Neutral
   ○ Disagree
   ○ Strongly Disagree

16. Would you be willing to take a short course on the principles of BIM to advance your knowledge of the subject?
   ○ Yes
   ○ No

17. Having BIM knowledge would make someone a more attractive candidate to employers.
   ○ Strongly Agree
   ○ Agree
   ○ Neutral
   ○ Disagree
   ○ Strongly Disagree

STOP, YOU HAVE REACHED THE END OF THE SURVEY, THANK YOU FOR PARTICIPATING.
APPENDIX B
Individual Responses to Surveys Distributed at the Annual SC SEA Meeting
Company Size (People): 0-25
College Degree Received from:
If you wouldn't mind us contacting you for more information, please leave your mailing and e-mail addresses below:
Your Name (optional): Paul G. Gurley
Company Name (optional): Bailey and Son Engineering
Mailing Address (optional):
Email Address (optional): pgurley@base91.com
Would you like a copy of the results from the survey? Yes

Does your current employer use Building Information Modeling (BIM)?
Answer Here: Yes Please Proceed to Question 1

1) Who develops the BIM model at your company?
Answer Here: CAD Technician

2) Who updates the BIM model at your company?
Answer Here: CAD Technician

3) Your company only uses BIM modeling when required by the architect.
Answer Here: Yes

4) What BIM software are you using?
Answer Here: Autodesk Revit Structure

5) What structural design software are you using?
Answer Here: RAM Structural System

6) What capabilities of BIM do you utilize?
Clash Detection: No
Visualization: Yes
Estimating: No
Design: Yes
Other, Please Specify:

7) What percentage of projects has your company used BIM for in the last year?
Answer Here: 0-25%

8) Using BIM has increased productivity at your company.
Answer Here: Disagree

9) Using BIM has reduced the amount of problems experienced during the following.
Design: Disagree
Plan Review: Neutral
Construction: Strongly Disagree
10) Were you formally trained on the principles of BIM?
   Answer Here: No

11) A class about BIM in a school’s curriculum would be beneficial to new graduates.
   Answer Here: Neutral

12) If a BIM class was offered, would you suggest students take it?
   Answer Here: Agree

13) Having BIM knowledge would make someone a more attractive candidate to employers.
   Answer Here: Agree

14) A class on BIM should be a requirement for students in the CE curriculum.
   Answer Here: Disagree

   You have reached the end of the survey, thank you for participating.

15) Do you feel like BIM usage would be a beneficial addition to your company?
   Answer Here:

16) Would you be willing to take a short course on the principles of BIM to advance your knowledge of the subject?
   Answer Here:

17) Having BIM knowledge would make someone a more attractive candidate to employers.
   Answer Here:

   You have reached the end of the survey, thank you for participating.
Company Size (People): > 50
College Degree Received from: Clemson
If you wouldn't mind us contacting you for more information, please leave your mailing and e-mail addresses below:
Your Name (optional): Todd Warren
Company Name (optional):

Mailing Address (optional):
Email Address (optional): twarren@davisfloyd.com
Would you like a copy of the results from the survey? Yes

Does your current employer use Building Information Modeling (BIM)?
Answer Here: No
Has a past employer used BIM?
Answer Here: No
Please Proceed to Question 15

1) Who develops the BIM model at your company?
Answer Here:

2) Who updates the BIM model at your company?
Answer Here:

3) Your company only uses BIM modeling when required by the architect.
Answer Here:

4) What BIM software are you using?
Answer Here:

5) What structural design software are you using?
Answer Here:

6) What capabilities of BIM do you utilize?
Clash Detection:
Visualization:
Estimating:
Design:
Other, Please Specify:

7) What percentage of projects has your company used BIM for in the last year?
Answer Here:

8) Using BIM has increased productivity at your company.
Answer Here:

9) Using BIM has reduced the amount of problems experienced during the following.
Design:
Plan Review:
Construction:
10) Were you formally trained on the principles of BIM?
   Answer Here:                         Short Course

11) A class about BIM in a school’s curriculum would be beneficial to new graduates.
    Answer Here:

12) If a BIM class was offered, would you suggest students take it?
    Answer Here:

13) Having BIM knowledge would make someone a more attractive candidate to employers.
    Answer Here:

14) A class on BIM should be a requirement for students in the CE curriculum.
    Answer Here:

   You have reached the end of the survey, thank you for participating.

15) Do you feel like BIM usage would be a beneficial addition to your company?
    Answer Here:                         Neutral

16) Would you be willing to take a short course on the principles of BIM to advance your knowledge of the subject?
    Answer Here:                         Yes

17) Having BIM knowledge would make someone a more attractive candidate to employers.
    Answer Here:                         Strongly Agree

   You have reached the end of the survey, thank you for participating.
Company Size (People): > 50
College Degree Received from: University of South Carolina
If you wouldn't mind us contacting you for more information, please leave your mailing and e-mail addresses below:
Your Name (optional): Edward Stehmeyer
Company Name (optional): Collins Engineers, Inc.
Mailing Address (optional):
1180 Sam Rittenberg Blvd, Suite 105
Charleston, SC 29407
Email Address (optional): estehmeyer@collinsengr.com
Would you like a copy of the results from the survey? Yes

Does your current employer use Building Information Modeling (BIM)?
Answer Here: Yes

1) Who develop the BIM model at your company?
Answer Here: Structural Engineer or EIT

2) Who updates the BIM model at your company?
Answer Here: Structural Engineer or EIT

3) Your company only uses BIM modeling when required by the architect.
Answer Here: No

4) What BIM software are you using?
Answer Here: Autodesk Revit Structure

5) What structural design software are you using?
Answer Here: SAP2000

6) What capabilities of BIM do you utilize?
   Clash Detection: Yes
   Visualization: Yes
   Estimating: Yes
   Design: No
   Other, Please Specify:

7) What percentage of projects has your company used BIM for in the last year?
   Answer Here: 26-50%

8) Using BIM has increased productivity at your company.
   Answer Here: Agree

9) Using BIM has reduced the amount of problems experienced during the following.
   Design: Agree
   Plan Review: Agree
   Construction: Agree
10) Were you formally trained on the principles of BIM?
   Answer Here: Yes
   How were you trained? Short Course

11) A class about BIM in a school’s curriculum would be beneficial to new graduates.
   Answer Here: Agree

12) If a BIM class was offered, would you suggest students take it?
   Answer Here: Agree

13) Having BIM knowledge would make someone a more attractive candidate to employers.
   Answer Here: Agree

14) A class on BIM should be a requirement for students in the CE curriculum.
   Answer Here: Neutral

   You have reached the end of the survey, thank you for participating.

15) Do you feel like BIM usage would be a beneficial addition to your company?
   Answer Here:

16) Would you be willing to take a short course on the principles of BIM to advance your knowledge of the subject?
   Answer Here:

17) Having BIM knowledge would make someone a more attractive candidate to employers.
   Answer Here:

   You have reached the end of the survey, thank you for participating.
Company Size (People): 0-25
College Degree Received from: USNA and Clemson
If you wouldn't mind us contacting you for more information, please leave your mailing and e-mail addresses below:
Your Name (optional): Al Schweickhardt
Company Name (optional): Applied Building Sciences
Mailing Address (optional): 1890 Milford Street, Charleston, SC 29405
Email Address (optional): aschweic@appliedbuildingsciences.com
Would you like a copy of the results from the survey? Yes

1) Who develops the BIM model at your company?
   Answer Here:

2) Who updates the BIM model at your company?
   Answer Here:

3) Your company only uses BIM modeling when required by the architect.
   Answer Here:

4) What BIM software are you using?
   Answer Here:

5) What structural design software are you using?
   Answer Here:

6) What capabilities of BIM do you utilize?
   Clash Detection:
   Visualization:
   Estimating:
   Design:
   Other, Please Specify:

7) What percentage of projects has your company used BIM for in the last year?
   Answer Here:

8) Using BIM has increased productivity at your company.
   Answer Here:

9) Using BIM has reduced the amount of problems experienced during the following.
   Design:
   Plan Review:
   Construction:
10) Were you formally trained on the principles of BIM?
   Answer Here:

11) A class about BIM in a school’s curriculum would be beneficial to new graduates.
   Answer Here:

12) If a BIM class was offered, would you suggest students take it?
   Answer Here:

13) Having BIM knowledge would make someone a more attractive candidate to employers.
   Answer Here:

14) A class on BIM should be a requirement for students in the CE curriculum.
   Answer Here:

You have reached the end of the survey, thank you for participating.

15) Do you feel like BIM usage would be a beneficial addition to your company?
   Answer Here: Agree

16) Would you be willing to take a short course on the principles of BIM to advance your knowledge of the subject?
   Answer Here: Yes

17) Having BIM knowledge would make someone a more attractive candidate to employers.
   Answer Here: Agree

You have reached the end of the survey, thank you for participating.
Company Size (People): 0-25
College Degree Received from: Clemson University
If you wouldn't mind us contacting you for more information, please leave your mailing and e-mail addresses below:
Your Name (optional): Brian Pietras
Company Name (optional): Rickborn & Associates, LLC
Mailing Address (optional): 266 West Coleman Blvd, Suite 102, Mount Pleasant, SC 29464-5651
Email Address (optional): bpietras@rickborn.com
Would you like a copy of the results from the survey? Yes

Does your current employer use Building Information Modeling (BIM)?
Answer Here: No
Has a past employer used BIM?
Answer Here: No

Please Proceed to Question 15

1) Who develops the BIM model at your company?
Answer Here:

2) Who updates the BIM model at your company?
Answer Here:

3) Your company only uses BIM modeling when required by the architect.
Answer Here:

4) What BIM software are you using?
Answer Here:

5) What structural design software are you using?
Answer Here:

6) What capabilities of BIM do you utilize?
Clash Detection:
Visualization:
Estimating:
Design:
Other, Please Specify:

7) What percentage of projects has your company used BIM for in the last year?
Answer Here:

8) Using BIM has increased productivity at your company.
Answer Here:

9) Using BIM has reduced the amount of problems experienced during the following.
Design:
Plan Review:
Construction:
10) Were you formally trained on the principles of BIM?
   Answer Here: Short Course

11) A class about BIM in a school’s curriculum would be beneficial to new graduates.
   Answer Here:

12) If a BIM class was offered, would you suggest students take it?
   Answer Here:

13) Having BIM knowledge would make someone a more attractive candidate to employers.
   Answer Here:

14) A class on BIM should be a requirement for students in the CE curriculum.
   Answer Here:

   You have reached the end of the survey, thank you for participating.

15) Do you feel like BIM usage would be a beneficial addition to your company?
   Answer Here: Disagree

16) Would you be willing to take a short course on the principles of BIM to advance your knowledge of the subject?
   Answer Here: Yes

17) Having BIM knowledge would make someone a more attractive candidate to employers.
   Answer Here: Neutral

   You have reached the end of the survey, thank you for participating.
Company Size (People): > 50
College Degree Received from: The Citadel
If you wouldn't mind us contacting you for more information, please leave your mailing and e-mail addresses below:
Your Name (optional): Clarence Hutto
Company Name (optional): US Army Corps of Engineers
Mailing Address (optional):
Email Address (optional): Clarence.Hutto@usace.army.mil
Would you like a copy of the results from the survey? Yes

Does your current employer use Building Information Modeling (BIM)?
Answer Here: No
Has a past employer used BIM?
Answer Here: Yes
Please Proceed to Question 1

1) Who develops the BIM model at your company?
   Answer Here: Structural Engineer or EIT

2) Who updates the BIM model at your company?
   Answer Here: CAD Technician

3) Your company only uses BIM modeling when required by the architect.
   Answer Here: Yes

4) What BIM software are you using?
   Answer Here: Bentley Structural Modeler

5) What structural design software are you using?
   Answer Here: SAP2000

6) What capabilities of BIM do you utilize?
   Clash Detection: Yes
   Visualization: Yes
   Estimating: Yes
   Design: No
   Other, Please Specify:

7) What percentage of projects has your company used BIM for in the last year?
   Answer Here: 26-50%

8) Using BIM has increased productivity at your company.
   Answer Here: Disagree

9) Using BIM has reduced the amount of problems experienced during the following.
   Design: Disagree
   Plan Review: Disagree
   Construction: Strongly Disagree
10) Were you formally trained on the principles of BIM?
   Answer Here: Yes
   How were you trained? Short Course

11) A class about BIM in a school’s curriculum would be beneficial to new graduates.
   Answer Here: Disagree

12) If a BIM class was offered, would you suggest students take it?
   Answer Here: Neutral

13) Having BIM knowledge would make someone a more attractive candidate to employers.
   Answer Here: Neutral

14) A class on BIM should be a requirement for students in the CE curriculum.
   Answer Here: Disagree

   You have reached the end of the survey, thank you for participating.

15) Do you feel like BIM usage would be a beneficial addition to your company?
   Answer Here:

16) Would you be willing to take a short course on the principles of BIM to advance your knowledge of the subject?
   Answer Here:

17) Having BIM knowledge would make someone a more attractive candidate to employers.
   Answer Here:

   You have reached the end of the survey, thank you for participating.
Company Size (People): 26-50
College Degree Received from: Clemson, B.S and M.S.
If you wouldn't mind us contacting you for more information, please leave your mailing and e-mail addresses below:
Your Name (optional):
Company Name (optional):
Mailing Address (optional):
Email Address (optional):
Would you like a copy of the results from the survey? Yes

Does your current employer use Building Information Modeling (BIM)?
Answer Here: No
Has a past employer used BIM?
Answer Here: No

1) Who develops the BIM model at your company?
Answer Here:

2) Who updates the BIM model at your company?
Answer Here:

3) Your company only uses BIM modeling when required by the architect.
Answer Here:

4) What BIM software are you using?
Answer Here:

5) What structural design software are you using?
Answer Here: STAAD-Pro

6) What capabilities of BIM do you utilize?
Clash Detection:
Visualization:
Estimating:
Design:
Other, Please Specify:

7) What percentage of projects has your company used BIM for in the last year?
Answer Here: 0-25%

8) Using BIM has increased productivity at your company.
Answer Here:

9) Using BIM has reduced the amount of problems experienced during the following.
Design:
Plan Review:
Construction:
10) Were you formally trained on the principles of BIM?
   Answer Here: Short Course

11) A class about BIM in a school’s curriculum would be beneficial to new graduates.
   Answer Here:

12) If a BIM class was offered, would you suggest students take it?
   Answer Here:

13) Having BIM knowledge would make someone a more attractive candidate to employers.
   Answer Here:

14) A class on BIM should be a requirement for students in the CE curriculum.
   Answer Here:

   You have reached the end of the survey, thank you for participating.

15) Do you feel like BIM usage would be a beneficial addition to your company?
   Answer Here: Neutral

16) Would you be willing to take a short course on the principles of BIM to advance your knowledge of the subject?
   Answer Here: Yes

17) Having BIM knowledge would make someone a more attractive candidate to employers.
   Answer Here: Neutral

   You have reached the end of the survey, thank you for participating.
Company Size (People): > 50
College Degree Received from: Clemson
If you wouldn't mind us contacting you for more information, please leave your mailing and e-mail addresses below:
Your Name (optional): John Orvin, PE
Company Name (optional): Davis & Floyd, Inc.

Mailing Address (optional):
Email Address (optional): jorvin@davisfloyd.com
Would you like a copy of the results from the survey? No

Does your current employer use Building Information Modeling (BIM)?
Answer Here: Yes

Please Proceed to Question 1

1) Who develops the BIM model at your company?
Answer Here: Structural Engineer or EIT

2) Who updates the BIM model at your company?
Answer Here: Structural Engineer or EIT

3) Your company only uses BIM modeling when required by the architect.
Answer Here: Yes

4) What BIM software are you using?
Answer Here: Autodesk Revit Structure

5) What structural design software are you using?
Answer Here: RAM Structural System

6) What capabilities of BIM do you utilize?
Clash Detection: Yes
Visualization: Yes
Estimating: Yes
Design: Yes
Other, Please Specify:

7) What percentage of projects has your company used BIM for in the last year?
Answer Here: 0-25%

8) Using BIM has increased productivity at your company.
Answer Here: Agree

9) Using BIM has reduced the amount of problems experienced during the following.
Design: Agree
Plan Review: Agree
Construction: Agree

75
10) Were you formally trained on the principles of BIM?
   Answer Here: Yes
   How were you trained? Short Course

11) A class about BIM in a school's curriculum would be beneficial to new graduates.
    Answer Here: Strongly Agree

12) If a BIM class was offered, would you suggest students take it?
    Answer Here: Strongly Agree

13) Having BIM knowledge would make someone a more attractive candidate to employers.
    Answer Here: Strongly Agree

14) A class on BIM should be a requirement for students in the CE curriculum.
    Answer Here: Strongly Agree

You have reached the end of the survey, thank you for participating.

15) Do you feel like BIM usage would be a beneficial addition to your company?
    Answer Here: Strongly Agree

16) Would you be willing to take a short course on the principles of BIM to advance your knowledge of the subject?
    Answer Here: Yes

17) Having BIM knowledge would make someone a more attractive candidate to employers.
    Answer Here: Strongly Agree

You have reached the end of the survey, thank you for participating.
Company Size (People): 0-25
College Degree Received from: GA Tech
If you wouldn't mind us contacting you for more information, please leave your mailing and e-mail addresses below:
Your Name (optional): Markus Ganahl
Company Name (optional): MMSA, Inc.

213 East Broad Street Greenville, SC
Mailing Address (optional): 213 East Broad Street Greenville, SC
Email Address (optional): mganahl@mmsainc.com
Would you like a copy of the results from the survey? Yes

Does your current employer use Building Information Modeling (BIM)?
Answer Here: Yes Please Proceed to Question 1

1) Who develops the BIM model at your company?
Answer Here: CAD Technician

2) Who updates the BIM model at your company?
Answer Here: CAD Technician

3) Your company only uses BIM modeling when required by the architect.
Answer Here: Yes

4) What BIM software are you using?
Answer Here: Autodesk Revit Structure

5) What structural design software are you using?
Answer Here: RAM Structural System

6) What capabilities of BIM do you utilize?
Clash Detection: Yes
Visualization: Yes
Estimating:
Design: No
Other, Please Specify:

7) What percentage of projects has your company used BIM for in the last year?
Answer Here: 0-25%

8) Using BIM has increased productivity at your company.
Answer Here: Neutral

9) Using BIM has reduced the amount of problems experienced during the following.
Design: Neutral
Plan Review: Neutral
Construction: Neutral
10) Were you formally trained on the principles of BIM?
Answer Here: Yes
How were you trained? Short Course

11) A class about BIM in a school's curriculum would be beneficial to new graduates.
Answer Here: Strongly Agree

12) If a BIM class was offered, would you suggest students take it?
Answer Here: Strongly Agree

13) Having BIM knowledge would make someone a more attractive candidate to employers.
Answer Here: Strongly Agree

14) A class on BIM should be a requirement for students in the CE curriculum.
Answer Here: Strongly Agree

You have reached the end of the survey, thank you for participating.

15) Do you feel like BIM usage would be a beneficial addition to your company?
Answer Here: Strongly Agree

16) Would you be willing to take a short course on the principles of BIM to advance your knowledge of the subject?
Answer Here: Yes

17) Having BIM knowledge would make someone a more attractive candidate to employers.
Answer Here: Strongly Agree

You have reached the end of the survey, thank you for participating.
Company Size (People): 0-25
College Degree Received from: Clemson
If you wouldn't mind us contacting you for more information, please leave your mailing and e-mail addresses below:
Your Name (optional):
Company Name (optional):

Mailing Address (optional):
Email Address (optional):
Would you like a copy of the results from the survey? No

Does your current employer use Building Information Modeling (BIM)?
Answer Here: No
Has a past employer used BIM?
Answer Here: No

Please Proceed to Question 15

1) Who develops the BIM model at your company?
   Answer Here:

2) Who updates the BIM model at your company?
   Answer Here:

3) Your company only uses BIM modeling when required by the architect.
   Answer Here:

4) What BIM software are you using?
   Answer Here:

5) What structural design software are you using?
   Answer Here:

6) What capabilities of BIM do you utilize?
   Clash Detection:
   Visualization:
   Estimating:
   Design:
   Other, Please Specify:

7) What percentage of projects has your company used BIM for in the last year?
   Answer Here:

8) Using BIM has increased productivity at your company.
   Answer Here:

9) Using BIM has reduced the amount of problems experienced during the following.
   Design:
   Plan Review:
   Construction:
10) Were you formally trained on the principles of BIM?
   Answer Here: 
   Short Course

11) A class about BIM in a school’s curriculum would be beneficial to new graduates.
   Answer Here:

12) If a BIM class was offered, would you suggest students take it?
   Answer Here:

13) Having BIM knowledge would make someone a more attractive candidate to employers.
   Answer Here:

14) A class on BIM should be a requirement for students in the CE curriculum.
   Answer Here:

   You have reached the end of the survey, thank you for participating.

15) Do you feel like BIM usage would be a beneficial addition to your company?
   Answer Here: 
   Agree

16) Would you be willing to take a short course on the principles of BIM to advance your knowledge of the subject?
   Answer Here: 
   Yes

17) Having BIM knowledge would make someone a more attractive candidate to employers.
   Answer Here: 
   Strongly Agree

   You have reached the end of the survey, thank you for participating.
Company Size (People): > 50
College Degree Received from: BS Civil Engineering
If you wouldn't mind us contacting you for more information, please leave your mailing and e-mail addresses below:
Your Name (optional):
Company Name (optional):

Mailing Address (optional):
Email Address (optional):
Would you like a copy of the results from the survey? No

Does your current employer use Building Information Modeling (BIM)?
Answer Here: No
Has a past employer used BIM?
Answer Here: No

1) Who develops the BIM model at your company?
Answer Here:

2) Who updates the BIM model at your company?
Answer Here:

3) Your company only uses BIM modeling when required by the architect.
Answer Here:

4) What BIM software are you using?
Answer Here:

Please Specify:

5) What structural design software are you using?
Answer Here:

6) What capabilities of BIM do you utilize?
Clash Detection:
Visualization:
Estimating:
Design:
Other, Please Specify:

7) What percentage of projects has your company used BIM for in the last year?
Answer Here:

8) Using BIM has increased productivity at your company.
Answer Here:

9) Using BIM has reduced the amount of problems experienced during the following.
Design:
Plan Review:
Construction:
10) Were you formally trained on the principles of BIM?
   Answer Here:

11) A class about BIM in a school’s curriculum would be beneficial to new graduates.
   Answer Here:

12) If a BIM class was offered, would you suggest students take it?
   Answer Here:

13) Having BIM knowledge would make someone a more attractive candidate to employers.
   Answer Here:

14) A class on BIM should be a requirement for students in the CE curriculum.
   Answer Here:

   You have reached the end of the survey, thank you for participating.

15) Do you feel like BIM usage would be a beneficial addition to your company?
   Answer Here: Disagree

16) Would you be willing to take a short course on the principles of BIM to advance your knowledge of the subject?
   Answer Here: No

17) Having BIM knowledge would make someone a more attractive candidate to employers.
   Answer Here: Neutral

   You have reached the end of the survey, thank you for participating.
Company Size (People): 26-50
College Degree Received from: The Citadel
If you wouldn't mind us contacting you for more information, please leave your mailing and e-mail addresses below:
Your Name (optional): Rob Still
Company Name (optional): ADC Engineering

Mailing Address (optional):
Email Address (optional):
Would you like a copy of the results from the survey? Yes

Does your current employer use Building Information Modeling (BIM)?
Answer Here: Yes Please Proceed to Question 1

1) Who develops the BIM model at your company?
Answer Here: Structural Engineer or EIT

2) Who updates the BIM model at your company?
Answer Here: Structural Engineer or EIT

3) Your company only uses BIM modeling when required by the architect.
Answer Here: No

4) What BIM software are you using?
Answer Here: Autodesk Revit Structure

5) What structural design software are you using?
Answer Here: RAM Structural System

6) What capabilities of BIM do you utilize?
Clash Detection: No
Visualization: Yes
Estimating: Yes
Design: No
Other, Please Specify:

7) What percentage of projects has your company used BIM for in the last year?
Answer Here: 26-50%

8) Using BIM has increased productivity at your company.
Answer Here: Neutral

9) Using BIM has reduced the amount of problems experienced during the following.
Design: Agree
Plan Review: Agree
Construction: Agree
10) Were you formally trained on the principles of BIM?
   Answer Here: No

11) A class about BIM in a school’s curriculum would be beneficial to new graduates.
   Answer Here: Agree

12) If a BIM class was offered, would you suggest students take it?
   Answer Here: Agree

13) Having BIM knowledge would make someone a more attractive candidate to employers.
   Answer Here: Strongly Agree

14) A class on BIM should be a requirement for students in the CE curriculum.
   Answer Here: Agree

   You have reached the end of the survey, thank you for participating.

15) Do you feel like BIM usage would be a beneficial addition to your company?
   Answer Here: Agree

16) Would you be willing to take a short course on the principles of BIM to advance your knowledge of the subject?
   Answer Here: No

17) Having BIM knowledge would make someone a more attractive candidate to employers.
   Answer Here: Agree

   You have reached the end of the survey, thank you for participating.
Company Size (People): > 50
College Degree Received from: The Citadel

If you wouldn't mind us contacting you for more information, please leave your mailing and e-mail addresses below:
Your Name (optional): Sayle Lewis
Company Name (optional): Fluor

Mailing Address (optional):
Email Address (optional): sayle.lewis@fluor.com
Would you like a copy of the results from the survey? No

Does your current employer use Building Information Modeling (BIM)?
Answer Here: Yes

1) Who develops the BIM model at your company?
   Answer Here: Structural Engineer or EIT

2) Who updates the BIM model at your company?
   Answer Here: Structural Engineer or EIT

3) Your company only uses BIM modeling when required by the architect.
   Answer Here: No

4) What BIM software are you using?
   Answer Here: Other
   Please Specify: Intergraph Frameworks and SP3D

5) What structural design software are you using?
   Answer Here: RISA

6) What capabilities of BIM do you utilize?
   Clash Detection: Yes
   Visualization: Yes
   Estimating: Yes
   Design: Yes
   Other, Please Specify: Engineering Models

7) What percentage of projects has your company used BIM for in the last year?
   Answer Here: 75-100%

8) Using BIM has increased productivity at your company.
   Answer Here: Strongly Agree

9) Using BIM has reduced the amount of problems experienced during the following.
   Design: Strongly Agree
   Plan Review: Strongly Agree
   Construction: Strongly Agree
10) Were you formally trained on the principles of BIM?
Answer Here: No

11) A class about BIM in a school’s curriculum would be beneficial to new graduates.
Answer Here: Agree

12) If a BIM class was offered, would you suggest students take it?
Answer Here: Agree

13) Having BIM knowledge would make someone a more attractive candidate to employers.
Answer Here: Neutral

14) A class on BIM should be a requirement for students in the CE curriculum.
Answer Here: Disagree

You have reached the end of the survey, thank you for participating.

15) Do you feel like BIM usage would be a beneficial addition to your company?
Answer Here:

16) Would you be willing to take a short course on the principles of BIM to advance your knowledge of the subject?
Answer Here:

17) Having BIM knowledge would make someone a more attractive candidate to employers.
Answer Here:

You have reached the end of the survey, thank you for participating.
Company Size (People): 0-25
College Degree Received from: University of South Carolina
If you wouldn't mind us contacting you for more information, please leave your mailing and e-mail addresses below:
Your Name (optional):
Company Name (optional):
Mailing Address (optional):
Email Address (optional):
Would you like a copy of the results from the survey? No

Does your current employer use Building Information Modeling (BIM)?
Answer Here: No
Has a past employer used BIM?
Answer Here: No Please Proceed to Question 15

1) Who develops the BIM model at your company?
   Answer Here:

2) Who updates the BIM model at your company?
   Answer Here:

3) Your company only uses BIM modeling when required by the architect.
   Answer Here:

4) What BIM software are you using?
   Answer Here:

5) What structural design software are you using?
   Answer Here:

6) What capabilities of BIM do you utilize?
   Clash Detection:
   Visualization:
   Estimating:
   Design:
   Other, Please Specify:

7) What percentage of projects has your company used BIM for in the last year?
   Answer Here:

8) Using BIM has increased productivity at your company.
   Answer Here:

9) Using BIM has reduced the amount of problems experienced during the following.
   Design:
   Plan Review:
   Construction:
10) Were you formally trained on the principles of BIM?
Answer Here:

11) A class about BIM in a school's curriculum would be beneficial to new graduates.
Answer Here:

12) If a BIM class was offered, would you suggest students take it?
Answer Here:

13) Having BIM knowledge would make someone a more attractive candidate to employers.
Answer Here:

14) A class on BIM should be a requirement for students in the CE curriculum.
Answer Here:

You have reached the end of the survey, thank you for participating.

15) Do you feel like BIM usage would be a beneficial addition to your company?
Answer Here: Disagree

16) Would you be willing to take a short course on the principles of BIM to advance your knowledge of the subject?
Answer Here: No

17) Having BIM knowledge would make someone a more attractive candidate to employers.
Answer Here: Neutral

You have reached the end of the survey, thank you for participating.
Company Size (People): 0-25
College Degree Received from: The Citadel, Clemson

If you wouldn’t mind us contacting you for more information, please leave your mailing and e-mail addresses below:
Your Name (optional): Mark Dillon
Company Name (optional): ADC Engineering
Mailing Address (optional): Hanahan, SC
Email Address (optional): markd@adcengineering

Would you like a copy of the results from the survey? Yes

Does your current employer use Building Information Modeling (BIM)?
Answer Here: Yes Please Proceed to Question 1

1) Who develops the BIM model at your company?
Answer Here: Structural Engineer or EIT

2) Who updates the BIM model at your company?
Answer Here: Structural Engineer or EIT

3) Your company only uses BIM modeling when required by the architect.
Answer Here: No

4) What BIM software are you using?
Answer Here: Autodesk Revit Structure

5) What structural design software are you using?
Answer Here: RAM Structural System

6) What capabilities of BIM do you utilize?
   Clash Detection: Yes
   Visualization: Yes
   Estimating: No
   Design: Yes
   Other, Please Specify:

7) What percentage of projects has your company used BIM for in the last year?
   Answer Here: 75-100%

8) Using BIM has increased productivity at your company.
   Answer Here: Neutral

9) Using BIM has reduced the amount of problems experienced during the following.
   Design: Strongly Agree
   Plan Review: Strongly Agree
   Construction: Strongly Agree
10) Were you formally trained on the principles of BIM?
   Answer Here: No

11) A class about BIM in a school’s curriculum would be beneficial to new graduates.
   Answer Here: Strongly Agree

12) If a BIM class was offered, would you suggest students take it?
   Answer Here: Agree

13) Having BIM knowledge would make someone a more attractive candidate to employers.
   Answer Here: Strongly Agree

14) A class on BIM should be a requirement for students in the CE curriculum.
   Answer Here: Strongly Agree

   You have reached the end of the survey, thank you for participating.

15) Do you feel like BIM usage would be a beneficial addition to your company?
   Answer Here:

16) Would you be willing to take a short course on the principles of BIM to advance your knowledge of the subject?
   Answer Here:

17) Having BIM knowledge would make someone a more attractive candidate to employers.
   Answer Here:

   You have reached the end of the survey, thank you for participating.
Company Size (People): 26-50
College Degree Received from: The Citadel
If you wouldn't mind us contacting you for more information, please leave your mailing and e-mail addresses below:
Your Name (optional):
Company Name (optional):

Mailing Address (optional):
Email Address (optional):
Would you like a copy of the results from the survey?

Does your current employer use Building Information Modeling (BIM)?
Answer Here: Yes  Please Proceed to Question 1

1) Who develops the BIM model at your company?
Answer Here: CAD Technician

2) Who updates the BIM model at your company?
Answer Here: CAD Technician

3) Your company only uses BIM modeling when required by the architect.
Answer Here: No

4) What BIM software are you using?
Answer Here: Bentley Structural Modeler

5) What structural design software are you using?
Answer Here: SAP2000

6) What capabilities of BIM do you utilize?
Clash Detection: Yes
Visualization: Yes
Estimating: Yes
Design: Yes
Other, Please Specify:

7) What percentage of projects has your company used BIM for in the last year?
Answer Here: 75-100%

8) Using BIM has increased productivity at your company.
Answer Here: Strongly Agree

9) Using BIM has reduced the amount of problems experienced during the following.
Design: Strongly Agree
Plan Review: Strongly Agree
Construction: Strongly Agree
10) Were you formally trained on the principles of BIM?
   Answer Here: Yes
   How were you trained? Short Course

11) A class about BIM in a school's curriculum would be beneficial to new graduates.
   Answer Here: Neutral

12) If a BIM class was offered, would you suggest students take it?
   Answer Here: Neutral

13) Having BIM knowledge would make someone a more attractive candidate to employers.
   Answer Here: Agree

14) A class on BIM should be a requirement for students in the CE curriculum.
   Answer Here: Neutral

   You have reached the end of the survey, thank you for participating.

15) Do you feel like BIM usage would be a beneficial addition to your company?
   Answer Here:

16) Would you be willing to take a short course on the principles of BIM to advance your knowledge of the subject?
   Answer Here:

17) Having BIM knowledge would make someone a more attractive candidate to employers.
   Answer Here:

   You have reached the end of the survey, thank you for participating.
Company Size (People): 0-25
College Degree Received from: The Citadel, Clemson
If you wouldn't mind us contacting you for more information, please leave your mailing and e-mail addresses below:
Your Name (optional):
Company Name (optional):
Mailing Address (optional):
Email Address (optional):
Would you like a copy of the results from the survey? No

Does your current employer use Building Information Modeling (BIM)?
Answer Here: No
Has a past employer used BIM?
Answer Here: No

1) Who develops the BIM model at your company?
Answer Here:

2) Who updates the BIM model at your company?
Answer Here:

3) Your company only uses BIM modeling when required by the architect.
Answer Here:

4) What BIM software are you using?
Answer Here: Intergraph Frameworks and SP3D

5) What structural design software are you using?
Answer Here:

6) What capabilities of BIM do you utilize?
Clash Detection:
Visualization:
Estimating:
Design:
Other, Please Specify:

7) What percentage of projects has your company used BIM for in the last year?
Answer Here:

8) Using BIM has increased productivity at your company.
Answer Here:

9) Using BIM has reduced the amount of problems experienced during the following.
Design:
Plan Review:
Construction:

Please Proceed to Question 15
10) Were you formally trained on the principles of BIM?
   Answer Here:

11) A class about BIM in a school’s curriculum would be beneficial to new graduates.
   Answer Here:

12) If a BIM class was offered, would you suggest students take it?
   Answer Here:

13) Having BIM knowledge would make someone a more attractive candidate to employers.
   Answer Here:

14) A class on BIM should be a requirement for students in the CE curriculum.
   Answer Here:
   
   You have reached the end of the survey, thank you for participating.

15) Do you feel like BIM usage would be a beneficial addition to your company?
   Answer Here: Agree

16) Would you be willing to take a short course on the principles of BIM to advance your knowledge of the subject?
   Answer Here: Yes

17) Having BIM knowledge would make someone a more attractive candidate to employers.
   Answer Here: Strongly Agree

   You have reached the end of the survey, thank you for participating.
Company Size (People): 0-25
College Degree Received from: University of Architecture, CE, and Geodesy, Bulgaria
If you wouldn't mind us contacting you for more information, please leave your mailing and e-mail addresses below:
Your Name (optional): Ani Carignan
Company Name (optional):
Mailing Address (optional):
Email Address (optional): aniarignan@gmail.com
Would you like a copy of the results from the survey? Yes

Does your current employer use Building Information Modeling (BIM)?
Answer Here: No
Has a past employer used BIM?
Answer Here: No

Please Proceed to Question 15

1) Who develops the BIM model at your company?
Answer Here:

2) Who updates the BIM model at your company?
Answer Here:

3) Your company only uses BIM modeling when required by the architect.
Answer Here:

4) What BIM software are you using?
Answer Here:

Please Specify: Intergraph Frameworks and SP3D

5) What structural design software are you using?
Answer Here:


6) What capabilities of BIM do you utilize?
Clash Detection:
Visualization:
Estimating:
Design:
Other, Please Specify:

7) What percentage of projects has your company used BIM for in the last year?
Answer Here:

8) Using BIM has increased productivity at your company.
Answer Here:

9) Using BIM has reduced the amount of problems experienced during the following.
Design:
Plan Review:
Construction:
10) Were you formally trained on the principles of BIM?
   Answer Here:

11) A class about BIM in a school’s curriculum would be beneficial to new graduates.
   Answer Here:

12) If a BIM class was offered, would you suggest students take it?
   Answer Here:

13) Having BIM knowledge would make someone a more attractive candidate to employers.
   Answer Here:

14) A class on BIM should be a requirement for students in the CE curriculum.
   Answer Here:

You have reached the end of the survey, thank you for participating.

15) Do you feel like BIM usage would be a beneficial addition to your company?
   Answer Here: Strongly Agree

16) Would you be willing to take a short course on the principles of BIM to advance your knowledge of the subject?
   Answer Here: Yes

17) Having BIM knowledge would make someone a more attractive candidate to employers.
   Answer Here: Strongly Agree

You have reached the end of the survey, thank you for participating.
Company Size (People): 0-25
College Degree Received from: The Citadel
If you wouldn't mind us contacting you for more information, please leave your mailing and e-mail addresses below:
Your Name (optional):
Company Name (optional):
Mailing Address (optional):
Email Address (optional):
Would you like a copy of the results from the survey? No

Does your current employer use Building Information Modeling (BIM)?
Answer Here: No
Has a past employer used BIM?
Answer Here: No Please Proceed to Question 15

1) Who develops the BIM model at your company?
Answer Here:

2) Who updates the BIM model at your company?
Answer Here:

3) Your company only uses BIM modeling when required by the architect.
Answer Here:

4) What BIM software are you using?
Answer Here:

5) What structural design software are you using?
Answer Here:

6) What capabilities of BIM do you utilize?
   Clash Detection:
   Visualization:
   Estimating:
   Design:
   Other, Please Specify:

7) What percentage of projects has your company used BIM for in the last year?
Answer Here:

8) Using BIM has increased productivity at your company.
Answer Here:

9) Using BIM has reduced the amount of problems experienced during the following.
   Design:
   Plan Review:
   Construction:
10) Were you formally trained on the principles of BIM?
   Answer Here:

11) A class about BIM in a school’s curriculum would be beneficial to new graduates.
   Answer Here:

12) If a BIM class was offered, would you suggest students take it?
   Answer Here:

13) Having BIM knowledge would make someone a more attractive candidate to employers.
   Answer Here:

14) A class on BIM should be a requirement for students in the CE curriculum.
   Answer Here:

You have reached the end of the survey, thank you for participating.

15) Do you feel like BIM usage would be a beneficial addition to your company?
   Answer Here: Neutral

16) Would you be willing to take a short course on the principles of BIM to advance your knowledge of the subject?
   Answer Here: Yes

17) Having BIM knowledge would make someone a more attractive candidate to employers.
   Answer Here: Strongly Disagree

You have reached the end of the survey, thank you for participating.
Company Size (People): 0-25
College Degree Received from: Clemson University
If you wouldn't mind us contacting you for more information, please leave your mailing and e-mail addresses below:
Your Name (optional): Charles Knobeloch
Company Name (optional): K&P Engineering, Inc.
Mailing Address (optional):
Email Address (optional): cknobelock@kp-inc.com
Would you like a copy of the results from the survey? Yes

Does your current employer use Building Information Modeling (BIM)?
Answer Here: No
Has a past employer used BIM?
Answer Here: No
Please Proceed to Question 15

1) Who develops the BIM model at your company?
Answer Here:

2) Who updates the BIM model at your company?
Answer Here:

3) Your company only uses BIM modeling when required by the architect.
Answer Here:

4) What BIM software are you using?
Answer Here:

5) What structural design software are you using?
Answer Here:

6) What capabilities of BIM do you utilize?
Clash Detection:
Visualization:
Estimating:
Design:
Other, Please Specify:

7) What percentage of projects has your company used BIM for in the last year?
Answer Here:

8) Using BIM has increased productivity at your company.
Answer Here:

9) Using BIM has reduced the amount of problems experienced during the following.
Design:
Plan Review:
Construction:
10) Were you formally trained on the principles of BIM?
Answer Here:

11) A class about BIM in a school’s curriculum would be beneficial to new graduates.
Answer Here:

12) If a BIM class was offered, would you suggest students take it?
Answer Here:

13) Having BIM knowledge would make someone a more attractive candidate to employers.
Answer Here:

14) A class on BIM should be a requirement for students in the CE curriculum.
Answer Here:

You have reached the end of the survey, thank you for participating.

15) Do you feel like BIM usage would be a beneficial addition to your company?
Answer Here: Disagree

16) Would you be willing to take a short course on the principles of BIM to advance your knowledge of the subject?
Answer Here: Yes

17) Having BIM knowledge would make someone a more attractive candidate to employers.
Answer Here: Agree

You have reached the end of the survey, thank you for participating.
APPENDIX C

Interview Notes

The following interviews were conducted to try and expand on the information discovered from the surveys. The people interviewed were chosen to try and create a broad demographic with representatives from a national structural engineering firm, a national multidisciplinary firm, typical South Carolina firms, and even someone with a generally apathetic view of BIM. The interviewee’s answers to the questions are in italics. All of the responses below are paraphrased, except for Christopher Smith’s interview which was done via e-mail so the responses are verbatim.

David Impson Interview

Do you feel that a class focusing on BIM should be a requirement or at least an option for students in an undergraduate curriculum? Should it be offered for all disciplines of civil engineering?

_The course should be an option for undergraduates at the same stage as AutoCAD or replace the AutoCAD class. A BIM course would predominantly be for structures students using Revit with other civil engineers using AutoCAD Civil 3D._

What is your opinion on how a BIM class should be taught? Should it focus primarily on the principles of BIM or be software package specific and if so, which? Is there a recommended level of knowledge as far as software packages go – exposure, working knowledge, proficient, expert?

_Ideally the class would be generic; however, it is easier to learn using a program. The student should have an experience level between exposure and working knowledge after having a course._

What are some capabilities that you feel should be included in or focused on in a BIM “first course” such as quantity takeoffs, 4-D models, etc.?

_Students should be exposed to modeling and what the elements are as well as an introduction to families. Collaboration with architects and MEP is also important._
When hiring a new employee, have you begun looking at BIM experience as a requirement? If not, do you see it moving that way soon?

*It is currently not a requirement, but it will move towards that in the future. At Britt Peters, the engineers are doing more engineering than drafting.*

Are architects the driving force behind the proliferation of BIM use at your company?

*The use of BIM is sometimes architect driven, but they are beginning to use it on their own. Britt Peters has been using Autodesk Revit for about four years.*

What kind of training do your employees undergo to become what you would consider proficient at BIM software?

*There is not a lot of external training available in the area. Greenville Tech is offering courses during the summer. On the job training and web tutorials are the main sources of learning right now.*

Do you feel like in a number of years, a BIM model will be a requirement for nearly all projects?

*It will not be a requirement for all projects, but large projects will most like require it. At Britt Peters, there are many repeated jobs, so the drawings are currently on AutoCAD from previous uses, but will eventually be transferred to Autodesk Revit.*

Can you talk a little bit about your experience going between BIM software and analysis programs?

*There has been limited success transferring models. There seems to be trouble coordinating complex geometries. Additionally, if a section is not properly defined, it will not transfer well.*

Are you letting the BIM software create construction drawings?

*Autodesk Revit creates all drawings when BIM is used on a project.*

Additional notes:

*BIM is where the industry is moving. Engineers are not overly involved with the actual modeling, but need to be aware of how it works and the capabilities.*
Balfour Beatty Interview

Do you feel that a class focusing on BIM should be a requirement or at least an option for students in an undergraduate curriculum? Should it be offered for all disciplines of civil engineering?

*BIM should be a requirement, but it should not be limited to a single course. It should be integrated into the entire curriculum.*

What is your opinion on how a BIM class should be taught? Should it focus primarily on the principles of BIM or be software package specific and if so, which? Is there a recommended level of knowledge as far as software packages go – exposure, working knowledge, proficient, expert?

*The course should focus primarily on BIM principles while introducing how and why BIM are used, what the benefits are, etc.*

What are some capabilities that you feel should be included in or focused on in a BIM “first course” such as quantity takeoffs, 4-D models, etc.?

*The course should have a focus on collaboration and integrated project deliveries. Navisworks and Autodesk Revit should be used in the course. Clash detection and collaboration are the two most used capabilities of BIM. Structural engineers should be introduced to the takeoff abilities including naming conventions and what is used to increase the ease of use for other disciplines.*

When hiring a new employee, have you begun looking at BIM experience as a requirement? If not, do you see it moving that way soon?

*BIM experience is a requirement based on what level of employment. Balfour Beatty has a BIM team that is used. New hires that have been made have all had exposure to BIM, including at schools such as Southern Poly and Appalachian State. When hiring new project engineers, BIM experience is a big plus.*

What kind of training do your employees undergo to become what you would consider proficient at BIM software?

*There is currently an effort being made to train current project engineers on BIM software. The type of training depends on what projects are happening at that time. Typically, there is one on one training for a few days, and then they are monitored afterwards during on the job training.*
Do you feel like in a number of years, a BIM model will be a requirement for nearly all projects?

The Raleigh office already tries to use BIM on all of their projects, especially if the architect has already created a model. The company tries to use BIM as much as possible because of the benefits associated with using it. Owners are actually making more of a push for BIM on projects than architects are.

Additional notes:

- Facilities management is becoming a capability that is becoming more prevalent.
- Balfour Beatty is interested in helping to push BIM for students.
- Penn State is integrating BIM into the curricula by utilizing joint projects that combine several facets from all disciplines. Auburn is doing something similar with a “Design/Build” Master’s degree that has construction management and architects working together in their last semester or year.
Scott Sprouse Interview

Do you feel that a class focusing on BIM should be a requirement or at least an option for students in an undergraduate curriculum? Should it be offered for all disciplines of civil engineering?

A BIM class should be an option for students.

What is your opinion on how a BIM class should be taught? Should it focus primarily on the principles of BIM or be software package specific and if so, which? Is there a recommended level of knowledge as far as software packages go – exposure, working knowledge, proficient, expert?

This class should focus on the basic principles of BIM.

What are some capabilities that you feel should be included in or focused on in a BIM “first course” such as quantity takeoffs, 4-D models, etc.?

Modeling in the software package, and integrating data with other disciplines. Students should have a working knowledge of the software package when leaving a BIM focused class.

When hiring a new employee, have you begun looking at BIM experience as a requirement? If not, do you see it moving that way soon?

When hiring new employees, Revit experience is a plus, but not a requirement.

Are architects the driving force behind the proliferation of BIM use at your company?

Revit is only used on projects that are architect driven (e.g., schools, college facilities, fieldhouses, and stadiums). Specifically, Revit is not used on industrial projects, but structural modeling/analysis is done for larger industrial projects as budget allows.

What kind of training do your employees undergo to become what you would consider proficient at BIM software?

Currently, only three employees have been trained on the capabilities of BIM in an eighteen hour course over two days. However, you are still working on becoming proficient by taking online training sessions.

Can you talk a little bit about your experience going between BIM software and analysis programs?

Do not have confidence going between RAM products and Revit, therefore, separate models are kept.
Additional notes:

*The level of proficiency on Revit and budgetary restraints at Bailey and Son is putting a ceiling on the quality of the BIM models.*
Jim Jacobi Interview

Do you feel that a class focusing on BIM should be a requirement or at least an option for students in an undergraduate curriculum? Should it be offered for all disciplines of civil engineering?

- A class on BIM should be an option for students to introduce them to the sphere of BIM. A full semester class is not required.
- Civil engineering students and civil w/ structural emphasis should be exposed to BIM. The non-structural side of CE has lagged behind, but is currently catching up with uses in site planning.
- Fitting a BIM class into a curriculum is a challenge because of the credit hour requirements, but should still be in place in light of this.

What is your opinion on how a BIM class should be taught? Should it focus primarily on the principles of BIM or be software package specific and if so, which? Is there a recommended level of knowledge as far as software packages go — exposure, working knowledge, proficient, expert?

A class should focus on the principles of BIM rather than a specific software package. The functionality of the programs is similar enough that the knowledge can be transferred. In addition, there is no guarantee that Revit will be the main program in the future. Using the software leader (currently Revit) to teach students, though. Student exposure to software should be somewhere between basic and working knowledge.

What are some capabilities that you feel should be included in or focused on in a BIM “first course” such as quantity takeoffs, 4-D models, etc.?

For a first course, visualization, coordination between trades, requirement of establishing connection between attributes and components, and going between analytical and BIM models should be focused on. Learning how to coordinate disciplines is very important. Contrast between the typical project delivery system and how it is done on BIM should be covered. The ability to integrate into a 4-D model and how to construct a reliable quantity takeoff should also be touched on.

When hiring a new employee, have you begun looking at BIM experience as a requirement? If not, do you see it moving that way soon?

BIM experience in a new hire is preferred, but not required because currently there are not enough universities that offer a class to make it a requirement.
Are architects the driving force behind the proliferation of BIM use at your company?

*Walter P. Moore was in front of architect use of BIM, when you started using it approximately 10 years before it became prolific. Mr. Jacobi pushed the use because he was influenced by experience in the industrial sector.*

Can you talk a little bit about your experience going between BIM software and analysis programs?

- *From an engineering standpoint: there needs to be tighter integration with analytical programs. Quantity takeoffs need to improve to increase reliability. Navisworks is improving interoperability between programs, but it needs to continue to improve.*
- *There is not a software package out currently that can switch seamlessly between analytical and BIM models. Walter P. Moore is currently having to manage duplicate models.*

Are you letting the BIM software create construction drawings?

*BIM is producing the construction drawings.*

Additional notes:

- *BIM exposure should start in a junior or senior level course.*
- *Walter P. Moore has used BIM on over 400 projects.*
- *Aeronautical and industrial sectors were first to adopt BIM principles. Integraph had "plant design system." Bentley had competing software. IBM-Dessault-Katea (Gary Technologies) for aeronautics. Graphisoft Archicad and Autodesk Architectural Desktop were before Revit. Tekla Structures is a robust BIM design platform predominantly used by steel fabricators because it moves into their software easily. For AEC BIM use, Revit and Navisworks rules the landscape currently.*
**Terrell Parrish Interview**

Do you feel that a class focusing on BIM should be a requirement or at least an option for students in an undergraduate curriculum? Should it be offered for all disciplines of civil engineering?

A class on BIM should be offered because all disciplines of design engineering will be using it soon.

What is your opinion on how a BIM class should be taught? Should it focus primarily on the principles of BIM or be software package specific and if so, which? Is there a recommended level of knowledge as far as software packages go – exposure, working knowledge, proficient, expert?

In a BIM-focused class, the student should be taught to think in "3-D" as well as focus on the interaction between the different trades. A class should start with the basic principles of BIM and focus on increased visualization.

When hiring a new employee, have you begun looking at BIM experience as a requirement? If not, do you see it moving that way soon?

When hiring a new employee, BIM knowledge is not a requirement, but definitely a plus. In the future, BIM knowledge may be a requirement for hiring.

Are architects the driving force behind the proliferation of BIM use at your company?

The use of BIM is sometimes architect driven, but they are beginning to use it on their own. Britt Peters has been using Autodesk Revit for about four years.

What kind of training do your employees undergo to become what you would consider proficient at BIM software?

At CMC Cary, people are introduced to BIM with a 1 week training session with Tekla, then the rest of training comes from on-the-job training. The engineers are not actively working with BIM, but they are getting up to speed.

Can you talk a little bit about your experience going between BIM software and analysis programs?

CMC Cary is not confident in the results when models are exchanged between Bentley RAM and Revit or Tekla so currently you are creating two separate models.

Are you letting the BIM software create construction drawings?

BIM create the construction drawings for CMC Cary.
Additional notes:

*In the future, BIM will become a "complete" design module used in all aspects of the design process.*
**Brian Pietras Interview**

What is your background on BIM and have you been involved with any projects that used it? Was the use of BIM on the project architect driven?

*The projects that BIM was used for were because the architect required it. The structural engineering information was put into the model, but the architects were asking for this very early in the design phase which caused problems.*

What is preventing BIM from being on Rickborn & Associates’ radar?

*The cost and size of projects are part of the reason Rickborn & Associates has not begun using BIM more often. The typical projects encountered in coastal SC do not necessitate BIM use. Currently, Rickborn & Associates predominantly use hand calculations for your projects but do occasionally use STAAD.*

Your survey result seemed a little apathetic towards BIM, was that based purely on your company or is that a general opinion for structural engineers?

*Those views on BIM use stem from negative personal experiences and not for structural engineers in general.*

Do you think a BIM course should be offered to students in their normal curriculum?

*You think that a BIM class should be an elective course for structural engineers or that maybe a structural communication class be introduced that utilizes some BIM principles but that BIM isn’t the main focus.*
Christopher Smith Interview

Do you feel that a class focusing on BIM should be a requirement or at least an option for students in an undergraduate curriculum? Should it be offered for all disciplines of civil engineering?

*Hard to say; if the undergrad/grad is in construction management, then probably yes. Engineering and drafting / 3D modeling are two very separate things, although both are ultimately required to get a structure built for your client. I would think sacrificing an undergraduate engineering class founded on the universally applicable principles of science for a BIM class built on an ever-changing platform and project-specific software would not necessarily be a good thing. One does not need to look too far to see that the current thought concerning the minimum level of competence for an entry level engineer, considering the increasing complexity of structures and codes, is a graduate degree in structural engineering or an additional equivalent 30 hours on top of your BS.*

When hiring a new employee, have you begun looking at BIM experience as a requirement? If not, do you see it moving that way soon?

*I think it may be helpful for you to separate the commercial industry from industrial, or maybe the smaller scope projects from the larger. In a small AE firm with limited resources it may be expected for an engineer to be well versed in BIM. As the size of the firm increases, it has been my observation, that engineers stick to more to engineering and designers are brought in for CAD and modeling/BIM. For very large firms or corporations and for very large projects the roles of the engineer and the designer are distinct. This is not to say however, that if an engineer is well-versed in BIM they cannot be a great asset to any engineering-type organization. I have witnessed engineers doing some really neat things with BIM.*

What are some capabilities that you feel should be included in or focused on in a BIM “first course” such as quantity takeoffs, 4-D models, etc.?

*Usually you can pull an MTO from a good structural analysis program, introducing the idea in a BIM class would be good though. Erection simulation or 4-D modeling can be very helpful, but more from a construction standpoint; this can be a great tool for project planning, material ordering and delivery, etc.. Engineers typically participate in erection sequencing as it requires some working knowledge of the structure.*
Are architects the driving force behind the proliferation of BIM use at your company?

Again, I think it may be helpful for you to separate the commercial industry from industrial, or maybe the smaller scope projects from the larger. Ultimately it is the client that is the driving force behind the use of BIM on their project. The customer either recognizes the additional value that BIM will bring to their project or they understand that it is a necessity due to the complexity of the project. Remember, this stuff costs money and the client controls the purse-strings, not the architect.

Do you feel like in a number of years, a BIM model will be a requirement for nearly all projects? Are there any expanded capabilities that you feel like will be used on most projects such as facility maintenance scheduling?

- It would have to depend on the size and complexity of the project and whether the future client would be willing to pay for this service. I would hope that just because firms/engineers have added another jig to their repertoire, it won’t get abused and go the path of mutually competitive destruction when pricing and offering services.
- Keeping equipment data (mechanical equipment lists or MELs) and maintenance schedules in BIM is a solid idea, but the owner would have to be willing to keep an engineer or tech on staff to keep the model current.

Can you talk a little bit about your experience when going between BIM software and analysis programs?

It has been my experience that it takes a disciplined approach to modeling and a good understanding of each program’s quirks, of both the analysis software and the BIM software, to minimize the headaches when going back and forth between both platforms. How each program treats cardinal points, offsets, member rotations (local axes), etc. and how the model was built has a significant impact on how much “cleaning-up” one will have to do when exporting/importing files between programs. Having some skills in programming and MS Access is very helpful for manipulating the data when “reconciling” the models.