Project Number: GFS-0807

Visualizing Construction

The Bartlett Center from Start to Finish

An Inter-Qualifying Project
Submitted to the faculty of
Worcester Polytechnic Institute
In partial fulfillment of the requirements for the
Degree of Bachelor of Science

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Submitted To:
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Terms:
A07, B07

Date: February 28, 2008

Abstract

This project addresses the importance of the use of visual aids in teaching and learning by exploring its potential on CE3020 material taught at WPI. A website is developed incorporating dynamic and static visuals, text information, and enhanced functionality progressing upon another recently developed website to aid students taking CE3020 at WPI. The site illustrates different construction phases of the recently built Bartlett Center (WPI); survey results expressing student's views on the importance of visual learning and teaching are analyzed.

Acknowledgements

I would like to thank Professor Salazar for his patience and motivation without which this project could not accomplish its goal. I would also like to thank Ryan Bourque and James Marois for providing access to their website, IQP project and other relevant information which formed the foundation for this IQP project.

Project Overview

This project involved the development of the “Visualizing Construction – Bartlett Center from Start to Finish” web-site. After reviewing the aforementioned “Visualizing the Bartlett Center Construction” and the IQP report by Bourque and Marois, and extensive research on visual learning styles and methods, a draft was initiated. The Bartlett Center – a recently constructed admissions building for Worcester Polytechnic Institute was chosen as the exemplary focal point to demonstrate the incorporation of visual aids with scheduling information and the process of construction. The Bartlett Center also proved to be a more practical example due to its location; today, WPI students interact with the structure almost on a daily basis, some of whom had the opportunity to observe its construction first hand during 2005 and 2006. The web-site was initially designed on paper, with emphasis on making use of visual data to relay information to the readers as outlined in the Bourque-Marois paper.

The web-site development process was a difficult one; with no prior experience the program Microsoft Office FrontPage 2003 was studied extensively to ensure a functional and effective tool for students. During the preliminary phases, the structure of the web-site was developed which evolved over the period of the development process. The construction process was simplified and broken down into terms that could be easily comprehended by novice users and categorized into twelve major construction phases, from Pre-Construction phases through Close-out.

Each phase was allotted its own page with a concise description of the respective term, along with an explanatory panel on the left that displayed information on concepts and terminology used in construction related to the step. Furthermore, the left panel also consisted of illustrations in the form of pie-charts and a Gantt schedule, which illustrated the breaking down of activities involved in

the form of a dependency relationship to convey the dependence of each step on the previous one in a logically ordered fashion, forming a precedence relationship.

Video clips of each phase of construction from Bartlett Center's actual construction footage were used to visually stimulate the viewers and effectively relay information mentioned in the text. Furthermore, an "interactive summary" page consisting of video clips, the complete schedule, activity breakdown overview and CSI list were integrated into one page for the viewers' convenience. This would also eliminate mundane use of text allowing the viewer to jump to any phase and instantly acquiring information related to each phase; hence, the viewer could witness the entire construction process of the Bartlett Center phase-by-phase in only twelve clicks.

After the prototype website was completed, an on-line survey questionnaire was sent to CE3020 students who took the course between 2003 and 2007. The survey collected the students' views and assessment of the web-site on the basis of ease of use, functionality, and effectiveness of visual aids, and educational value.

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1.0 Introduction

The emphasis on using visual media to support teaching and learning has been increasing for over more than a decade. As educators and learners we must acknowledge the fact that today in the 21st century, we are living in a state of global media saturation. Visual information exerts very powerful influences on us socially, emotionally and intellectually; as we evolve, our intellect has developed "Visual Intelligence"; Michael B. McGrath and Judith R. Brown's "Visual Learning for Science and Engineering" paper discusses and explores the diverse benefits of visual aids.

A vast majority of the jobs now require visual problem solving in the field of engineering, biology, chemistry, mathematics, etc. proving we are becoming a visually integrated culture. Yet, the teaching style which is proven to be most effective, learning through visualization, is not being fully utilized. It is imperative that educators around the world strive to improve their teaching methods by incorporating visual imagery and thus stimulating visual thinking, and set a standard which helps students improve their competence not only in critical analysis of visual imagery, but in visual communication as well.

Today, few educators make use of an array of visual information derived from a variety of sources such as the traditional static media such as pictures and PowerPoint slides, as can be seen in many classes on WPI's tech savvy campus. However, it is not suffice in today's competitive dog-eat-dog world. Educators must prepare students to effectively interact with today's experiences as well as tomorrows by enhancing their educational opportunities by moving up to "incorporation of the digital media that is manipulative"[1]. This report explores the possibilities of the incorporation of visual aids in the subject of civil engineering, specifically the process of construction.

This report attempts to integrate dynamic and static visual data with the process of construction, which may appear simple at most times, but is really quite

[1] McGrath, M. and J. Brown, "Visual Learning for Science and Engineering," IEEE Computer Graphics and Applications, Volume 25 No. 5, pp. 56-63.

complicated involving a relationship of intermingled tasks and events. Visual learning may simplify information so it can be interpreted better, and as a result understood better by novice students. In the following chapters facts, methodologies and results regarding visual learning and teaching are outlined which were reviewed and cross-analyzed with results from an educational experiment based (Appendix D) on the development of a web-site titled “Visualizing Construction – The Bartlett Center from Start to Finish” (Appendix H) which incorporated various forms of visual imagery to demonstrate the process of construction in simpler terms. These results essentially helped to prove or disprove the effectiveness of visual aids in teaching and learning. Furthermore, the web-site was fine tuned to provide beginner civil engineering students with a tool to understand the principles, concepts and processes of construction from a construction management perspective as taught in CE3020.

2.0 Background

This report is the result of further research and development conducted by Mustansir Jivanjee for an IQP Project exploring the potential of learning using visual aids. The project reviewed, analyzed and progressed upon a previous IQP project authored by two WPI students Ryan Bourque and James Marois, who initially explored the subject.

2.1 The Bourque – Marois Paper

Ryan Bourque and James Marois seeking to prove the benefits of visual aids targeted a similar problem in their paper titled "Visualizing the Bartlett Center Construction" [2]. Their project involved the development of a web-site explaining the process of construction and analyzing feedback from CE3020 students, which in the end brought back important results. It was a test to confirm the effectiveness of the implementation of visual aids in the case of learning the process of construction, and the result was positive. Although their website, in my opinion, failed to incorporate sufficient use of illustrations and visual data to convey the relevant information and hence ineffectively portray the importance of illustrative aids, their paper notes key points regarding the subject. Following, is an analysis of their work.

2.2 Creativity in Education and Learning

Creativity in Education & Learning rendered some key facts that were used to shape their project. A. J. Cropley defines the differences between creativity and intelligence in "Creativity in Education & Learning: A Guide for Teachers and Educators". The main difference between the two is that the function of intelligence is to acquire, recall, and memorize already known information and then apply it, while Creativity is the skill to develop or invent new ways to utilize the already known information for application. Keeping this in mind it is rudimentary that WPI students have the

[2] "Visualizing Construction – The Bartlett Center Construction," by Ryan Bourque & James Morais

necessary intelligence and knowledge but in a lot of cases lack the ability to apply the acquired information toward specific projects in new and creative ways. Their paper states that in the case of studying civil engineering the role of imagery is evident: visualizations trigger different parts of the brain which auditory learning does not. With this portion of the brain functioning, students can link the two styles of learning together and apply them to arrive at more creative solutions to problems.[3]

2.3 Learning and Teaching Styles in Engineering Education

Learning and Teaching Styles in Engineering Education by Richard Felder gave an in depth analysis of learning styles and related them to explicit engineering topics. Richard Felder, a co-director at the American Society for Engineering Education and National Effective Teaching Institute also shows how each learning style relates to its corresponding teaching style. It is stated that visual learners correspond with a presentation type teaching environment. The work recognizes that students can learn in a variety of ways; however it categorizes learning into three main methods. One such method is teaching using visualization, although it may not be the most widely used tactic approach in college, it has been proven to be highly effective. This method involves the use of pictures, diagrams, video, or other visual mediums that students can analyze and learn from. Another method is auditory learning where people use language in to order obtain knowledge. Both reading and listening to lectures are included in this category. The last technique is known as kinesthetic. In this form of learning people learn from physical feelings: taste, touch, and/or smell.[4]

[3] "Creativity in Education & Learning: A Guide for Teachers and Educators" by A. J. Cropley

[4] "Visualizing Construction – The Bartlett Center Construction," by Ryan Bourque & James Morais

2.4 The Kolb Cycle

The main theory behind the David Kolby's Kolb Learning Cycle can be explained by the quote: "Learning is the process whereby knowledge is created through the transformation of experience."[5]

In 1984, David Kolby developed a cycle consisting of four phases that best explain how people gain knowledge (see Fig. 1). The first phase is Concrete Experience (CE), where the student is educated by means of an example, video, case study, or any experience where a learner can extract a piece of knowledge. After the student reviews the experience from multiple perspectives, they reflect upon what they have just obtained, they might ask themselves: What happened? What did I observe? This phase is called Reflective Observation (RO). The third phase is called Abstract Conceptualization (AC), where the learners develop theories and look for patterns. Conclusions drawn by Kolby were reached from the experience and correlations were drawn between variables. For example, when A happens, B will result. The final phase is called Active Experimentation (AE), where the learners brainstorm ways of how to apply the information they have obtained in another example in the future. The overall concept of the Kolby Learning Cycle is to use information obtained from past experiences to learn new skills, facts, or ways of thinking and to apply them in the future.[6]

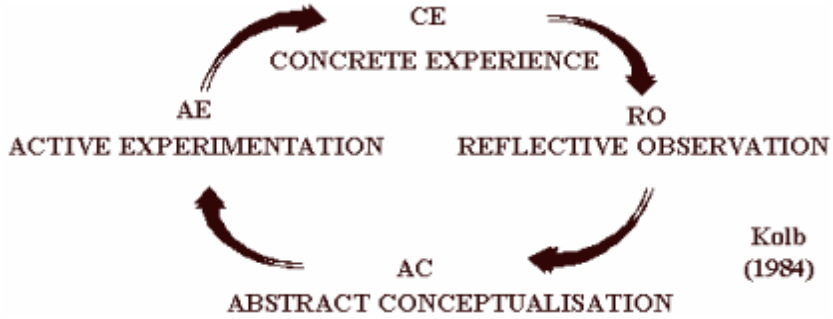

Figure 1 - The Kolb Cycle

[5] Kolb, D. 1984 Experiential Learning: Experience as the Source of Learning and Development Englewood Cliffs, NJ: Prentice Hall
[6] "Visualizing Construction – The Bartlett Center Construction," by Ryan Bourque & James Morais

2.5 Observations and Results from the Bourque – Marois paper

Ryan Bourque and James Marois developed a web-site in 2006 using visual aids targeting Project Management CE students and received feedback from users via a survey. They received 45 responses from a control group of CE students over the past 4 years with CE3020 knowledge – 15% responded. Many responses were suggested at improving the site's aesthetics and efficiency by streamlining the navigation controls. But the most important feedback they received as stated in their report was that 95.6% of the respondents agreed that the web-site prove as a useful for its intended purpose – to better student's understanding of the construction process overall.

They posed a question in their survey "Do you feel the use of this site would be beneficial in any classes other than CE 3020?" to which common responses ranged from courses such as CE3021 – Cost Estimating to CE1030 – Introduction to Civil Engineering.

The Bourque – Morais paper and website was successful in accomplishing its primary goal: Visual aids can be, and should be implemented to more than one course and offer the student population diversity in styles of learning for better understanding and information retention. The results of Bourque and Morias' paper brought realization to the fact that more effective visual aids along with added functionality should be incorporated.

3.0 Visually aided Communication

As mentioned before, the importance of visual learning in today's competitive and fast paced world cannot be emphasized more. Educators in the Science, Mathematics, and Technology and Engineering disciplines are urged to adopt visual methods to communicate about science and engineering. Exploring the vast domain of visual learning has the ability to engage students' interest and the potential to make any subject more appealing, as a result captivating more minds into the field of science and engineering.

3.1 Why Visual Learning is Essential

Visual learning methods open up a new portal to problem solving, encourage new ways to think about science and engineering which are out-of-the-box, and enhance the education and practice of science and engineering.

Visual approaches let scientists and engineers communicate more complex and subtle concepts to each other and to students, and visual approaches to learning can engage the student more fully in the ideas. A revolutionary change to scientists' way of thinking is evidenced by the fact that they now say they cannot do scientific research or communication without visualization. This "visualization revolution" showed that letting scientists engage the higher cognitive parts of the brain by thinking and communicating visually improved how they performed their research. [7]

[7] (1. B. H. McCormick et al. (Eds.) "Visualization in Scientific Computing," *Computer Graphics*, Vol. 21, Number, 6, Nov. 1987.)

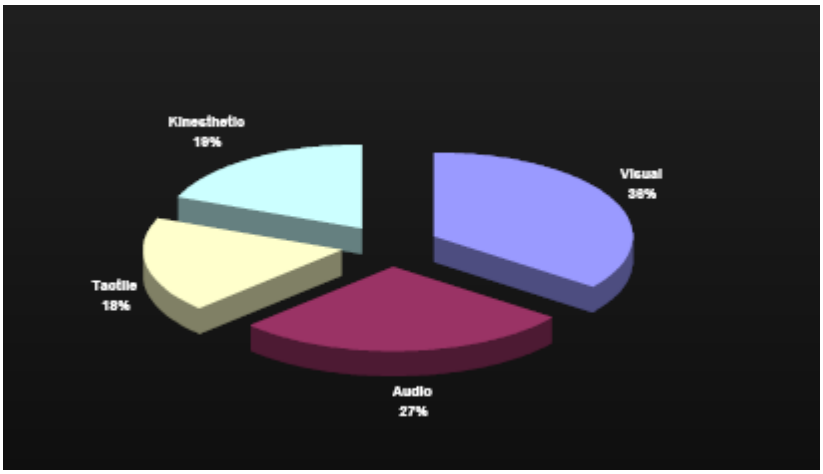

Figure 2 - Learning Styles of Average Student in CE/ES 256, Fall 2000 - Professor Fernando Cadena

According to a study conducted by a Civil Engineering Professor Fernando Cadena of NMSU, as figure 2 illustrates, he states "the students in his Environmental Science class (33 engineering and environmental science sophomores) shows that on the average the students in this class prefer the visual and audio styles." [8]

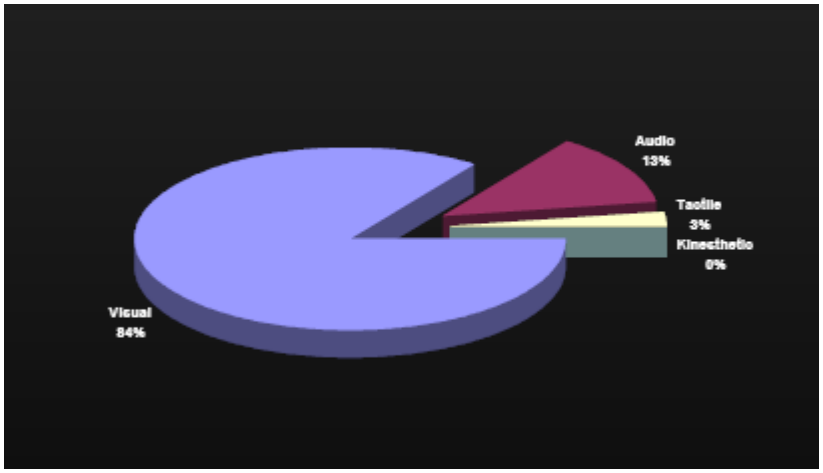

Figure 3 - Preferred Learning Style in CE/ES 256, Fall 2000 - Professor Fernando Cadena

Furthermore, he discovered from his survey that "by far the majority of the students in his class preferred the visual style. These trends appear to be common in the engineering profession. It is not surprising to see seasoned engineers take full advantage of visual aids to communicate design concepts." [9] This is illustrated in Fig. 3.

8

9 "Implementing Innovative Visual Aids in Engineering Education", Fernando Cadena, Professor, Civil Engineering, NMSU

3.2 Technology Advancement

Visual learning has existed in the sciences for a long time, for example in Chemistry, the stick and ball models to demonstrate bonding and molecule assembly. However, it cannot be ignored that with time technology has evolved providing us with more ways to teach and learn using visual imagery. Mathematics programs such as Maple and Matlab allow students to define complex symbolic and numerical models and visualize their output.

Other subjects such as biology make use of detailed models illustrating complex functions of the human anatomy, such as the human heart. These models use visual methods to convey the functionality ranging from the beating heart pumping blood through the circulation system and the brain to the human brain transmitting neurons form nerve stimuli.[10]

It is therefore evident that the form of visual aids has transformed over the years. As we evolve further and discover more complex relationships and reactions in our surroundings, educators must develop more ways to relay new information to future minds for the ultimate betterment and progress of humanity. A good example of the incorporation of visual data into engineering is the Building Information Model (BIM), a visual tool to help educate construction engineering students

"The Building Information Model (BIM) is a set of information generated and maintained throughout the life cycle of a building. BIM covers geometry, spatial relationships, geographic information, quantities and properties of building components (for example manufacturers' details). BIM can be used to demonstrate the entire building life cycle including the processes of construction and facility operation. Quantities and shared properties of materials can easily be extracted. Scopes of work

[10] McGrath, M. and J. Brown, "Visual Learning for Science and Engineering," IEEE Computer Graphics and Applications, Volume 25 No. 5, pp. 56-63.

can be isolated and defined. Systems, assemblies, and sequences are able to be shown in a relative scale with the entire facility or group of facilities."[11]

The implementation of BIM may very possibly improve visualization, enhancing the user's understanding, and hence productivity due to easy retrieval of information. BIM proponents claim users may increase their coordination of construction documents, their speed of getting their work done with reduced costs, and relative ease improving overall efficiency. Visual Teaching as conducted using BIM is one of the many important methods of promoting visual learning in today's world.

3.3 Cross-Cultural Communication

The world's population is growing at a fast rate. The WPI student body shows the diversity of cultures present studying various disciplines such as engineering and chemistry. This may pose as some form of a barrier for communication in any medium; be it language or interdisciplinary, for example communication may be more difficult between a chemist and a biologist in the same university than between two chemists in different countries. However, these communication barriers can be overcome using visuals as this is a more universal form of communication as shown in a study by Jacqueline Ford Morie, Associate Director of Creative Development at the University of Southern California's Institute for Creative Technologies. Although many variables must be taken into consideration such as cultural differences, but visual aids in learning may break communication medium barriers for a more generic understanding, therefore overcoming cross-cultural challenges be they across disciplines or across nations.

[11] What is BIM? - By Professor Charles M. Eastman, Director of AEC Integration Lab at Georgia Tech.

4.0 Visualizing Construction: The Bartlett Center from Start to Finish

The web-site development process was a difficult one; with no prior experience the program Microsoft Office FrontPage 2003 was studied extensively to ensure a functional and effective tool for students. During the preliminary stages, the structure of the web-site was developed which evolved over the period of the development process. The construction process was simplified and broken down into terms that could be easily comprehended by novice users and categorized into twelve major construction steps, from Pre-Construction phases through Close-out.

4.1 About the Web-site

Teaching the construction process to civil engineering students at WPI in a program does not have specific courses dedicated to this purpose; not all material is covered is given proper attention, but rather a generic overview. Therefore using a construction example seemed like an appropriate topic to conduct this educational experiment on, as it posed some challenges in determining and developing visual data for its intended purpose. The example of Bartlett Center using actual data also provided a good way to illustrate different information in different visual styles. The actual schedule and some visual data was provided by the Gilbane Building Company who was the CM fro this project, and some contributions were made by Ryan Bourque and James Morais, including the information from their paper and website, which were the stepping stones for this project.

4.2 The Development Process

The compilation of the preliminary data was provided by Professor Salazar, which comprised of references to IQPs previously conducted on the topic as well as spreadsheets from CE3020 listing tasks broken down by CSI code (Appendix F – List of Activities & Appendix G – Reduced List of Owner's Activities, and some Primavera documents (Appendix E) containing all the scheduling information, courtesy of Gilbane.

The first step towards making progress was to research and account for all work that had been accomplished on the subject in the past. The Bourque – Marois paper and web-site was determined as a good start-off point as it posed a challenge on the web-site development criteria. The web-site development process was an important milestone because all observations, results and conclusions were to be drawn from the said web-site which would illustrate effective visual imagery. These visuals would be tested upon by conducting a survey amongst a control group of CE students with prior and on-going knowledge of CE3020 Project Management. The results were analyzed and evaluated to get concrete results that the visual aids did indeed make the expected impact on understanding of students, and this would be evident from the feedback received. Therefore, a new a web-site was sought to be developed.

4.3 Index of Learning Styles Questionnaire

Before any progress could be made on the web-site, another control survey was created for input into the web-site (see Appendix A for survey results). For this, use of The Felder Survey (Appendix B) was sought. Felder, as aforementioned, was a co-director at the American Society for Engineering Education and National Effective Teaching Institute. He developed a survey comprised of forty four questions, the result of which could be categorized into various groups, one of which was Visual Learners VS Verbal Learners. Appropriate questions from the Felder Survey were compiled to put the statistics to the test.

The survey was titled Index of Learning Styles Questionnaire derived from Felder's original survey, and was sent to forty CE colleagues with prior knowledge of CE3020 in the early stages of the project. The response rate was 80%; results may be found in Appendix A.

2. When I think about what I did yesterday, I am most likely to get			
		Response Percent	**Response Count**
a picture.		**93.8%**	30
words.		9.4%	3

Figure 4 - Question 2 from the Index of Learning Styles Questionnaire

A question was posed regarding information retention on a daily basis by asking the question, "When I think about what I did yesterday, I am most likely to get…" 93.8% responded they would think of a picture than something verbal or auditory (Fig. 4). This provides indication that Felder's statement "processes can be made more tangible through visualization"[12] and the fact that visual imagery plays a major role in information retention and/or understanding information.

Another question was posed "I prefer courses that emphasize" with the choices, "A. Concrete Material (facts, data)", or "B. Abstract Material (concepts, theories)." 71.9% of the control group responded with A. Facts and data are forms of information that require retention rather than understanding in the case of concepts and theories. Hence, if processes can be made more tangible through visualization and abstract material can

[12] "Learning and Teaching Styles in Engineering Education" by L.L. Silverman/Felder

be taught using visual aids enabling students to grasp material with ease, concepts and theories can be made less ‘dreadful’.

9. Once I understand			
		Response Percent	Response Count
all the parts, I understand the whole thing.		**65.6%**	21
the whole thing, I see how the parts fit.		43.8%	14

Figure 5 - Question 9 from the Index of Learning Styles Questionnaire

One more crucial question was selected from Felder’s Survey: (Fig. 5) “Once I understand…” with two choices: “A. All the parts, I understand the whole thing”, or “B. The whole thing, I see how the parts fit.” According to Felder, learning styles can be grouped as Sequential VS Global learners, where sequential learners obtain information by means of logically ordered steps. Global learners happen to learn in bits and pieces and progress learning randomly with no connections, and then see the big picture, if they see it at all. 65.6% of the respondents replied with option B, hence providing another important guideline for the web-site development process. Attention must be paid not only on visual aids, but also on how and in what sequence it is presented.

Researching and organizing various sources of information related to the subject, and conducting weekly meetings with Professor Salazar resulted in the web-site’s gradual evolution of the preliminary design. Microsoft Office FrontPage 2003 was chosen as the primary web-site design program due to its user friendly interface, and after trial and error, and extensive self-study the skeletal frames and structure of the web-site was developed.

4.4 Pre-Construction Phase through Close-out, and More

The complex process of construction in its entirety was broken down into the following twelve easy to understand phases:

- Pre-Construction Phases
- Construction Schedule
- Bartlett Center Schedule
- Mobilization
- Excavation
- Foundation
- Steel Frame
- Exterior Walls & Roofing
- Interior Walls, Mechanical & HVAC
- Landscaping
- Finishing/Punch-list
- Close-out

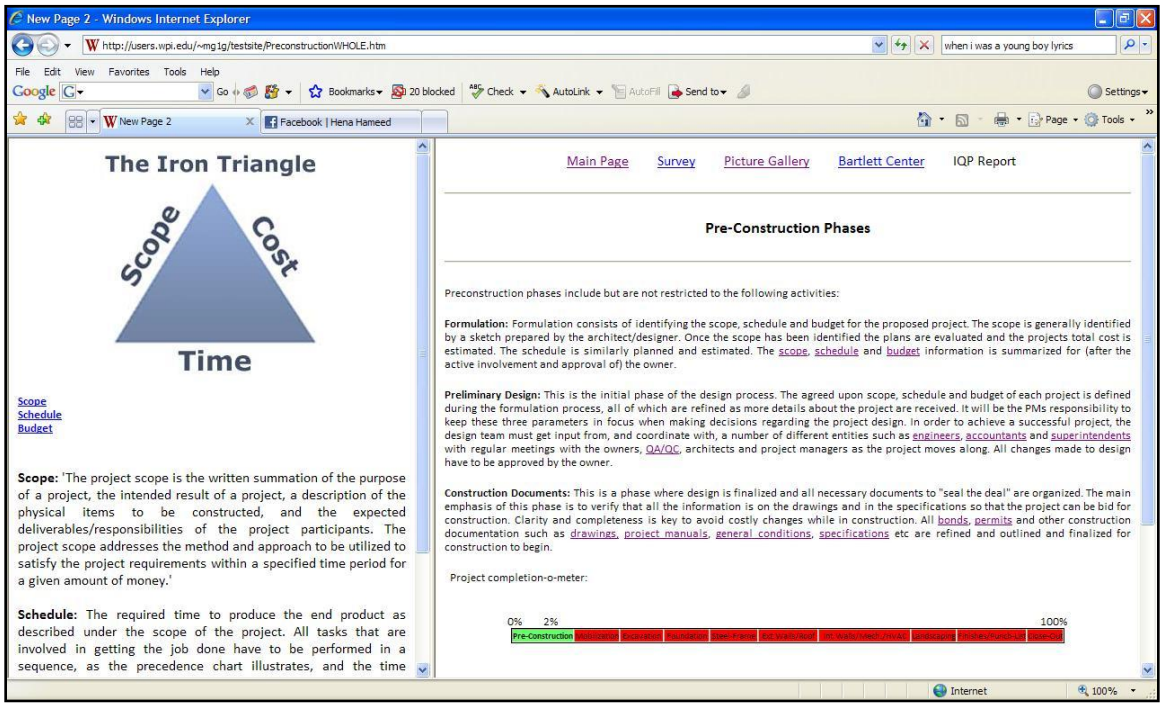

Figure 6 - Dedicated page comprising of a main page, and a side panel (left)

Each page was split into a main page and a side panel as shown in Figure 6.

The figure shows how each phase was allotted its individual page and briefly explained, with construction concepts and terminology explained in the left panel for easy understanding of novice users. Incorporated into each page was a “Project Completion-o-meter” illustrating the percentage of construction completed phase-by-phase. This not only emphasized the dependency of each phase regarding its position in the precedence relationship of construction phases, but also helped the process of flow of construction reminding students every step was a step forward as illustrated in Figure 7 below.

Figure 7 - Project Completion-o-meter illustrating percentage of project complete with respective phase.

Along with the “Project Completion-o-meter”, a Gantt chart was also provided to help students keep track of the phase and all its activities with respect to the project as a whole as shown in Figure 8.

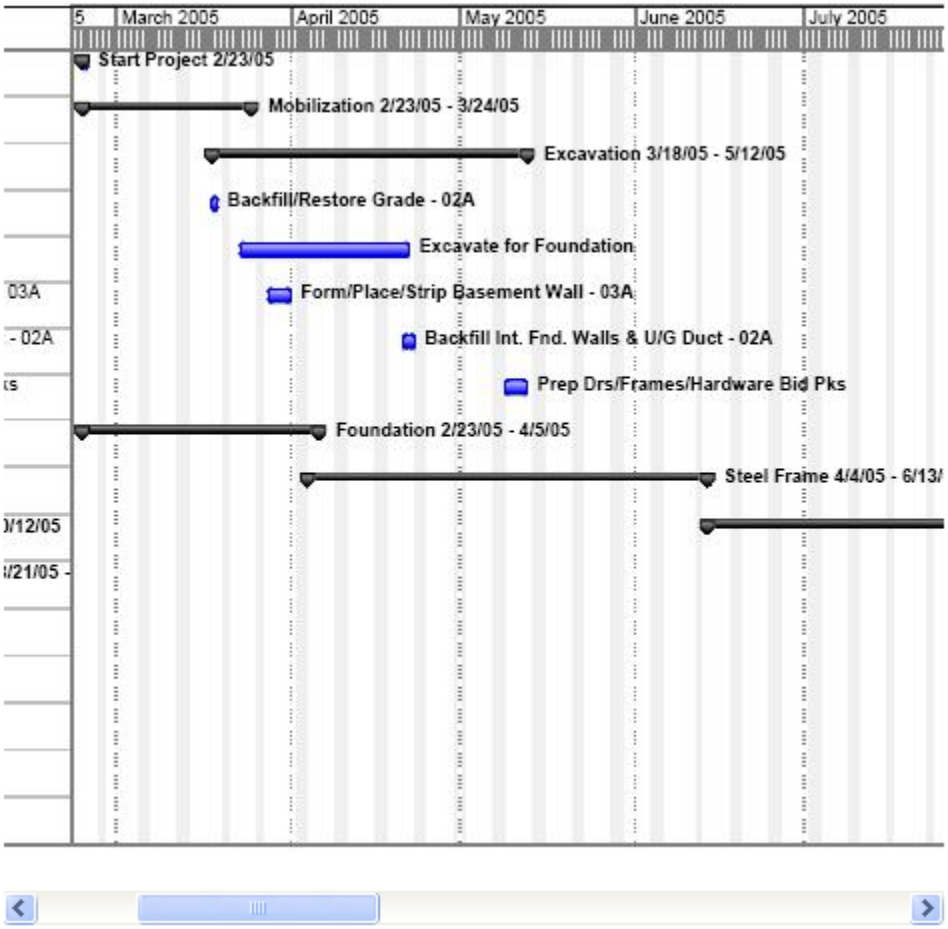

Figure 8 - Gantt chart illustrating break-down of tasks in the phase Excavation.

A scroll bar was provided for easy navigation of the phase schedule with respect to the entire project schedule on the same page to prevent students from losing track of what was essential, i.e. the process of construction, rather than getting lost in a sea of different windows.

After an explanation and breakdown of information via the static forms of visual data, the page also provided actual video footage of the phase that had been recorded during the construction of the Bartlett Center. An example is illustrated in Figure 9.

Figure 9 - Example of video footage provided from Higgins Labs (left) & Harrington Auditorium (right)

This was an important step because it helped students who had just acquired the information relating to the phase from the text and other static visual data, and present it from a dynamic point of view. This proved to be helpful as it allowed students to look at the tasks broken down by CSI code.

CSI is a technical society formed by an association of individual members in the U.S. non-residential building design and construction industry, which develop voluntary standards for the preparation of specifications, organize continuing education sessions to train practitioners to read and write written construction documents, and hold product shows in their effort to continually improve the process of non-residential building design and construction.[13]

The video footage showed the phase from two angles, from Higgins Laboratory as well as Harrington Auditorium using webcams positioned there by the WPI ATC for the entire construction of the project. This form of visual data would allow students to relate to the information provided on the page on a higher level.

[13] http://www.ordesignandconstruction.com/glossary.htm, Copyright © 2002

The side panel not only provided the user with definitions of technical terminology, but also with an overview in terms of percent time of the total project duration for the phase the page displayed as shown in Figure 10.

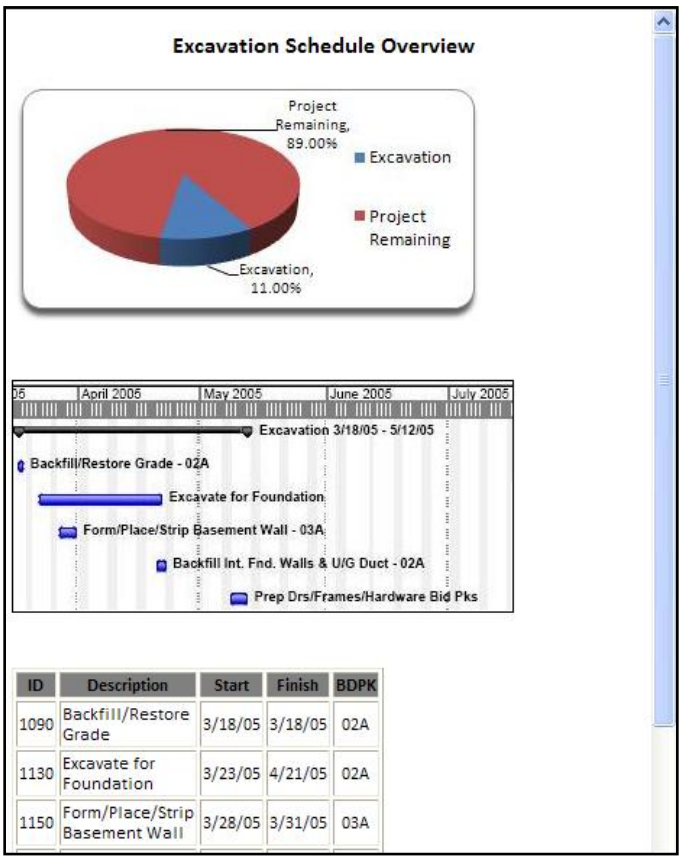

Figure 10 - Side panel displaying an overview of the Excavation Phase.

The side panel was also provided with a scroll bar for on-page navigation preventing students from getting lost. It comprised information such as percentage of the project completed with the completion of each phase in the form of a pie-chart, a different form of displaying numerical data. It also included a mini-schedule comprising only of the task break-down of the phase in question. This allowed easy access to information, isolating the users from the main page focusing their attention on the information at hand by displaying the task sub-duration within duration period of the entire phase. Right below the mini-schedule, the tasks displayed were broken down in detail by ID, Description, Start date of task, Finish date of task and Bid Package number.

The summation of all the information alone conveyed a new set of information in terms of detail as opposed to the main page.

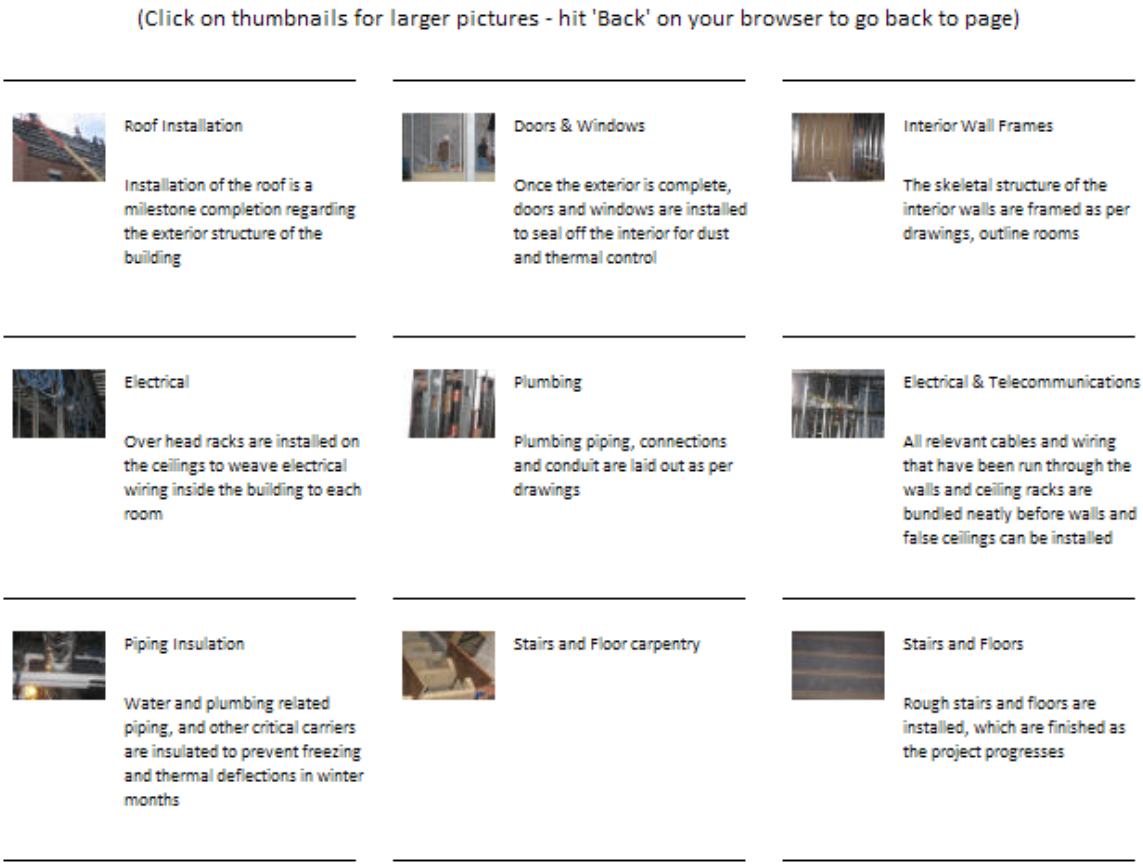

Figure 11 - Example of pictures provided for the phase Interior Walls, Mechanical & HVAC, where no video footage was available.

In some cases where video data could not be applied, more still pictures of phase were posted. As can be seen in Figure 11, information for each picture was provided with an option to make the image bigger for better viewing. For example, in the phase Interior Walls, Mechanical and HVAC, video footage was not available because the webcams could not document the inside of the building. However, a picture was provided for some of the tasks involved.

In addition to each page dedicated to each phase of construction, a summary page was also provided. This page proved to be a major break-through as it allowed the

compilation of all available visual data on one interactive page. The breakdown of the summary page is illustrated in Figure 12 with window numbers 1, 2, 3 and 4 respectively.

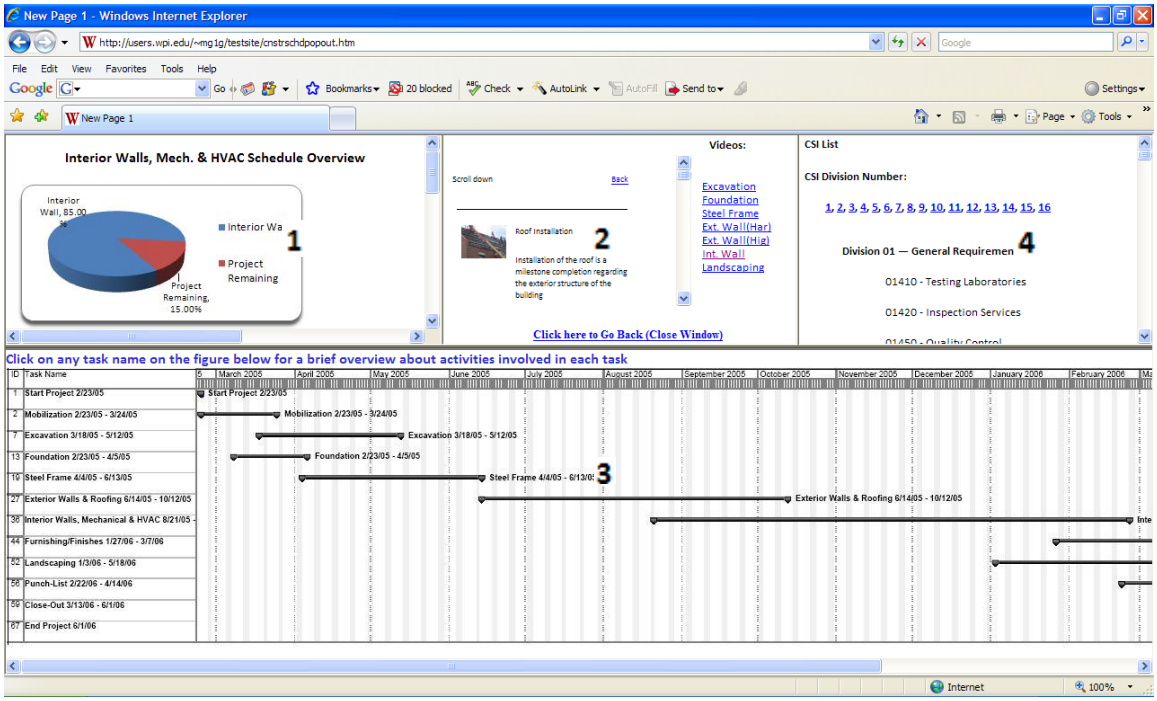

Figure 12 - Summary page broken into four independent smaller pages.

The summary page can be looked as a four-in-one page (refer to Figure 12):

1. The first page displayed an overview of a phase similar to what could be seen on the side-panel when on the main page of a certain phase. It summarized the phase-related information such as percentage of project completed with the completion of the phase, a mini-schedule with a break-down of each of the tasks involved and listed them by ID, Description, Start date of task, Finish date of task and Bid Package number. An independent scroll bar was provided.

2. The second page displayed all dynamic forms of visual data in its entirety. A list of all the phases comprised in the construction process was listed and hyperlinked, which if clicked would display a video or a list of pictures of the respective phase within the same page. In the case of pictures, a dedicated scroll bar was provided for easy navigation.

3. The third page comprised a ‘collapsed’ version of the schedule to provide the user with precedence relationship guidelines preventing confusion which was possible with the volume of information displayed on the page. Each phase was listed on the Gantt chart similar to ones that could be found on the main page, and was made interactive by making each phase “click-able”. Clicking on a certain phase, for example, Interior Walls, Mechanical and HVAC, page 1 and 2 would display the Interior Walls, Mechanical and HVAC overview and dynamic data respectively. Thus, by allowing the user to interact with the Gantt chart control over information displayed was relinquished allowing the user to freely jump to his or her phase of choice instantaneously summarizing and transforming all relevant data by one click. An Independent scroll bar was provided to view the schedule with ease, preventing font shrinkage.

4. The fourth and the last page remained constant throughout the interaction process. This page displayed the CSI list as a reference, breaking down the sixteen divisions with each applicable task involved in each phase to be identified as shown in Figure 13. In addition to an independent scroll bar, each division was also provided with a “Top” button (see Figure 13), clicking which resulted the user to be sent to the top of the page where links were provided to jump to a CSI division of choice to prevent confusion and ease in navigation.

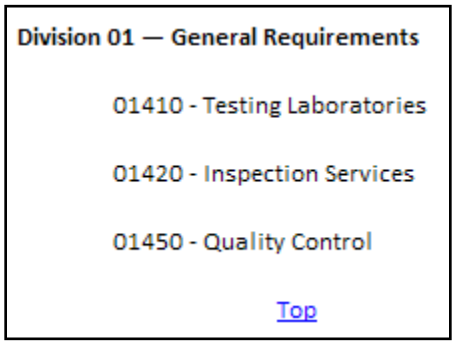

Figure 13 - CSI List, Division 01: General Requirements.

With the construction process broken down into twelve distinct steps, with each phase having a dedicated page, and with the information displayed in different forms of visual aid in addition to text, it became evident that navigation could become confusing for the user. The lack of ease in navigation would damp the effectiveness of information that needed to be conveyed. Hence, a solution was proposed. Each phase was to be displayed in the form of a button at the bottom of each page totaling twelve buttons in all; the result of clicking each would lead to the user being re-directed to the main page of the phase clicked on. These buttons are shown below in Figure 14.

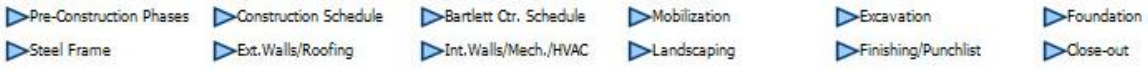

Figure 14 - Navigation Links for all phases.

These buttons were designed to catch the users' attention in the case of his or her intention to browse to another phase, or to aid them in the event of getting 'lost'. Hence, the web-site's functionality was ensured preventing a student from feeling overwhelmed, improving effectiveness and efficiency of the web-site.

4.5 Review of website improvements

In comparison to the previous version of this website, a lot more visual data was embedded into the new web-site. However, in the process of compiling pictures, videos and other visual imagery, the volume of information increased proportionally.

The Bourque-Morais website made use of a simplistic time-line methodology outlining the milestone phases; each phase highlighted denoting its location in the chain of phases of construction. The time-line is illustrated in Figure 15. This proved to be a strong tool in relaying the related information without any major complications. Each phase following the next was shown cascading giving it a precedence relationship effect complete with dates as well.

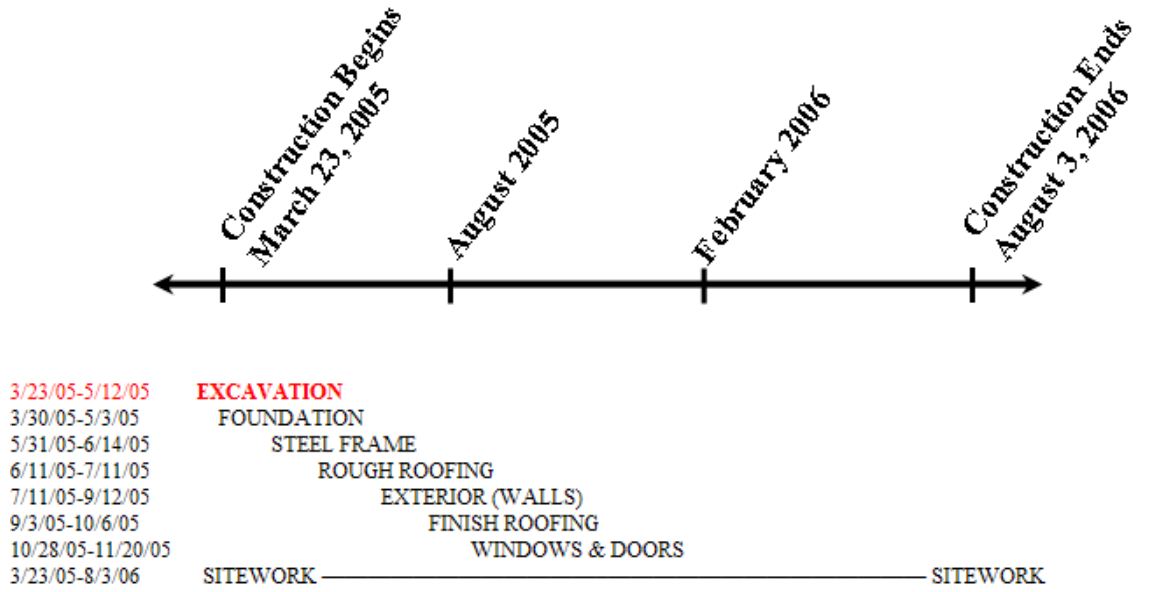

Figure 15 - The Bourque - Morais sequential time-line.

This methodology was taken into consideration in the development of schedules related to each phase in the form of Gantt Charts, forming a more detailed and contoured time-line relaying more information by breaking down tasks involved with each phase, where each task followed another to show a precedence relationship within a phase as well. For example, in the Foundation phase, the task Fabricate Steel was followed by Steel Delivery, then Erect Basement Steel, Erect First Floor Steel, and henceforth, until the tasks involved in the phase were completed leading into the next phase, i.e. Exterior Walls & Roofing. This is illustrated in Figure 16 on the following page.

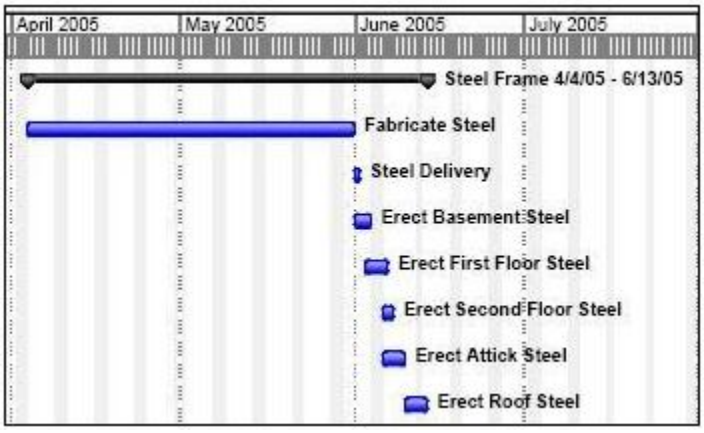

Figure 16 - Precedence relationship of the task breakdown structure within the Steel Frame phase.

Hence, the complete timeline of phases could be broken down into a timeline of tasks by phase, generating a schedule of tasks as well as their respective phases as demonstrated in Figure 17. A legible version of this schedule, as provided on the website, may be found in Appendix I.

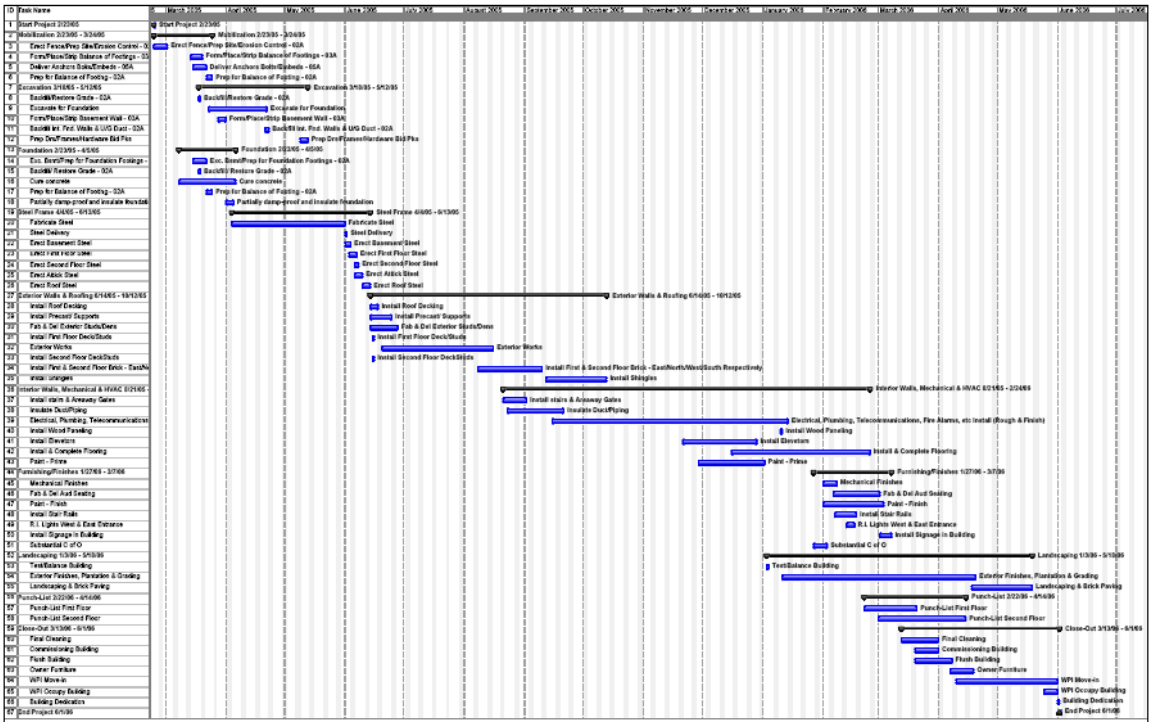

Figure 17 - Complete precedence relationship structure by phases and respective tasks.

Microsoft Publisher was used to generate these Gantt Charts, a tool that is used in today's world to generate detailed construction schedules; this program also proved to be much more user friendly than another notorious scheduling program, Primavera.

This process allowed a greater amount of construction information to be captured by the updated version of the website, where technical construction jargon was explained by hyper-linking every term rendered confusing to novice users.

The navigation on the Bourque-Marois website was also further developed. Each page allotted to a phase was not only provided with links to all phases to retrieve information of choice, but with a link specific to the sequential process of construction (precedence relationship-wise), promoting gradual flow of information as portrayed by

the illustrations aforementioned. This was thought to help students to keep on track of the timelines developed to avoid confusion, while giving them the freedom to access any phase of choice. For example, as can be seen in Figure 18, when a viewer desires to move onto the following phase, he or she is initially presented with the option to link back to a previous phase as outlined by the timeline, or go to the next phase of the precedence relationship, i.e. Exterior Walls & Roofing. Were a viewer to select an alternate phase, links to allow them to do so were provided immediately after these options.

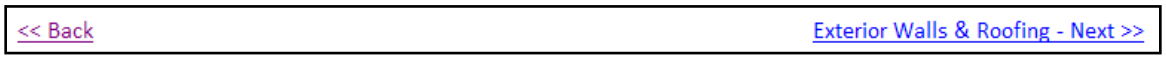

Figure 18 - Precedence Relationship links

Hence, the results from the Index of Learning Styles Questionnaire (Appendix A) were put to good use, helping to shape the website into a more efficient tool for students promoting sequential learning, using aids to capture abstract material in concrete form and ultimately, helping students understand the material in an expeditious manner.

5.0 Results

The survey (Appendix A) was derived from Felder's Original Survey (Appendix B), which was then sent out to a group of CE students for feedback on the various aspects of teaching styles. The results of that survey are discussed as follows.

5.1 Survey Results

Upon substantial completion of the website, a survey was created to assess its functionality and efficiency based on the responses of that survey, and pointers on how to make it better were sought.

The survey had to be a controlled one in order to consistently determine the contributions of the new version of the website when compared with the work accomplished by previous authors. CE 3020 students and alumni from class groups A03 through A07 were chosen as the control group, totaling the number of potential participants to 276. The survey was designed with questions similar to those posed by Ryan Bourque and James Morais in their survey to maintain consistency so that the results obtained may be compared to their results to measure the progress achieved (Appendix C).

However, a large number of student's have graduated since they took the course and their WPI email address is no longer operational. This reduced the list dramatically from 276 students to 140, nearly half of the original amount.

Only 20 CE 3020 alumni responded which is equivalent to 15%. A 100% of the respondents were Civil Engineering majors with no responses from the A03 class group.

The control group was questioned on their construction knowledge and construction experience prior to taking the CE3020 course, to obtain generic demographic information regarding their familiarity with Construction Information. Most

of the participants faired moderately on both aspects of the question, as illustrated in Figure 19.

2. Please select your level of current construction knowledge/construction experience.			
Construction Knowledge			
	None	**Some**	**Extensive**
Please select your level of knowledge and experience	0.0% (0)	**85.0% (17)**	15.0% (3)
Construction Experience			
	None	**Some**	**Extensive**
Please select your level of knowledge and experience	25.0% (5)	**75.0% (15)**	0.0% (0)

Figure 19 - Construction Knowledge/ Construction Experience survey results.

The web-site faired well on ratings (as can be seen in Appendix D) scoring with the 80% majority rating it a 5 out of 5 on content, 4 out of 5 on aesthetics and 4 out of 5 on functionality.

When asked to what extent visual aids were important in improving student's understanding of a subject, the results ranged from moderate to very high, with 50% being the majority voting its importance to be high. Of the other half of the survey population respondents, 20% voted for its importance being moderate, where as 30% claimed its importance was very high. (See Fig. 20)

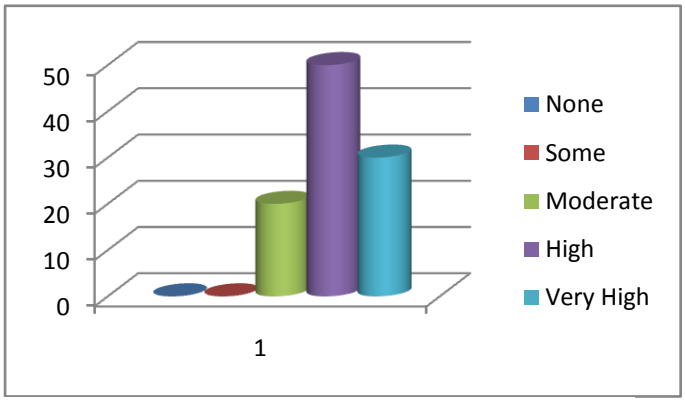

Figure 20 - Importance of Visual Aids

The results clearly showed that visual aids were crucial to students not only for understanding of material being covered in any subject, but as a preference. However,

the experiment's results had to be compared and contrasted with results obtained from previous work.

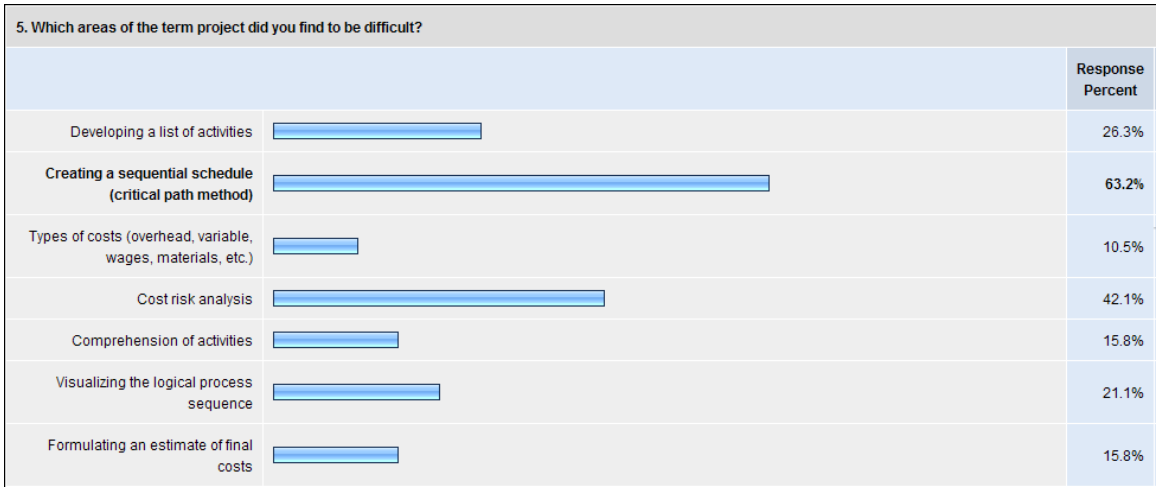

Figure 21 - Areas of the term project that may have been difficult for students.

Students were asked standard questions similar to those asked in the survey conducted previously as deemed appropriate. One such question asked what areas of the term project were difficult for students understanding in a multiple choice format where students could choose multiple answers. Figure 21 breaks down the hurdles that posed a challenge for students of which the three highest were 'Creating A Sequential Schedule' (63.2%), 'Cost Risk Analysis' (42.1%) and 'Developing A List of Activities' (26.3%). However, the response rate for the choice 'Visualizing the logical process sequence' faired as the fourth highest obstacle in the term project, an option for which the response rate was expected to be higher considering the positive response rate to the question discussed earlier, i.e. regarding the importance of visual aids in understanding a subject. It is interesting that the creation of a schedule received 64%, one of the most important objectives of this work. However, visualization of the process only received 21%.

Another question the students were asked was whether the website would prove to be useful in helping them over come the challenges that the term project presented them. 85% of the students voted yes while the remaining 15% voted maybe (Appendix D). Students were asked for feedback on how the website could be improved. Most of the respondents felt that the website was suffice content and navigation wise, however

it is important to mention for future progress that some respondents suggested that a more aesthetic and professional interface be used and that “CE3020 needed very detailed part of the project and the website only provided a broad overview and for those who need visualization it only gave basic information” (see Appendix D). However, since the goal of this project was to give novice students the big picture in order to help them visualize, understand and put together the smaller working parts themselves, the content was suffice.

The survey proved the website would be an efficient and effective tool in helping students taking CE3020 understand and overcome the challenges they faced by visualizing the process of construction from a project management perspective.

Students were also requested to suggest what other courses the website could prove helpful for. One student responded suggesting, “Yes, I think that websites similar to this or branched off of this website could help with many civil engineering courses at this school. However, I think the site may contain too much help and that if it were improved upon anymore it would take away from the difficulty of the class. I think the class is viewed as a very hard class to get an A in and as a person who got one of those A's I wouldn't want to see other kids take the course and miss out on the time and effort I put into it because in a way the class itself and how it is structured shows you the importance of time management. I say this because I think I learned more from the amount of effort I had to put into the class to get that A than anything. This site seems to just kind of hand everyone the answers and if I were to offer advice to people in this class it would be learn to budget the responsibilities of this class early so everything doesn't pile on at the end. This site would allow kids to slack off more and would take away from the feeling that you are really working on a project of your own and make it seem more like you are just replicating what has already been accomplished.” This may give the instructor an incentive to raise expectations on the course.

This was considered as very helpful feedback. Even though some of the students thought it would take away the essence of the effort that should be put into the class to get an A, he or she believed the website would give other students an unfair chance at

achieving a similar grade. However, thought was put into this issue during the websites preliminary stages, and hence Microsoft publisher was used to develop precedence relationships and files were not provided as it is not only a good tool to illustrate the point precedence relationships make, but also succeeded in not giving away any Primavera related answers which students were required to figure out themselves for the CE3020 term project. The feedback hence essentially suggests that the website could make an even leveled playing field for all students, helping weaker students understand the crucial basics better and faster, while at the same time pushing students that excel to put more work into advanced topics in helping them secure a higher grade, hence giving them more educational value. Other classes this tool could be used toward, as per suggestions in the survey results (Appendix D) were CE3020, CE3021, CE3022 and CE535.

5.2 Conclusion

"Visual thinking is crucial to the future of learning, with particular connections to collaborative learning methodologies, distance learning, and virtual learning environments."[14] On a global scale, efforts in seeking means to enunciate and interpret the subtle differences of visual realm must be increased. Collaboration across different cultures and professional disciplines needs to be established not only for a macro-scale welfare, but for a more unitary and micro-scale benefits; students having difficulty understanding material may not only improve their understanding but may also taken upon dual majors for self betterment, and ultimately, betterment for humanity.

Further studies along with applications of the results of studies regarding visual learning need to be assessed and implemented simultaneously. The field of academia needs to embrace the fact that the use of imagery for teaching science and engineering is a respectable approach, and could very well catalyze scientific discovery and invention by encouraging out of the norm thinking eliminating one-dimensional textbook thinking.

[14] "Implementing Innovative Visual Aids in Engineering Education", Fernando Cadena, Professor, Civil Engineering, NMSU

5.3 Recommendations

The website proved to be a successful accomplishment. However, it is far from perfect. It is suggested that further refinement of the visualization process by improving the navigation features by making the interface more user friendly. It is also suggested that a more sleek and more attractive/addictive interface be used to capture the young students' attention in today's fast paced technological environment so that the website may preserve it's appeal. It is also suggested that the content be revised and sharpened around the edges to eliminate information that may send a novice mind to wander or contribute to his or her confusion, and more visual emphasis be made on the sequencing of the processes of construction. And of course, use of better and more efficient visual data should be implemented.

The main goal of this project was to help students to better understand the construction process through visualization. This website was aimed at giving them a broader knowledge of all the activities involved in construction as an aid to classroom lectures, not to replace them. Schools all over the world should start adopting the visual medium of learning not only as suggested by science, but also as demanded and desired by today's students.

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7.0 Appendices

Appendix A – Index of Learning Styles Survey Results

SurveyMonkey.com
because knowledge is everything

survey title:
Index of Learning Styles Questionaire
Edit Title
Page: Learning Using Visual Aids

1. I prefer courses that emphasize

	Response Percent	Response Count
concrete material (facts, data).	**71.9%**	23
abstract material (concepts, theories).	34.4%	11
	answered question	**32**
	skipped question	**0**

2. When I think about what I did yesterday, I am most likely to get

	Response Percent	Response Count
a picture.	**93.8%**	30
words.	9.4%	3
	answered question	**32**
	skipped question	**0**

3. When I solve math problems

	Response Percent	Response Count

3. When I solve math problems		
I usually work my way to the solutions one step at a time.	**62.5%**	20
I draw an illustration of the problem to understand the problem better.	40.6%	13
	answered question	**32**
	skipped question	**0**

4. I like teachers		
	Response Percent	**Response Count**
who put a lot of diagrams on the board.	**71.9%**	23
who spend a lot of time explaining.	37.5%	12
	answered question	**32**
	skipped question	**0**

5. I remember best		
	Response Percent	**Response Count**
what I see.	**84.4%**	27
what I hear.	25.0%	8
	answered question	**32**

6. It is more important to me that an instructor

6. It is more important to me that an instructor

	Response Percent	Response Count
lay out the material in clear sequential steps.	**71.9%**	23
give me an overall picture and relate the material to other subjects.	34.4%	11
answered question		**32**
skipped question		**0**

7. I prefer to get new information in

	Response Percent	Response Count
pictures, diagrams, graphs, or maps.	**75.0%**	24
written directions or verbal information.	31.3%	10
answered question		**32**
skipped question		**0**

8. I tend to picture places I have been

	Response Percent	Response Count
easily and fairly accurately.	**87.5%**	28
with difficulty and without much detail.	15.6%	5
answered question		**32**

8. I tend to picture places I have been		
	skipped question	**0**

9. Once I understand			
		Response Percent	**Response Count**
all the parts, I understand the whole thing.		**65.6%**	21
the whole thing, I see how the parts fit.		43.8%	14
	answered question		**32**
	skipped question		**0**

10. In a book with lots of pictures and charts, I am likely to			
		Response Percent	**Response Count**
look over the pictures and charts carefully.		**80.6%**	25
focus on the written text.		25.8%	8
	answered question		**31**
	skipped question		**1**

Appendix B – Felder's Original Index of Learning Styles Questionnaire

Index of Learning Styles Questionnaire

Barbara A. Soloman
First-Year College
North Carolina State University
Raleigh, North Carolina 27695

Richard M. Felder
Department of Chemical Engineering
North Carolina State University
Raleigh, NC 27695-7905

Directions

Please provide us with your full name. Your name will be printed on the information that is returned to you.

Full Name

For each of the 44 questions below select either "a" or "b" to indicate your answer. Please choose only one answer for each question. If both "a" and "b" seem to apply to you, choose the one that applies more frequently. When you are finished selecting answers to each question please select the submit button at the end of the form.

1. I understand something better after I
   - **(a)** try it out.
   - **(b)** think it through.
2. I would rather be considered
   - **(a)** realistic.
   - **(b)** innovative.
3. When I think about what I did yesterday, I am most likely to get
   - **(a)** a picture.
   - **(b)** words.
4. I tend to
   - **(a)** understand details of a subject but may be fuzzy about its overall structure.
   - **(b)** understand the overall structure but may be fuzzy about details.
5. When I am learning something new, it helps me to
   - **(a)** talk about it.
   - **(b)** think about it.
6. If I were a teacher, I would rather teach a course
   - **(a)** that deals with facts and real life situations.
   - **(b)** that deals with ideas and theories.
7. I prefer to get new information in
   - **(a)** pictures, diagrams, graphs, or maps.
   - **(b)** written directions or verbal information.
8. Once I understand
   - **(a)** all the parts, I understand the whole thing.
   - **(b)** the whole thing, I see how the parts fit.
9. In a study group working on difficult material, I am more likely to

(a) jump in and contribute ideas.

(b) sit back and listen.

10. I find it easier

(a) to learn facts.

(b) to learn concepts.

11. In a book with lots of pictures and charts, I am likely to

(a) look over the pictures and charts carefully.

(b) focus on the written text.

12. When I solve math problems

(a) I usually work my way to the solutions one step at a time.

(b) I often just see the solutions but then have to struggle to figure out the steps to get to them.

13. In classes I have taken

(a) I have usually gotten to know many of the students.

(b) I have rarely gotten to know many of the students.

14. In reading nonfiction, I prefer

(a) something that teaches me new facts or tells me how to do something.

(b) something that gives me new ideas to think about.

15. I like teachers

(a) who put a lot of diagrams on the board.

(b) who spend a lot of time explaining.

16. When I'm analyzing a story or a novel

(a) I think of the incidents and try to put them together to figure out the themes.

(b) I just know what the themes are when I finish reading and then I have to go back and find the incidents that demonstrate them.

17. When I start a homework problem, I am more likely to

(a) start working on the solution immediately.

(b) try to fully understand the problem first.

18. I prefer the idea of

(a) certainty.

(b) theory.

19. I remember best

(a) what I see.

(b) what I hear.

20. It is more important to me that an instructor

(a) lay out the material in clear sequential steps.

(b) give me an overall picture and relate the material to other subjects.

21. I prefer to study

(a) in a study group.

(b) alone.

22. I am more likely to be considered

(a) careful about the details of my work.

(b) creative about how to do my work.

23. When I get directions to a new place, I prefer

(a) a map

(b) written instructions.

24. I learn

(a) at a fairly regular pace. If I study hard, I'll "get it."

(b) in fits and starts. I'll be totally confused and then suddenly it all "clicks."

25. I would rather first

(a) try things out.

(b) think about how I'm going to do it.

26. When I am reading for enjoyment, I like writers to

(a) clearly say what they mean.

(b) say things in creative, interesting ways.

27. When I see a diagram or sketch in class, I am most likely to remember

(a) the picture.

(b) what the instructor said about it.

28. When considering a body of information, I am more likely to

(a) focus on details and miss the big picture.

(b) try to understand the big picture before getting into the details.

29. I more easily remember

(a) something I have done.

(b) something I have thought a lot about.

30. When I have to perform a task, I prefer to

(a) master one way of doing it.

(b) come up with new ways of doing it.

31. When someone is showing me data, I prefer

(a) charts or graphs.

(b) text summarizing the results.

32. When writing a paper, I am more likely to

(a) work on (think about or write) the beginning of the paper and progress forward.

(b) work on (think about or write) different parts of the paper and then order them.

33. When I have to work on a group project, I first want to

(a) have "group brainstorming" where everyone contributes ideas.

(b) brainstorm individually and then come together as a group to compare ideas.

34. I consider it higher praise to call someone

(a) sensible.

(b) imaginative.

35. When I meet people at a party, I am more likely to remember

(a) what they looked like.

(b) what they said about themselves.

36. When I am learning a new subject, I prefer to

(a) stay focused on that subject, learning as much about it as I can.

(b) try to make connections between that subject and related subjects.

37. I am more likely to be considered

(a) outgoing.

(b) reserved.

38. I prefer courses that emphasize

(a) concrete material (facts, data).

(b) abstract material (concepts, theories).

39. For entertainment, I would rather

(a) watch television.

(b) read a book.

40. Some teachers start their lectures with an outline of what they will cover. Such outlines are

(a) somewhat helpful to me.

(b) very helpful to me.

41. The idea of doing homework in groups, with one grade for the entire group,

(a) appeals to me.

(b) does not appeal to me.

42. When I am doing long calculations,

(a) I tend to repeat all my steps and check my work carefully.

(b) I find checking my work tiresome and have to force myself to do it.

43. I tend to picture places I have been

(a) easily and fairly accurately.

(b) with difficulty and without much detail.

44. When solving problems in a group, I would be more likely to

(a) think of the steps in the solution process.

(b) think of possible consequences or applications of the solution in a wide range of areas.

When you have completed filling out the above form please click on the Submit button below. Your results will be returned to you. If you are not satisified with your answers above please click on Reset to clear the form.

Submit Reset

Dr. Richard Felder, felder@ncsu.edu

Appendix C – Bourque – Morais Survey Results

Results Summary

Show All Pages and Questions

Export... View Detail >>

Filter Results

To analyze a subset of your data, you can create one or more filters.

Add Filter...

Total: 45
Visible: 45

Share Results

Your results can be shared with others, without giving access to your account.

Configure...

Status: Enabled
Reports: Summary and Detail

1. From Start to Finish

1. Name (optional)	
View **Total Respondents**	**16**

(skipped this question)	**29**

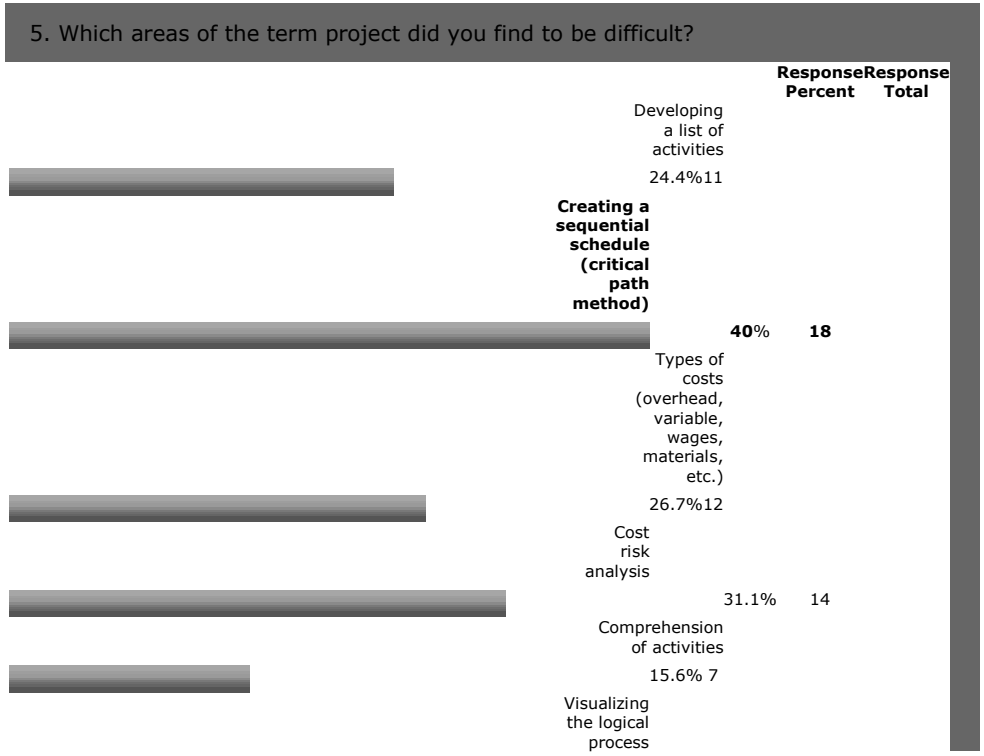
2. What is your major?

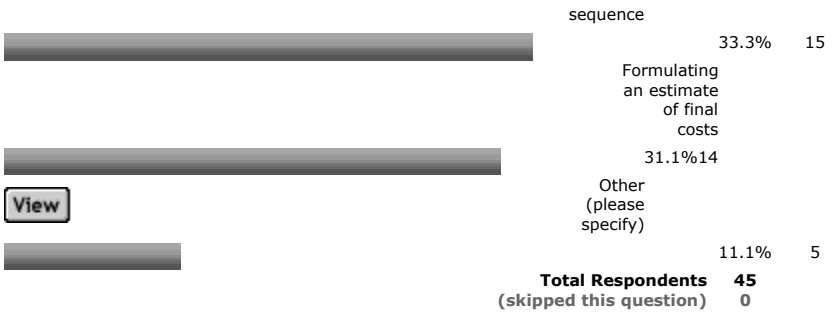
		Response Percent	Response Total
CEE		**91.1%**	**41**
CM		4.4%	2
MGE		0%	0
OIE		0%	0
View Other (please specify)		4.4%	2
	Total Respondents		**45**
	(skipped this question)		**0**

3. What term did you take CE3020

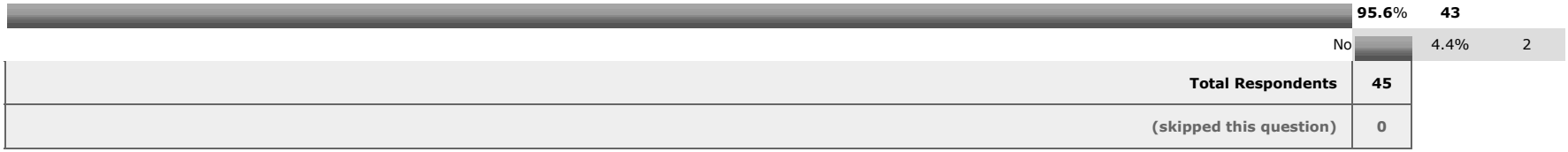
		Response Percent	Response Total
A04		4.4%	2
A05		40%	18
A06		**51.1%**	**23**
View Other (please specify)		4.4%	2
	Total Respondents		**45**
	(skipped this question)		**0**

4. What was your construction experience prior to CE3020?			
		Response Percent	**Response Total**
None		42.2%	19
Some		**48.9%**	**22**
Extensive		8.9%	4
	Total Respondents		**45**
	(skipped this question)		**0**





6. Do you think this site could be helpful for the intended purposes?



	Response Percent	Response Total
Yes	95.6%	43
No	4.4%	2
Total Respondents		45
(skipped this question)		0

7. Please, rate (1=poor, 5=excellent) this site on each of these categories.

	1	2	3	4	5	Response Average
Content (information: text & graphics)	0% (0)	7% (3)	20% (9)	**44% (20)**	29% (13)	**3.96**
Appearance (looks)	2% (1)	11% (5)	16% (7)	**47% (21)**	24% (11)	**3.80**
Functionability (ease of navigation)	2% (1)	2% (1)	24% (11)	**42% (19)**	29% (13)	**3.93**
					Total Respondents	**45**
					(skipped this question)	**0**

8. How could the site be improved?	
View Total Respondents	19
(skipped this question)	26

9. Do you think that this website could be helpful in any other civil engineering courses? IF so which ones?	
View Total Respondents	20
(skipped this question)	25

Appendix D – Mustansir Jivanjee Survey Results

SurveyMonkey.com
because knowledge is everything

survey title:
Visualizing Construction: The Bartlett Center Edit Title
Page: Visualizing Construction - Bartlett Center From Start to Finish.

1. What is your major?

Select Major

	CEE	CM	MGE	OIE	Other (please specify)	Response Count
Select a major from the menu	**100.0% (20)**	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	20

view Other (see below)	1
answered question	**20**
skipped question	**0**

2. Please select your level of current construction knowledge/construction experience.

Construction Knowledge

	None	Some	Extensive	Response Count
Please select your level of knowledge and experience	0.0% (0)	**85.0% (17)**	15.0% (3)	20

Construction Experience

	None	Some	Extensive	Response Count
Please select your level of knowledge and experience	25.0% (5)	**75.0% (15)**	0.0% (0)	20

answered question	**20**
skipped question	**0**

3. To what extent do you consider visual input important in improving your understanding of a subject?

3. To what extent do you consider visual input important in improving your understanding of a subject?

		Response Percent	Response Count
None		0.0%	0
Some		0.0%	0
Moderate		20.0%	4
High		**50.0%**	10
Very High		30.0%	6
	answered question		**20**
	skipped question		**0**

4. What term did you take CE3020

		Response Percent	Response Count
A03		0.0%	0
A04		10.0%	2
A05		25.0%	5
A06		30.0%	6
A07		**35.0%**	7
	answered question		**20**

5. Which areas of the term project did you find to be difficult?

5. Which areas of the term project did you find to be difficult?

	Response Percent	Response Count
Developing a list of activities	26.3%	5
Creating a sequential schedule (critical path method)	**63.2%**	12
Types of costs (overhead, variable, wages, materials, etc.)	10.5%	2
Cost risk analysis	42.1%	8
Comprehension of activities	15.8%	3
Visualizing the logical process sequence	21.1%	4
Formulating an estimate of final costs	15.8%	3
 Other (see below)		3
answered question		**19**
skipped question		**1**

6. Do you think this web-site could be helpful for its intended purpose?

	Response Percent	Response Count
Yes	**75.0%**	15
No	10.0%	2
Maybe	20.0%	4

6. Do you think this web-site could be helpful for its intended purpose?

answered question	**20**
skipped question	**0**

7. Please, rate (1=poor, 5=excellent) this site on each of these categories.

	1	2	3	4	5	Response Count
Content (information: text & graphics)	0.0% (0)	10.0% (2)	25.0% (5)	30.0% (6)	**35.0% (7)**	20
Appearance (looks)	5.0% (1)	15.0% (3)	30.0% (6)	**40.0% (8)**	10.0% (2)	20
Functionability (ease of navigation)	5.0% (1)	15.0% (3)	25.0% (5)	**35.0% (7)**	20.0% (4)	20
				answered question		**20**
				skipped question		**0**

8. Do you think that this website could be helpful in any civil engineering courses other than CE3020? IF so, which ones?

	Response Count
view (see below)	10
answered question	**10**
skipped question	**10**

9. How could this web-site be improved for its intended purpose?

	Response Count

9. How could this web-site be improved for its intended purpose?	
view (see below)	8
answered question	**8**
skipped question	**12**

Other Responses

Question 1	Comment Text	Response Date
1.	Fire Protection	Mon, 12/3/07 10:07 PM

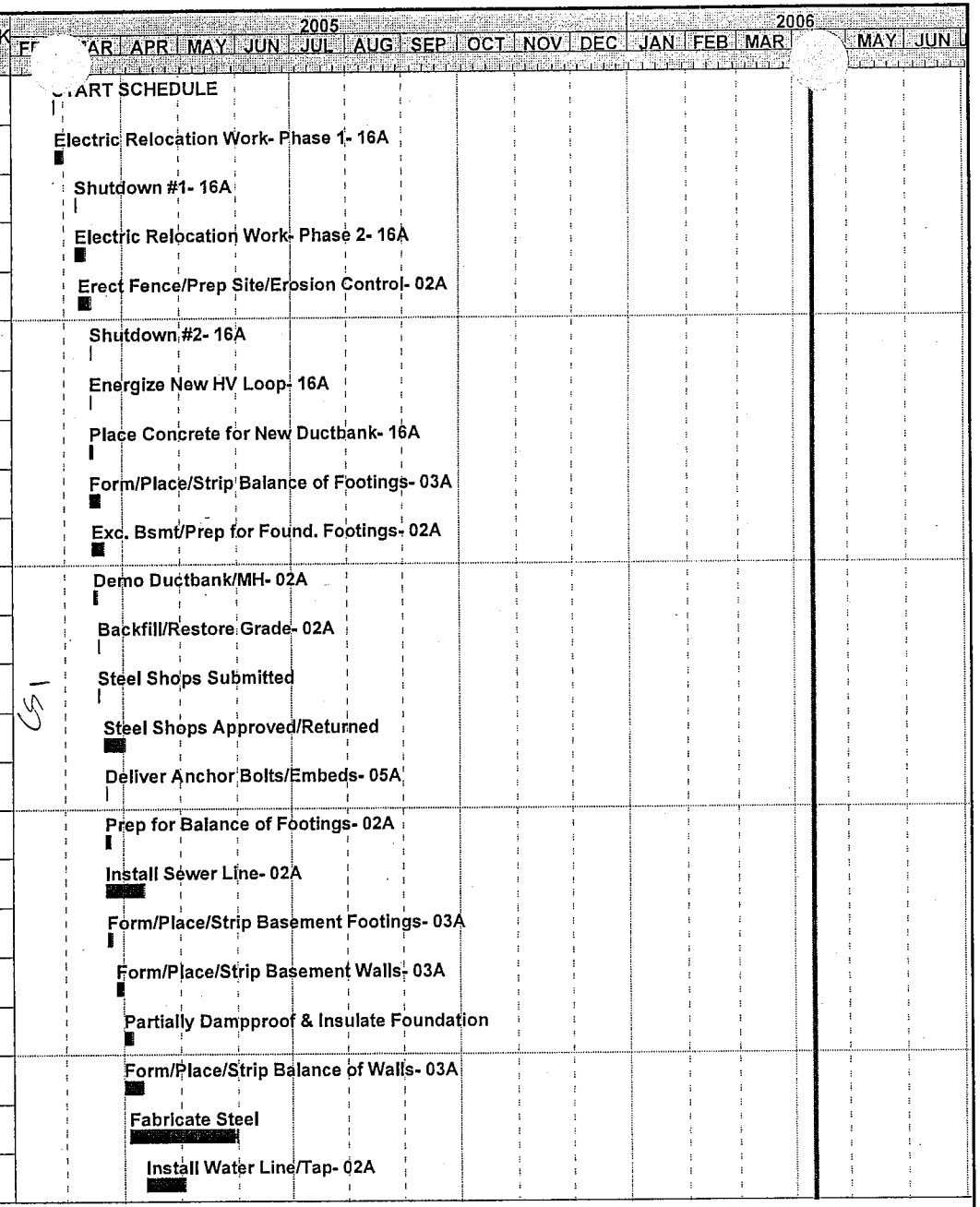
Question 5	Comment Text	Response Date
1.	Using the required computer program	Thu, 12/20/07 4:06 PM
2.	I didn't find the course difficult outside of managing my own time to complete the large amount of work.	Mon, 12/10/07 2:43 PM
3.	Primavera	Sun, 12/9/07 10:07 AM

Question 8	Comment Text	Response Date
1.	Maybe a cost estimating class or another project management class	Thu, 12/20/07 4:06 PM
2.	Yes, I think that websites similar to this or branched off of this website could help with many civil engineering courses at this school. However, I think the site may contain too much help and that if it were improved upon anymore it would take away from the diffculty of the class. I think the class is viewed as a very hard class to get an A in and as a person who got one of those A's I wouldn't want to see other kids take the course and miss out on the time and effort I put into it because in a way the class itself and how it is structured shows you the importance of time management. I say this because I think I learned more from the amount of effort I had to put into the class to get that A than anything. This site seems to just kinda hand everyone the answers and if I were to offer advice to people in this class it would be learn to budget the responsibilities of this class early so everything doesn't pile on at the end. This site would allow kids to slack off more and would take away from the feeling that you are really working on a project of your own and make it seem more like you are jsut replicating what has already been accomplished.	Tue, 12/11/07 11:45 PM
3.	Any of the CE302- courses i.e. 3022, 3021	Tue, 12/11/07 2:54 PM
4.	A website would be helpful - this website was difficult to navigate and seemed lack approachable content.	Tue, 12/11/07 10:18 AM
5.	none that i can think of	Mon, 12/10/07 2:51 PM
6.	I think the website is most useful for the final project, in 3020 (seeing how to organize information). I didn't take any other class this would have been useful for, but 3020 was the only CM class I took.	Mon, 12/10/07 2:43 PM
7.	CE 535	Mon, 12/10/07 2:15 PM
8.	CE3022	Sun, 12/9/07 10:07 AM
9.	Cost Estimating	Tue, 12/4/07 6:33 PM
10.	CE3021, CE3022	Tue, 12/4/07 3:43 PM

Question 9	Comment Text	Response Date
1.	Maybe a cost estimating class or another project management class	Thu, 12/20/07 4:06 PM
2.	Yes, I think that websites similar to this or branched off of this website could help with many civil engineering courses at this school. However, I think the site may contain too much help and that if it were improved upon anymore it would take away from the diffculty of the class. I think the class is viewed as a very hard class to get an A in and as a person who got one of those A's I wouldn't want to see other kids take the course and miss out on the time and effort I put into it because in a way the class itself and how it is structured shows you the importance of time management. I say this because I think I learned more from the amount of effort I had to put into the class to get that A than anything. This site seems to just kinda hand everyone the answers and if I were to offer advice to people in this class it would be learn to budget the responsibilities of this class early so everything doesn't pile on at the end. This site would allow kids to slack off more and would take away from the feeling that you are really working on a project of your own and make it seem more like you are jsut replicating what has already been accomplished.	Tue, 12/11/07 11:45 PM
3.	Any of the CE302- courses i.e. 3022, 3021	Tue, 12/11/07 2:54 PM
4.	A website would be helpful - this website was difficult to navigate and seemed lack approachable content.	Tue, 12/11/07 10:18 AM
5.	none that i can think of	Mon, 12/10/07 2:51 PM
6.	I think the website is most useful for the final project, in 3020 (seeing how to organize information). I didn't take any other class this would have been useful for, but 3020 was the only CM class I took.	Mon, 12/10/07 2:43 PM
7.	CE 535	Mon, 12/10/07 2:15 PM
8.	CE3022	Sun, 12/9/07 10:07 AM
9.	Cost Estimating	Tue, 12/4/07 6:33 PM
10.	CE3021, CE3022	Tue, 12/4/07 3:43 PM

Appendix E – Gilbane Construction Co. Primavera Schedule (Bartlett Center)

Activity ID	Activity Description	Orig Dur	Actual Duration	Early Start	Early Finish	BDPK	BDPK
10	START SCHEDULE	1	1	23FEB05A	23FEB05A		
1000	Electric Relocation Work- Phase 1- 16A	3	3	24FEB05A	28FEB05A	UTIL	16A
1020	Shutdown #1- 16A	1	1	07MAR05A	07MAR05A	UTIL	16A
1030	Electric Relocation Work- Phase 2- 16A	5	5	07MAR05A	11MAR05A	UTIL	16A
1100	Erect Fence/Prep Site/Erosion Control- 02A	4	4	09MAR05A	14MAR05A	SITE	02A
1060	Shutdown #2- 16A	1	1	14MAR05A	14MAR05A	UTIL	16A
1070	Energize New HV Loop- 16A	1	1	14MAR05A	14MAR05A	UTIL	16A
1050	Place Concrete for New Ductbank- 16A	2	2	14MAR05A	15MAR05A	UTIL	16A
1130	Form/Place/Strip Balance of Footings- 03A	3	5	14MAR05A	19MAR05A	SITE	03A
1110	Exc. Bsmt/Prep for Found. Footings- 02A	5	5	15MAR05A	21MAR05A	SITE	02A
1080	Demo Ductbank/MH- 02A	2	2	16MAR05A	17MAR05A	UTIL	02A
1090	Backfill/Restore Grade- 02A	1	1	18MAR05A	18MAR05A	UTIL	02A
1210	Steel Shops Submitted	1	1	18MAR05A	18MAR05A	STRU	05A
1220	Steel Shops Approved/Returned	10	10	21MAR05A	01APR05A	STRU	05A
1115	Deliver Anchor Bolts/Embeds- 05A	1	1	22MAR05A	22MAR05A	SITE	05A
1126	Prep for Balance of Footings- 02A	3	3	22MAR05A	24MAR05A	SITE	02A
1122	Install Sewer Line- 02A	15	15	22MAR05A	11APR05A	SITE	02A
1120	Form/Place/Strip Basement Footings- 03A	3	3	23MAR05A	25MAR05A	SITE	03A
1150	Form/Place/Strip Basement Walls- 03A	4	4	28MAR05A	31MAR05A	SITE	03A
1153	Partially Dampproof & Insulate Foundation	4	2	01APR05A	04APR05A	SITE	03A
1160	Form/Place/Strip Balance of Walls- 03A	8	6	01APR05A	10APR05A	SITE	03A
1225	Fabricate Steel	41	41	04APR05A	31MAY05A	STRU	05A
1124	Install Water Line/Tap- 02A	15	15	12APR05A	02MAY05A	SITE	02A



Start Date	23FEB05
Finish Date	31MAY06
Data Date	12APR06
Run Date	12APR06 14:17

Early Bar
Progress Bar
Critical Activity

BT08 Sheet 1 of 15

GILBANE (BT08)

BARTLETT ADMISSIONS BUILDING

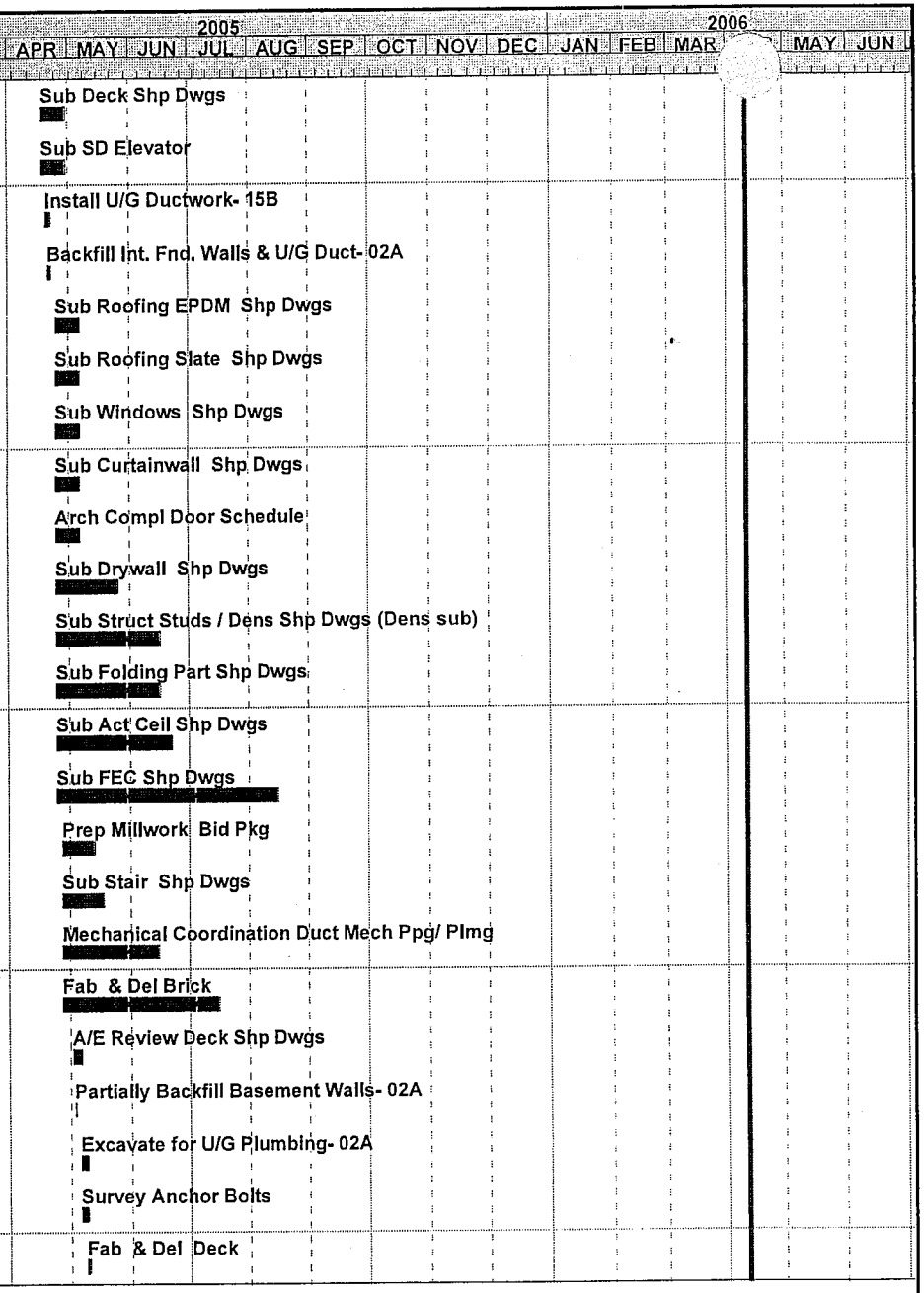
PROJECT COMPLETION REPORT BY ES / EF

Gilbane

upd 8 FINAL SCHEDULE

Date	Revision	Checked	Approved

Activity ID	Activity Description	Orig Dur	Actual Duration	Early Start	Early Finish	BDPK	BDPK
5012	Sub [illegible] Shp Dwgs	10	10	18APR05A	29APR05A	STRU	05A
5402	Sub SD Elevator	10	10	18APR05A	29APR05A	STRU	14A
1170	Install U/G Ductwork- 15B	5	3	20APR05A	22APR05A	SITE	15C
1175	Backfill Int. Fnd. Walls & U/G Duct- 02A	2	2	21APR05A	22APR05A	SITE	02A
5042	Sub Roofing EPDM Shp Dwgs	10	10	25APR05A	06MAY05A	STRU	07A
5052	Sub Roofing Slate Shp Dwgs	10	10	25APR05A	06MAY05A	STRU	07A
5062	Sub Windows Shp Dwgs	10	10	25APR05A	06MAY05A	STRU	08A
5072	Sub Curtainwall Shp Dwgs	10	10	25APR05A	06MAY05A	STRU	08A
5370	Arch Compl Door Schedule	10	10	25APR05A	06MAY05A	STRU	08B
5082	Sub Drywall Shp Dwgs	25	23	25APR05A	25MAY05A	STRU	09A
5092	Sub Struct Studs / Dens Shp Dwgs (Dens sub)	11	38	25APR05A	16JUN05A	STRU	09A
5112	Sub Folding Part Shp Dwgs	11	38	25APR05A	16JUN05A	STRU	09A
5102	Sub Act Ceil Shp Dwgs	41	41	25APR05A	21JUN05A	STRU	09A
5122	Sub FEC Shp Dwgs	41	79	25APR05A	15AUG05A	STRU	09A
5212	Prep Millwork Bid Pkg	6	12	28APR05A	13MAY05A	STRU	06A
5022	Sub Stair Shp Dwgs	15	15	28APR05A	18MAY05A	STRU	05A
5412	Mechanical Coordination Duct Mech Ppg/ Plmg	10	34	28APR05A	15JUN05A	STRU	15C
5000	Fab & Del Brick	55	55	28APR05A	15JUL05A	EAST	04A
5014	A/E Review Deck Shp Dwgs	5	5	02MAY05A	06MAY05A	STRU	05A
1155	Partially Backfill Basement Walls- 02A	1	1	03MAY05A	03MAY05A	SITE	02A
1177	Excavate for U/G Plumbing- 02A	2	2	06MAY05A	09MAY05A	SITE	02A
1230	Survey Anchor Bolts	2	2	06MAY05A	09MAY05A	STRU	05A
5016	Fab & Del Deck	2	2	09MAY05A	10MAY05A	STRU	05A



Start Date	23FEB05
Finish Date	31MAY06
Data Date	12APR06
Run Date	12APR06 14:17

Early Bar
Progress Bar
Critical Activity

BT08 Sheet 2 of 15

GILBANE (BT08)

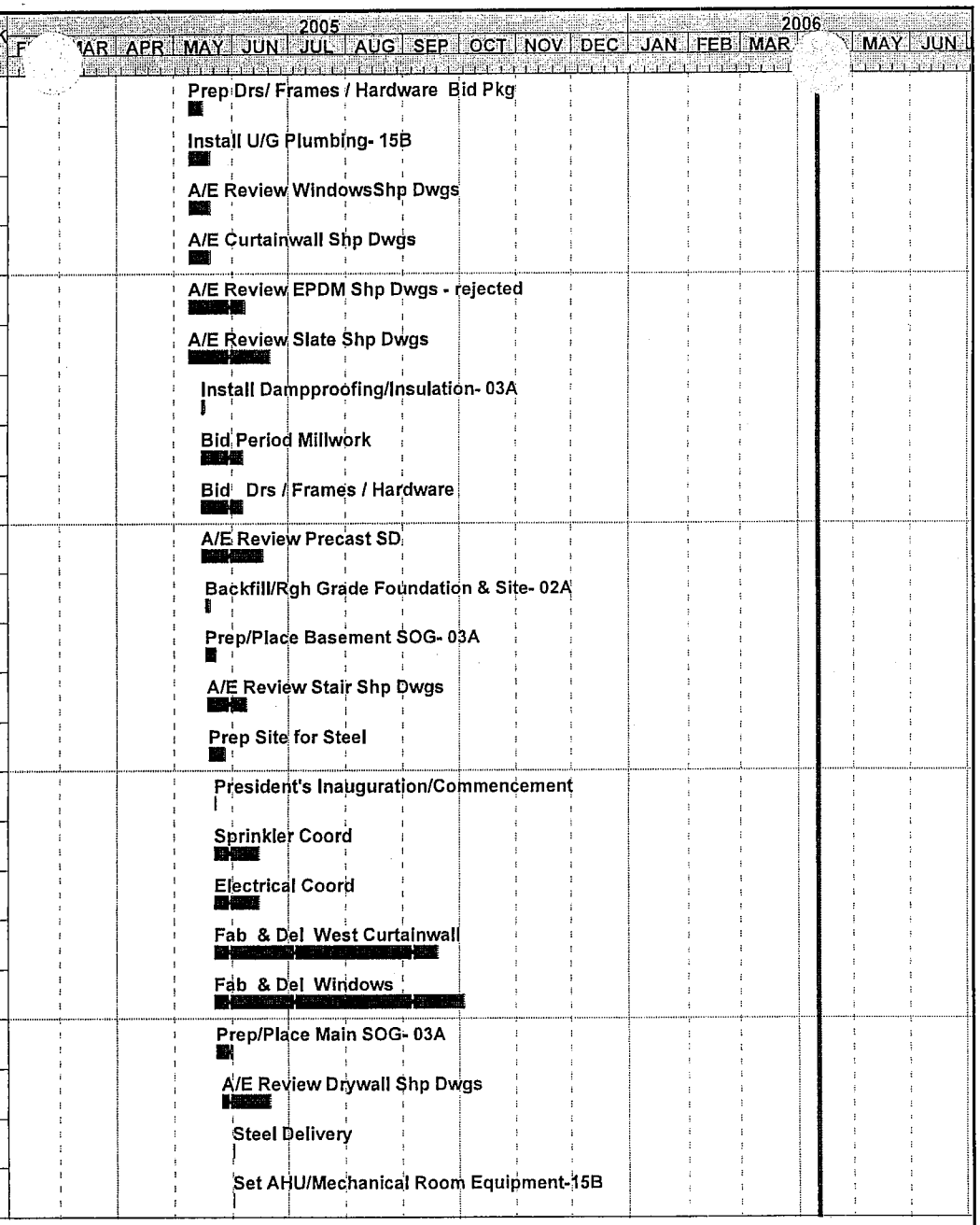
BARTLETT ADMISSIONS BUILDING

PROJECT COMPLETION REPORT BY ES / EF

upd 8 FINAL SCHEDULE

Date	Revision	Checked	Approved

Activity ID	Activity Description	Orig Dur	Actual Duration	Early Start	Early Finish	BDPK	BDPK
5372	Prep Drs/ Frames / Hardware Bid Pkg	10	6	09MAY05A	16MAY05A	STRU	08B
1180	Install U/G Plumbing- 15B	10	10	09MAY05A	20MAY05A	SITE	02A
5064	A/E Review WindowsShp Dwgs	10	10	09MAY05A	20MAY05A	STRU	08A
5074	A/E Curtainwall Shp Dwgs	10	10	09MAY05A	20MAY05A	STRU	08A
5044	A/E Review EPDM Shp Dwgs - rejected	15	21	09MAY05A	07JUN05A	STRU	07A
5054	A/E Review Slate Shp Dwgs	10	30	09MAY05A	20JUN05A	STRU	07A
1196	Install Dampproofing/Insulation- 03A	2	2	16MAY05A	17MAY05A	SITE	03A
5214	Bid Period Millwork	15	15	16MAY05A	06JUN05A	STRU	06A
5374	Bid Drs / Frames / Hardware	15	15	16MAY05A	06JUN05A	STRU	08B
5001	A/E Review Precast SD	10	24	16MAY05A	17JUN05A	EAST	04A
1198	Backfill/Rgh Grade Foundation & Site- 02A	3	3	18MAY05A	20MAY05A	SITE	02A
1183	Prep/Place Basement SOG- 03A	4	4	18MAY05A	23MAY05A	SITE	03A
5024	A/E Review Stair Shp Dwgs	10	14	19MAY05A	08JUN05A	STRU	05A
1204	Prep Site for Steel	6	6	20MAY05A	27MAY05A	SITE	02A
1202	President's Inauguration/Commencement	1	1	23MAY05A	23MAY05A	SITE	99A
5414	Sprinkler Coord	14	17	23MAY05A	15JUN05A	STRU	15C
5416	Electrical Coord	14	17	23MAY05A	15JUN05A	STRU	15C
5076	Fab & Del West Curtainwall	83	83	23MAY05A	19SEP05A	STRU	08A
5066	Fab & Del Windows	93	93	23MAY05A	03OCT05A	STRU	08A
1185	Prep/Place Main SOG- 03A	5	5	24MAY05A	31MAY05A	SITE	03A
5084	A/E Review Drywall Shp Dwgs	10	17	26MAY05A	20JUN05A	STRU	09A
1240	Steel Delivery	1	1	01JUN05A	01JUN05A	STRU	05A
1351	Set AHU/Mechanical Room Equipment-15B	5	1	01JUN05A	01JUN05A	MECH	15C



Start Date	23FEB05
Finish Date	31MAY06
Data Date	12APR06
Run Date	12APR06 14:17

Early Bar
Progress Bar
Critical Activity

BT08 Sheet 3 of 15

GILBANE (BT08)

BARTLETT ADMISSIONS BUILDING

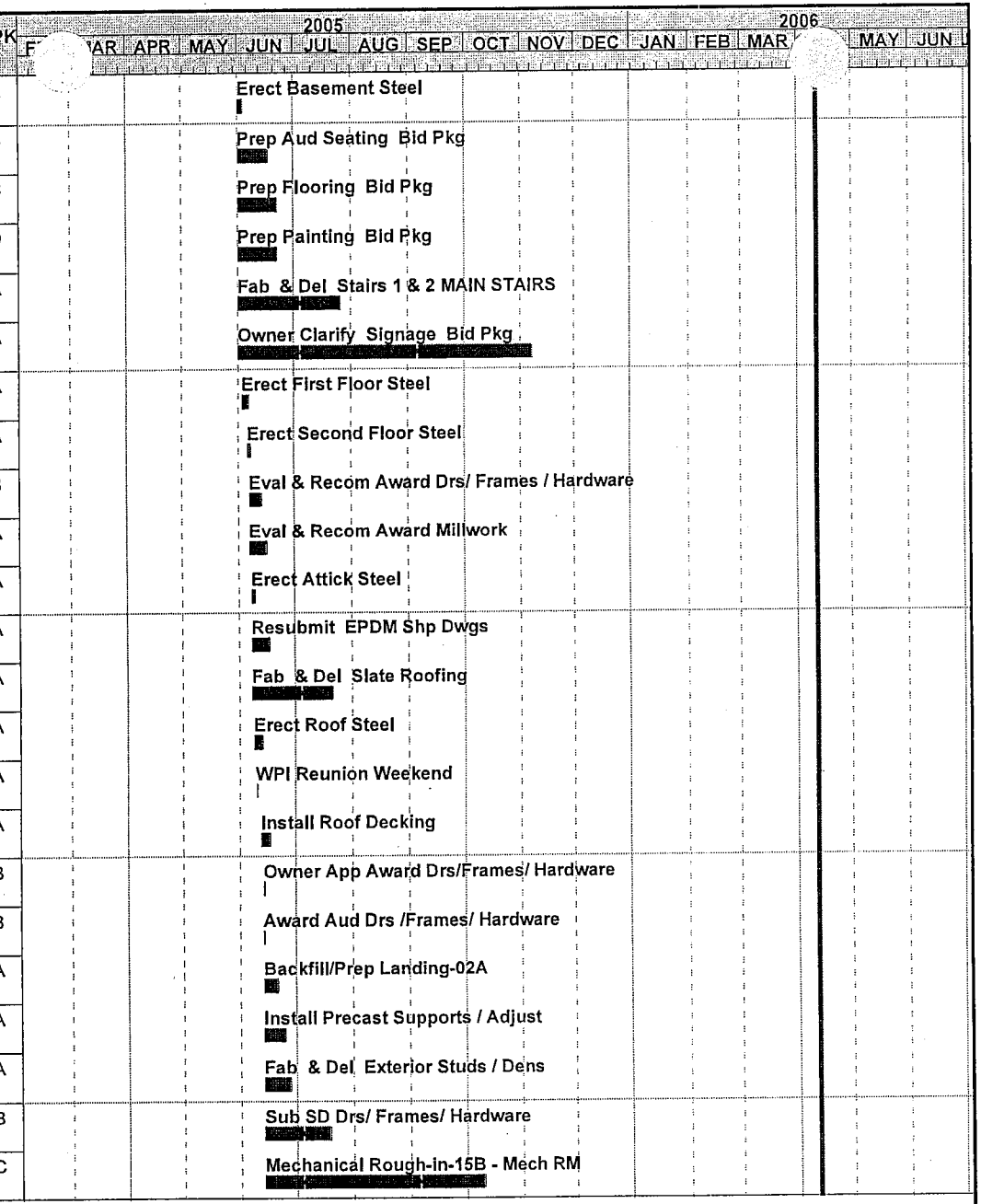
PROJECT COMPLETION REPORT BY ES / EF

Gilbane

upd 8 FINAL SCHEDULE

Date	Revision	Checked	Approved

Activity ID	Activity Description	Orig Dur	Actual Duration	Early Start	Early Finish	BDPK	BDPK
1260	Erect Basement Steel	3	3	01JUN05A	03JUN05A	STRU	05A
5342	Prep Aud Seating Bid Pkg	12	13	01JUN05A	17JUN05A	STRU	12C
5132	Prep Flooring Bid Pkg	15	15	01JUN05A	21JUN05A	STRU	09C
5182	Prep Painting Bid Pkg	15*	15	01JUN05A	21JUN05A	STRU	09D
5026	Fab & Del Stairs 1 & 2 MAIN STAIRS	38	38	01JUN05A	25JUL05A	STRU	05A
5311	Owner Clarify Signage Bid Pkg	53	112	01JUN05A	07NOV05A	STRU	10A
1270	Erect First Floor Steel	5	2	03JUN05A	06JUN05A	STRU	05A
1275	Erect Second Floor Steel	5	2	06JUN05A	07JUN05A	STRU	05A
5376	Eval & Recom Award Drs/ Frames / Hardware	5	5	07JUN05A	13JUN05A	STRU	08B
5216	Eval & Recom Award Millwork	8	8	07JUN05A	16JUN05A	STRU	06A
1277	Erect Attick Steel	3	2	08JUN05A	09JUN05A	STRU	05A
5045	Resubmit EPDM Shp Dwgs	5	8	08JUN05A	17JUN05A	STRU	07A
5056	Fab & Del Slate Roofing	30	30	08JUN05A	20JUL05A	STRU	07A
1280	Erect Roof Steel	10	3	09JUN05A	13JUN05A	STRU	05A
1255	WPI Reunion Weekend	1	1	10JUN05A	10JUN05A	STRU	99A
1290	Install Roof Decking	5	5	13JUN05A	17JUN05A	STRU	05A
5378	Owner App Award Drs/Frames/ Hardware	2	1	14JUN05A	14JUN05A	STRU	08B
5384	Award Aud Drs /Frames/ Hardware	1	1	14JUN05A	14JUN05A	STRU	08B
1340	Backfill/Prep Landing-02A	5	5	14JUN05A	20JUN05A	BASE	02A
1318	Install Precast Supports / Adjust	9	9	14JUN05A	24JUN05A	STRU	05A
5096	Fab & Del Exterior Studs / Dens	10*	10	14JUN05A	27JUN05A	STRU	09A
5386	Sub SD Drs/ Frames/ Hardware	24	24	14JUN05A	18JUL05A	STRU	08B
1380	Mechanical Rough-in-15B - Mech RM	77	83	14JUN05A	10OCT05A	MECH	15C



Start Date	23FEB05
Finish Date	31MAY06
Data Date	12APR06
Run Date	12APR06 14:17

Early Bar
Progress Bar
Critical Activity

BT08

Sheet 4 of 15

GILBANE (BT08)

BARTLETT ADMISSIONS BUILDING

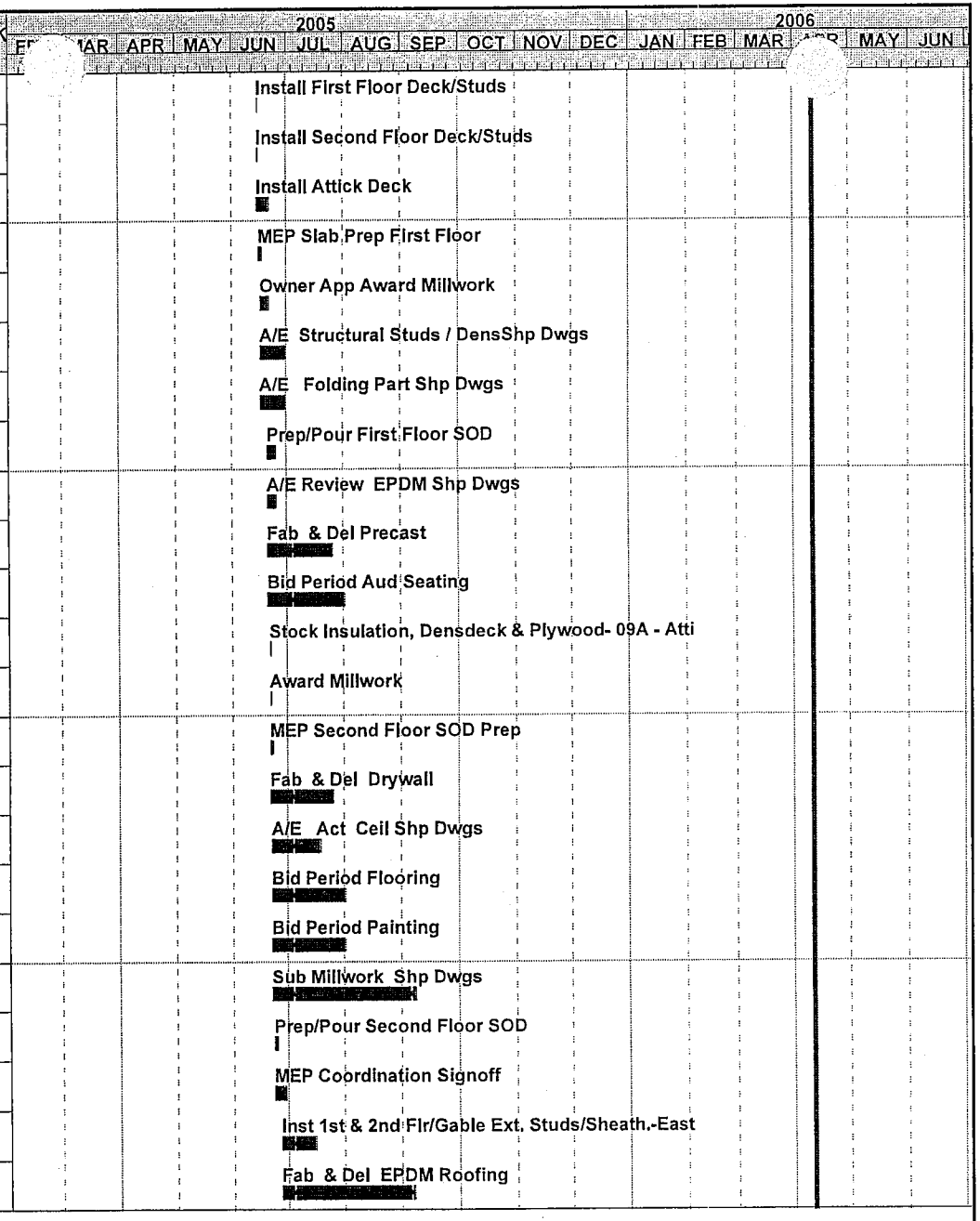
PROJECT COMPLETION REPORT BY ES / EF

Gilbane

upd 8 FINAL SCHEDULE

Date	Revision	Checked	Approved

Activity ID	Activity Description	Orig Dur	Actual Duration	Early Start	Early Finish	BDPK	BDPK
1295	Instal...st Floor Deck/Studs	1	1	15JUN05A	15JUN05A	STRU	05A
1297	Install Second Floor Deck/Studs	1	1	15JUN05A	15JUN05A	STRU	05A
1300	Install Attick Deck	4	4	15JUN05A	20JUN05A	STRU	05A
1298	MEP Slab Prep First Floor	2	2	16JUN05A	17JUN05A	STRU	15C
5222	Owner App Award Millwork	2	2	17JUN05A	20JUN05A	STRU	06A
5094	A/E Structural Studs / DensShp Dwgs	10	10	17JUN05A	30JUN05A	STRU	09A
5114	A/E Folding Part Shp Dwgs	10	10	17JUN05A	30JUN05A	STRU	09A
1299	Prep/Pour First Floor SOD	5	5	20JUN05A	24JUN05A	STRU	03A
5047	A/E Review EPDM Shp Dwgs	5	5	20JUN05A	24JUN05A	STRU	07A
5002	Fab & Del Precast	25	25	20JUN05A	25JUL05A	EAST	04A
5344	Bid Period Aud Seating	17	30	20JUN05A	01AUG05A	STRU	12C
2190	Stock Insulation, Densdeck & Plywood- 09A - Atti	1	1	21JUN05A	21JUN05A	ATTI	09A
5224	Award Millwork	1	1	21JUN05A	21JUN05A	STRU	06A
1302	MEP Second Floor SOD Prep	2	2	21JUN05A	22JUN05A	STRU	15C
5086	Fab & Del Drywall	14	24	21JUN05A	25JUL05A	STRU	09A
5104	A/E Act Ceil Shp Dwgs	10	18	22JUN05A	18JUL05A	STRU	09A
5134	Bid Period Flooring	18	28	22JUN05A	01AUG05A	STRU	09C
5184	Bid Period Painting	22	28	22JUN05A	01AUG05A	STRU	09D
5032	Sub Millwork Shp Dwgs	15	54	22JUN05A	07SEP05A	STRU	06A
1304	Prep/Pour Second Floor SOD	2	2	23JUN05A	24JUN05A	STRU	03A
5420	MEP Coordination Signoff	5	5	23JUN05A	29JUN05A	STRU	15C
2490	Inst 1st & 2nd Flr/Gable Ext. Studs/Sheath.-East	14	14	27JUN05A	15JUL05A	EAST	09A
5046	Fab & Del EPDM Roofing	40	50	27JUN05A	06SEP05A	STRU	07A



Start Date	23FEB05
Finish Date	31MAY06
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Early Bar
Progress Bar
Critical Activity

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GILBANE (BT08)

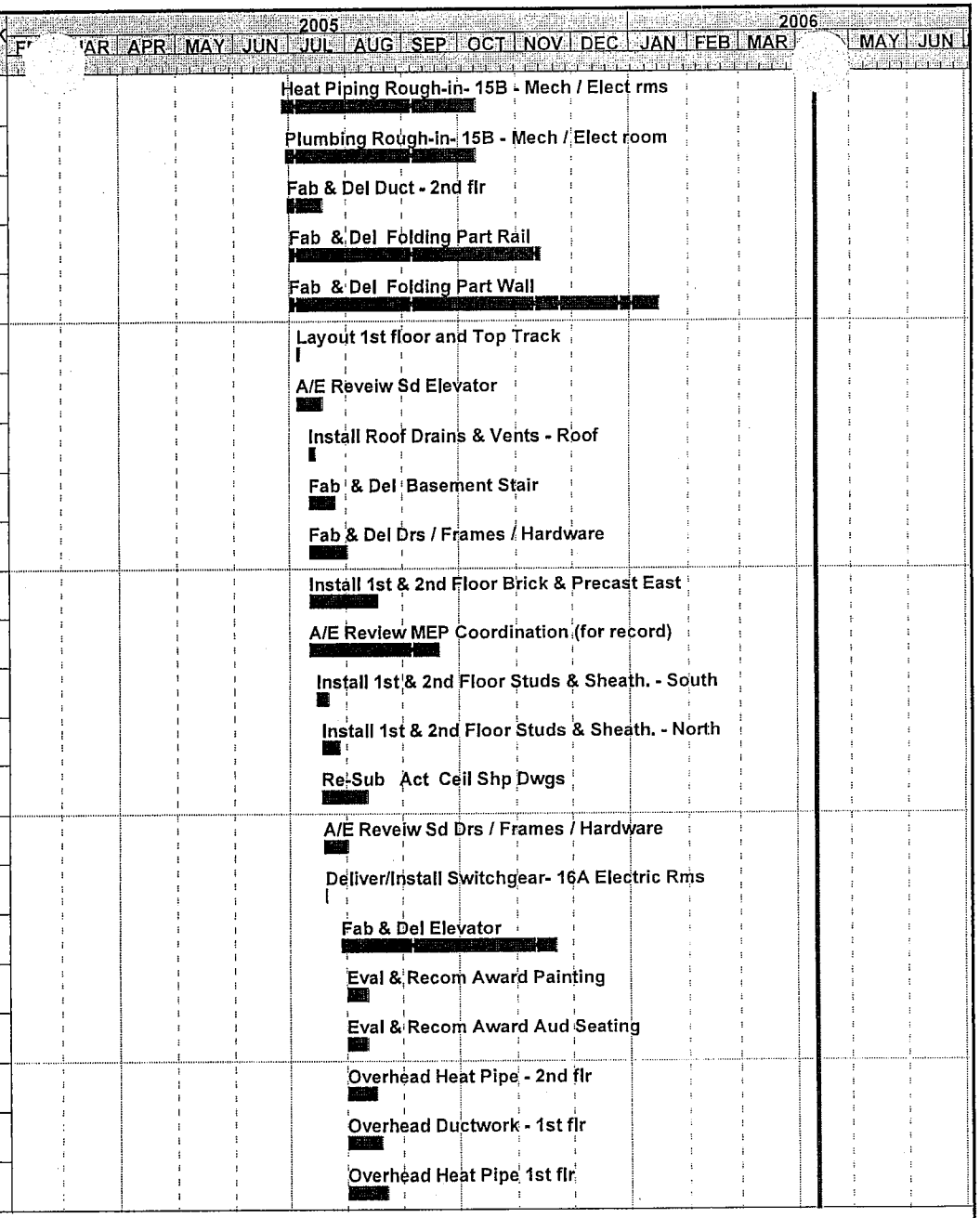
BARTLETT ADMISSIONS BUILDING

PROJECT COMPLETION REPORT BY ES / EF

upd 8 FINAL SCHEDULE

Date	Revision	Checked	Approved

Activity ID	Activity Description	Orig Dur	Actual Duration	Early Start	Early Finish	BDPK	BDPK
1390	Heat . . ng Rough-in- 15B - Mech / Elect rms	68	74	27JUN05A	10OCT05A	MECH	15C
1400	Plumbing Rough-in- 15B - Mech / Elect room	66	72	29JUN05A	10OCT05A	MECH	15C
5422	Fab & Del Duct - 2nd flr	27	12	30JUN05A	18JUL05A	STRU	15C
5116	Fab & Del Folding Part Rail	150	94	01JUL05A	14NOV05A	STRU	09A
5117	Fab & Del Folding Part Wall	155	136	01JUL05A	16JAN06A	STRU	09A
1577	Layout 1st floor and Top Track	2	2	05JUL05A	06JUL05A	FIRS	09A
5404	A/E Reveiw Sd Elevator	10	10	05JUL05A	18JUL05A	STRU	14A
3090	Install Roof Drains & Vents - Roof	3	3	12JUL05A	14JUL05A	ROOF	15C
5027	Fab & Del Basement Stair	25	10	12JUL05A	25JUL05A	STRU	05A
5392	Fab & Del Drs / Frames / Hardware	15	15	12JUL05A	01AUG05A	STRU	08B
2520	Install 1st & 2nd Floor Brick & Precast East	27	27	12JUL05A	17AUG05A	EAST	04A
5418	A/E Review MEP Coordination (for record)	5	50	12JUL05A	20SEP05A	STRU	15C
2900	Install 1st & 2nd Floor Studs & Sheath. - South	8	5	15JUL05A	21JUL05A	SOUT	09A
2600	Install 1st & 2nd Floor Studs & Sheath. - North	8	8	18JUL05A	27JUL05A	NORT	09A
5105	Re-Sub Act Ceil Shp Dwgs	10	19	18JUL05A	11AUG05A	STRU	09A
5388	A/E Reveiw Sd Drs / Frames / Hardware	10	10	19JUL05A	01AUG05A	STRU	08B
1445	Deliver/Install Switchgear- 16A Electric Rms	1	1	20JUL05A	20JUL05A	MECH	16A
5406	Fab & Del Elevator	131	80	29JUL05A	21NOV05A	STRU	14A
5186	Eval & Recom Award Painting	5	9	01AUG05A	11AUG05A	STRU	09D
5346	Eval & Recom Award Aud Seating	5	9	01AUG05A	11AUG05A	STRU	12C
1835	Overhead Heat Pipe - 2nd flr	10	12	01AUG05A	16AUG05A	SECO	15C
1580	Overhead Ductwork - 1st flr	15	15	01AUG05A	19AUG05A	FIRS	15C
1590	Overhead Heat Pipe 1st flr	16	16	01AUG05A	22AUG05A	FIRS	15C



Start Date	23FEB05
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Early Bar
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GILBANE (BT08)

BARTLETT ADMISSIONS BUILDING

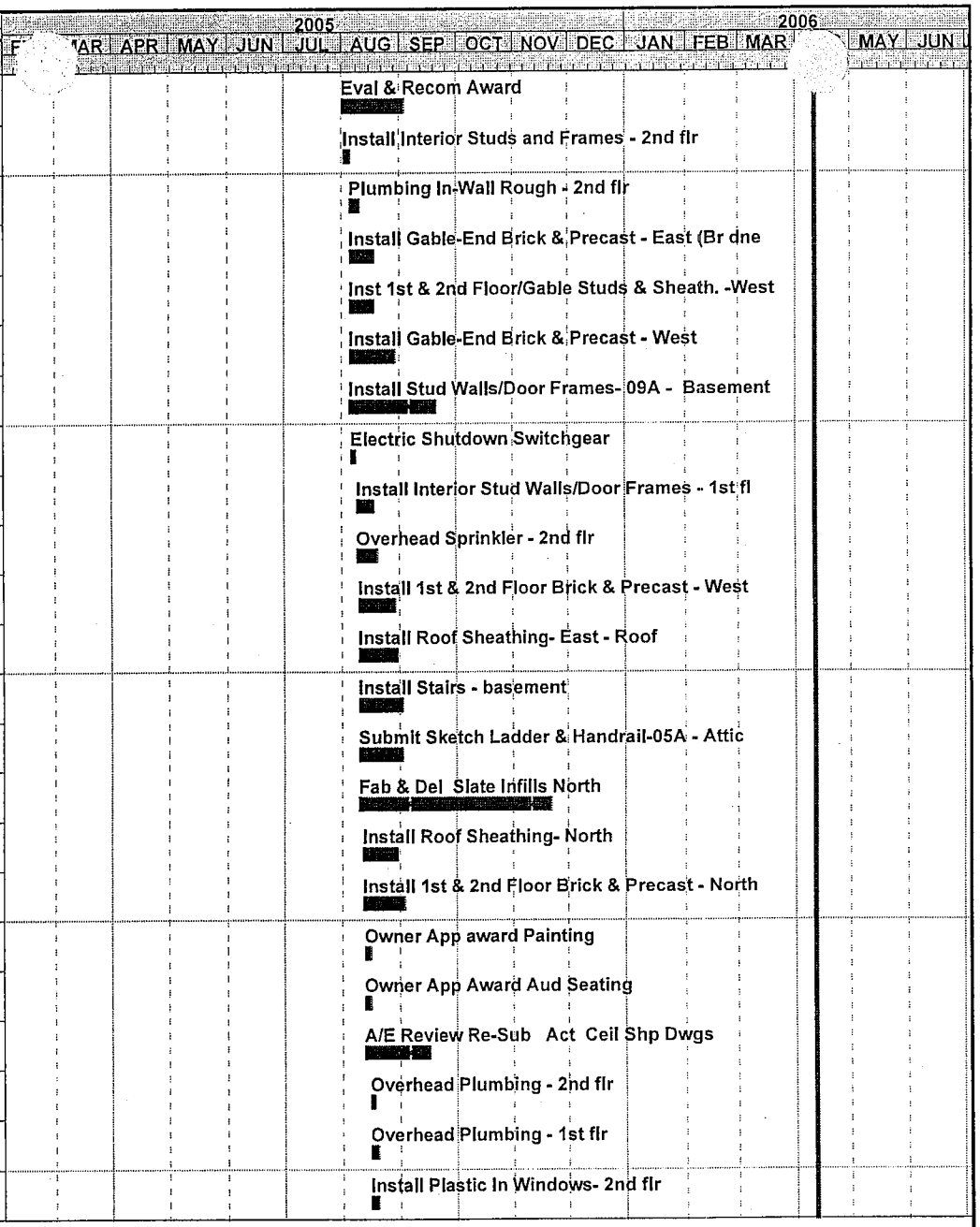
PROJECT COMPLETION REPORT BY ES / EF

Gilbane

upd 8 FINAL SCHEDULE

Date	Revision	Checked	Approved

Activity ID	Activity Description	Orig Dur	Actual Duration	Early Start	Early Finish	BDPK	BDPK
5136	Eval ...com Award	5	25	01AUG05A	02SEP05A	STRU	09C
1860	Install Interior Studs and Frames - 2nd flr	10	4	02AUG05A	05AUG05A	SECO	09A
1885	Plumbing In-Wall Rough - 2nd flr	4	3	05AUG05A	09AUG05A	SECO	15C
2546	Install Gable-End Brick & Precast - East (Br dne	9	9	05AUG05A	17AUG05A	EAST	04A
2700	Inst 1st & 2nd Floor/Gable Studs & Sheath. -West	9	9	05AUG05A	17AUG05A	WEST	09A
2770	Install Gable-End Brick & Precast - West	17	17	05AUG05A	29AUG05A	WEST	04A
1375	Install Stud Walls/Door Frames- 09A - Basement	3	32	05AUG05A	20SEP05A	BASE	09A
2715	Electric Shutdown Switchgear	2	0	06AUG05A	07AUG05A	WEST	16A
1630	Install Interior Stud Walls/Door Frames - 1st fl	8	8	08AUG05A	17AUG05A	FIRS	09A
1855	Overhead Sprinkler - 2nd flr	10	10	08AUG05A	19AUG05A	SECO	15B
2720	Install 1st & 2nd Floor Brick & Precast - West	15	15	09AUG05A	29AUG05A	WEST	04A
3100	Install Roof Sheathing- East - Roof	3	16	09AUG05A	30AUG05A	ROOF	07A
1503	Install Stairs - basement	18*	18	09AUG05A	01SEP05A	BASE	05A
6000	Submit Sketch Ladder & Handrail-05A - Attic	3	18	09AUG05A	01SEP05A	ATTI	05A
6010	Fab & Del Slate Infills North	124	73	09AUG05A	21NOV05A	NORT	07A
3110	Install Roof Sheathing- North	3	14	11AUG05A	30AUG05A	ROOF	07A
2610	Install 1st & 2nd Floor Brick & Precast - North	17	17	11AUG05A	02SEP05A	NORT	04A
5192	Owner App award Painting	2	2	12AUG05A	15AUG05A	STRU	09D
5348	Owner App Award Aud Seating	2	2	12AUG05A	15AUG05A	STRU	12C
5107	A/E Review Re-Sub Act Ceil Shp Dwgs	10	25	12AUG05A	16SEP05A	STRU	09A
1840	Overhead Plumbing - 2nd flr	3	3	15AUG05A	17AUG05A	SECO	15C
1600	Overhead Plumbing - 1st flr	5	5	15AUG05A	19AUG05A	FIRS	15C
1924	Install Plastic In Windows- 2nd flr	5	5	15AUG05A	19AUG05A	SECO	09A



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Early Bar
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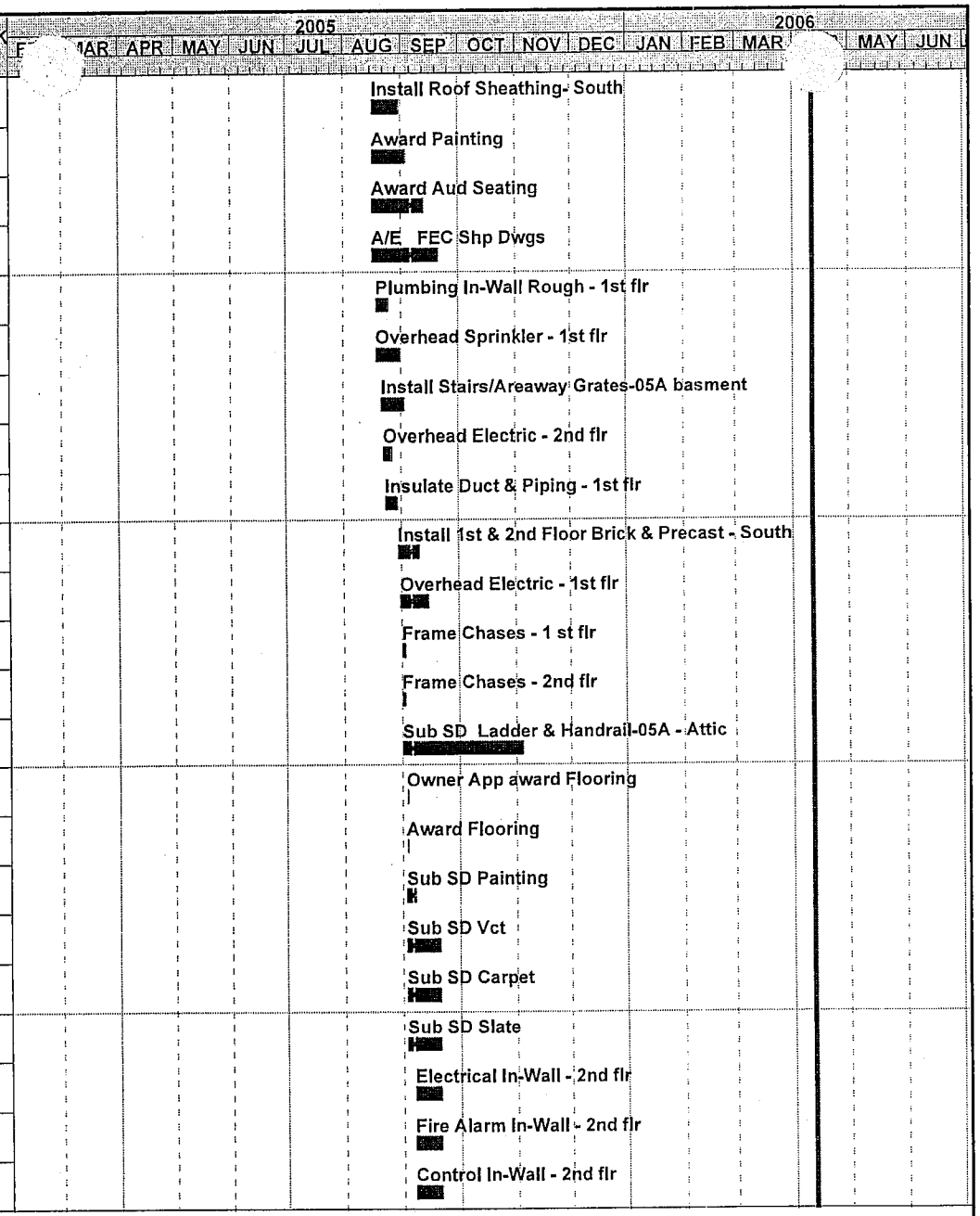
Activity ID	Activity Description	Orig Dur	Actual Duration	Early Start	Early Finish	BDPK	BDPK
3130	Insta[illegible]f Sheathing- South	3	11	16AUG05A	30AUG05A	ROOF	07A
5194	Award Painting	1	14	16AUG05A	02SEP05A	STRU	09D
5354	Award Aud Seating	1	19	16AUG05A	12SEP05A	STRU	12C
5124	A/E FEC Shp Dwgs	10	25	16AUG05A	20SEP05A	STRU	09A
1636	Plumbing In-Wall Rough - 1st flr	5	5	18AUG05A	24AUG05A	FIRS	15C
1620	Overhead Sprinkler - 1st flr	10	10	18AUG05A	31AUG05A	FIRS	15B
1360	Install Stairs/Areaway Grates-05A basment	12*	12	21AUG05A	01SEP05A	BASE	05A
1850	Overhead Electric - 2nd flr	5	5	22AUG05A	26AUG05A	SECO	16A
1663	Insulate Duct & Piping - 1st flr	5	5	23AUG05A	29AUG05A	FIRS	15C
2910	Install 1st & 2nd Floor Brick & Precast - South	8	8	30AUG05A	09SEP05A	SOUT	04A
1610	Overhead Electric - 1st flr	10	10	31AUG05A	14SEP05A	FIRS	16A
1661	Frame Chases - 1 st flr	2	1	01SEP05A	01SEP05A	FIRS	09A
1921	Frame Chases - 2nd flr	2	1	01SEP05A	01SEP05A	SECO	09A
2005	Sub SD Ladder & Handrail-05A - Attic	107	46	01SEP05A	04NOV05A		05A
5142	Owner App award Flooring	2	1	02SEP05A	02SEP05A	STRU	09C
5144	Award Flooring	1	1	02SEP05A	02SEP05A	STRU	09C
5196	Sub SD Painting	10	2	02SEP05A	06SEP05A	STRU	09D
5146	Sub SD Vct	10	12	02SEP05A	20SEP05A	STRU	09C
5156	Sub SD Carpet	10	12	02SEP05A	20SEP05A	STRU	09C
5166	Sub SD Slate	10	12	02SEP05A	20SEP05A	STRU	09C
1890	Electrical In-Wall - 2nd flr	10	11	06SEP05A	20SEP05A	SECO	16A
1895	Fire Alarm In-Wall - 2nd flr	5	11	06SEP05A	20SEP05A	SECO	16A
1900	Control In-Wall - 2nd flr	5	11	06SEP05A	20SEP05A	SECO	16A



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GILBANE (BT08)

BARTLETT ADMISSIONS BUILDING

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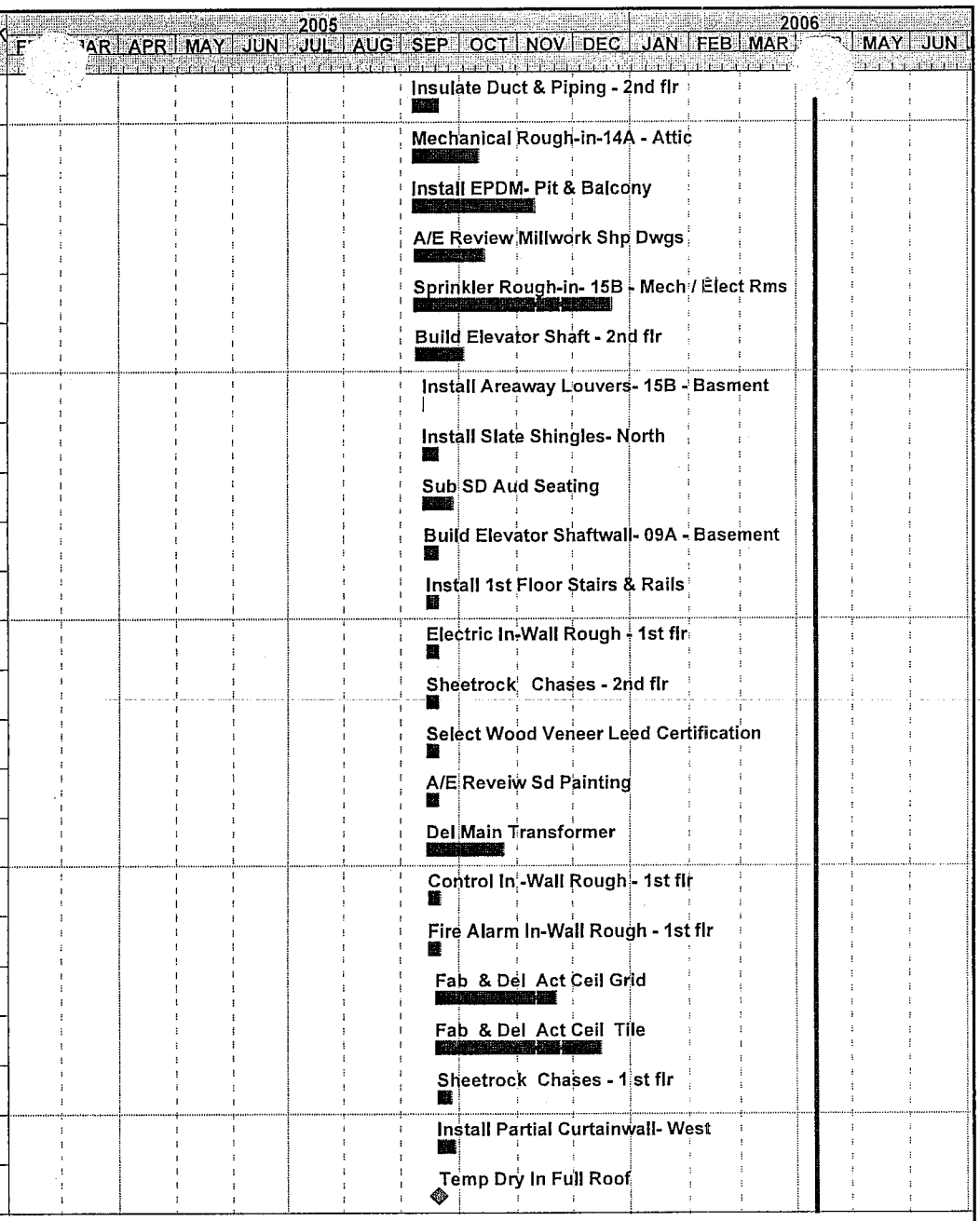
1920	Insulate Duct & Piping - 2nd flr	5	11	06SEP05A	20SEP05A	SECO	15C
2270	Mechanical Rough-in-14A - Attic	19	26	06SEP05A	11OCT05A	ATTI	15C
3180	Install EPDM- Pit & Balcony	5	48	06SEP05A	10NOV05A	ROOF	07A
5034	A/E Review Millwork Shp Dwgs	10	28	07SEP05A	14OCT05A	STRU	06A
1410	Sprinkler Rough-in- 15B - Mech / Elect Rms	104	74	07SEP05A	21DEC05A	MECH	15C
1905	Build Elevator Shaft - 2nd flr	5	18	08SEP05A	03OCT05A	SECO	09A
1465	Install Areaway Louvers- 15B - Basment	2	1	12SEP05A	12SEP05A	BASE	15C
3140	Install Slate Shingles- North	5	7	12SEP05A	20SEP05A	ROOF	07A
5356	Sub SD Aud Seating	10	12	12SEP05A	27SEP05A	STRU	12C
1450	Build Elevator Shaftwall- 09A - Basement	3	6	13SEP05A	20SEP05A	BASE	09A
1285	Install 1st Floor Stairs & Rails	5	5	14SEP05A	20SEP05A	STRU	05A
1640	Electric In-Wall Rough - 1st flr	5	5	14SEP05A	20SEP05A	FIRS	16A
1922	Sheetrock Chases - 2nd flr	5	5	14SEP05A	20SEP05A	SECO	09A
5033	Select Wood Veneer Leed Certification	5	5	14SEP05A	20SEP05A	STRU	06A
5198	A/E Reveiw Sd Painting	10	5	14SEP05A	20SEP05A	STRU	09D
2291	Del Main Transformer	23	29	14SEP05A	24OCT05A	ATTI	16A
1645	Control In -Wall Rough - 1st flr	5	5	15SEP05A	21SEP05A	FIRS	16A
1647	Fire Alarm In-Wall Rough - 1st flr	5	5	15SEP05A	21SEP05A	FIRS	16A
5106	Fab & Del Act Ceil Grid	96	45	19SEP05A	21NOV05A	STRU	09A
5110	Fab & Del Act Ceil Tile	96	62	19SEP05A	15DEC05A	STRU	09A
1664	Sheetrock Chases - 1 st flr	5	5	20SEP05A	26SEP05A	FIRS	09A
2755	Install Partial Curtainwall- West	7	7	20SEP05A	28SEP05A	WEST	08A
3190	Temp Dry In Full Roof	0	0	21SEP05A		ROOF	07A



Start Date	23FEB05
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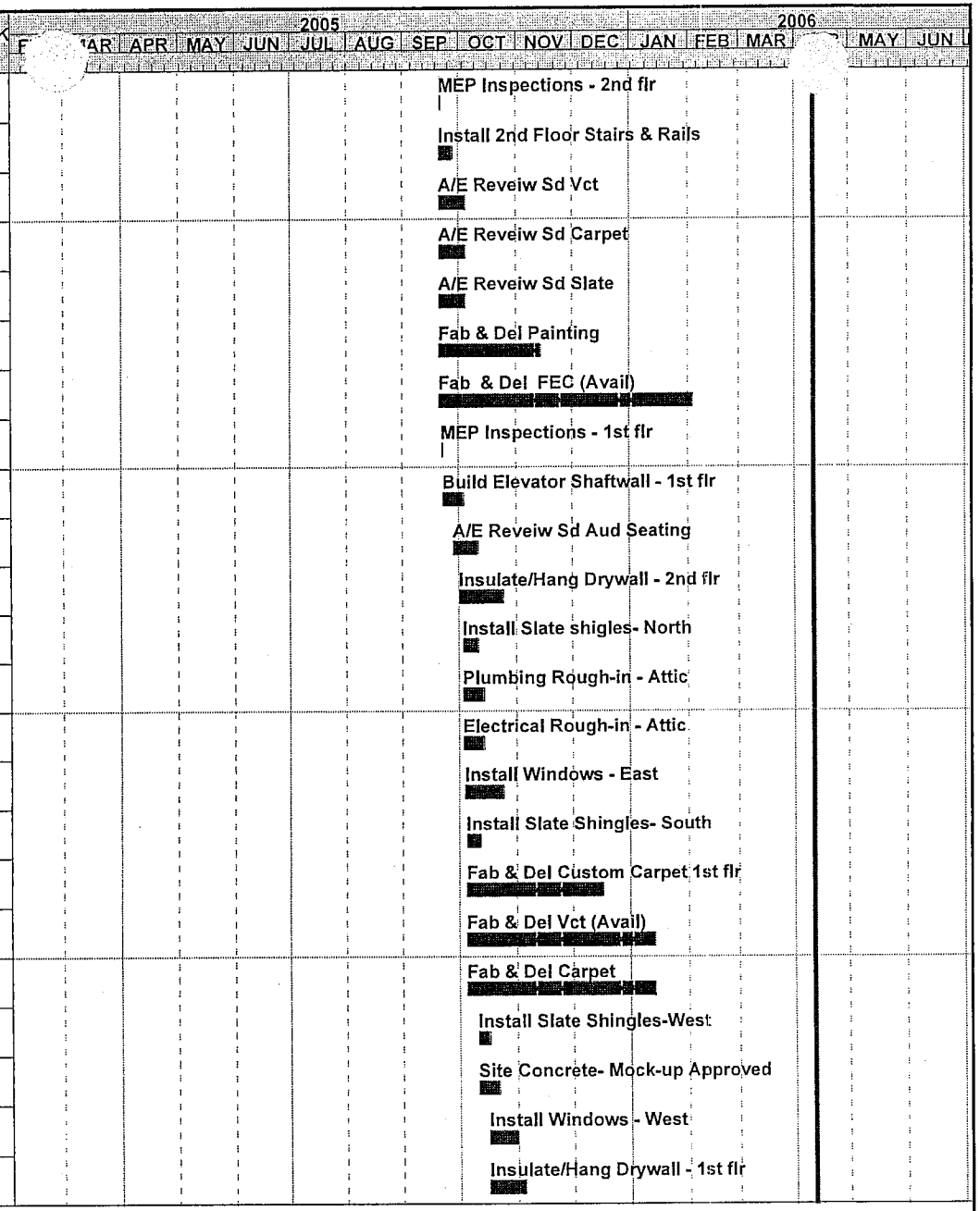
Activity ID	Activity Description	Orig Dur	Actual Duration	Early Start	Early Finish	BDPK	BDPK
1910	MEP Inspections - 2nd flr	1	1	21SEP05A	21SEP05A	SECO	15C
1305	Install 2nd Floor Stairs & Rails	5	5	21SEP05A	27SEP05A	STRU	05A
5148	A/E Reveiw Sd Vct	10	10	21SEP05A	04OCT05A	STRU	09C
5158	A/E Reveiw Sd Carpet	10	10	21SEP05A	04OCT05A	STRU	09C
5168	A/E Reveiw Sd Slate	10	10	21SEP05A	04OCT05A	STRU	09C
5202	Fab & Del Painting	94	38	21SEP05A	14NOV05A	STRU	09D
5126	Fab & Del FEC (Avail)	30	94	21SEP05A	03FEB06A	STRU	09A
1660	MEP Inspections - 1st flr	1	1	22SEP05A	22SEP05A	FIRS	15C
1650	Build Elevator Shaftwall - 1st flr	7	7	23SEP05A	03OCT05A	FIRS	09A
5358	A/E Reveiw Sd Aud Seating	10	10	28SEP05A	11OCT05A	STRU	12C
1925	Insulate/Hang Drywall - 2nd flr	5	16	01OCT05A	24OCT05A	SECO	09A
3150	Install Slate shigles- North	5	7	03OCT05A	11OCT05A	ROOF	07A
2280	Plumbing Rough-in - Attic	10	10	03OCT05A	14OCT05A	ATTI	15C
2290	Electrical Rough-in - Attic	10	10	03OCT05A	14OCT05A	ATTI	16A
2550	Install Windows - East	15	15	04OCT05A	24OCT05A	EAST	08A
3170	Install Slate Shingles- South	5	6	05OCT05A	12OCT05A	ROOF	07A
5163	Fab & Del Custom Carpet 1st flr	84	51	05OCT05A	16DEC05A	STRU	09C
5152	Fab & Del Vct (Avail)	30	69	05OCT05A	13JAN06A	STRU	09C
5162	Fab & Del Carpet	30	69	05OCT05A	13JAN06A	STRU	09C
3160	Install Slate Shingles-West	5	5	11OCT05A	17OCT05A	ROOF	07A
3248	Site Concrete- Mock-up Approved	3	9	11OCT05A	21OCT05A	IMPR	03A
2780	Install Windows - West	10	11	17OCT05A	31OCT05A	WEST	08A
1670	Insulate/Hang Drywall - 1st flr	5	15	17OCT05A	04NOV05A	FIRS	09A



Start Date	23FEB05
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Early Bar
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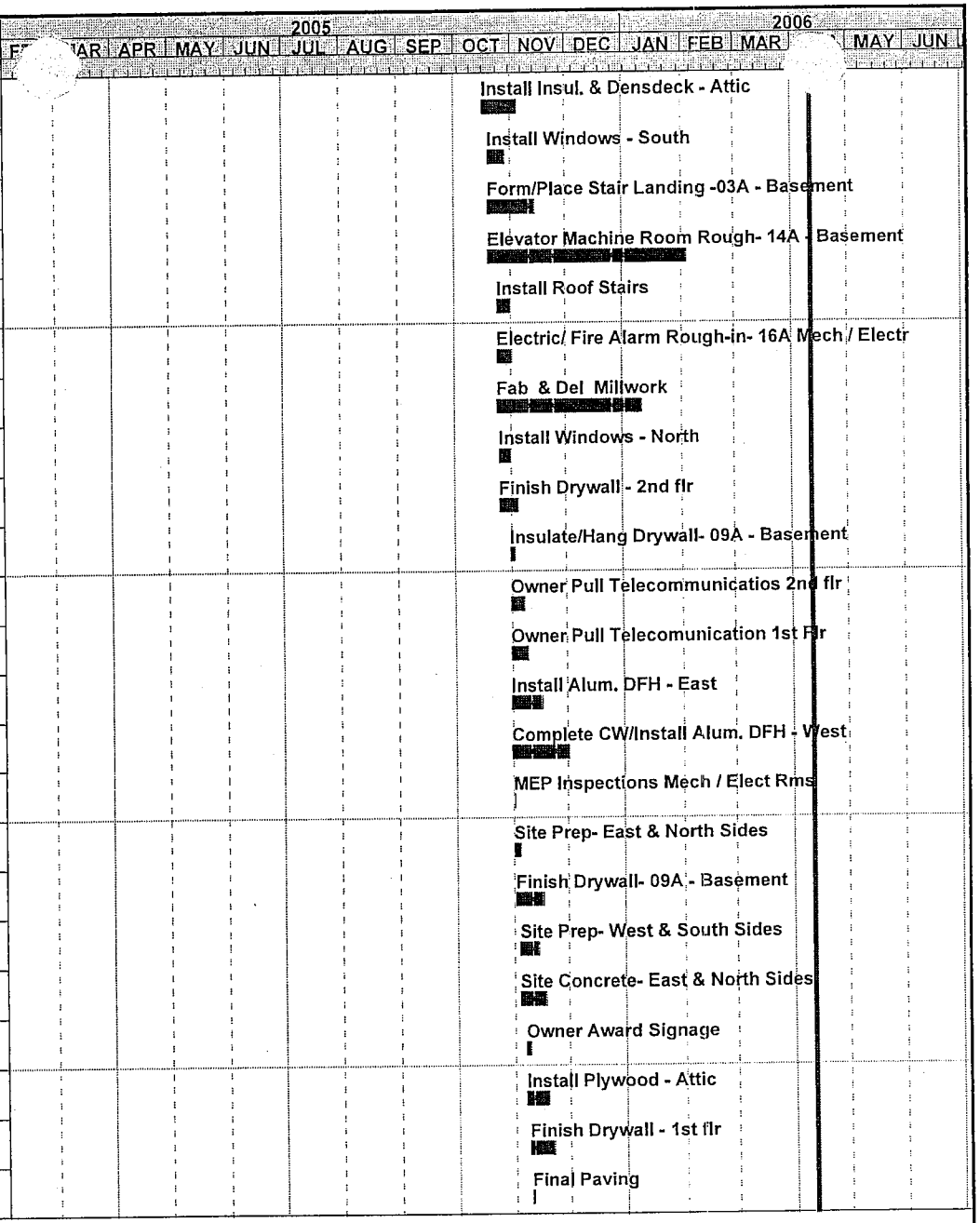
Activity ID	Activity Description	Orig Dur	Actual Duration	Early Start	Early Finish	BDPK	BDPK
2300	Insta. ul. & Densdeck - Attic	15	15	17OCT05A	04NOV05A	ATTI	09A
2950	Install Windows - South	5	7	20OCT05A	28OCT05A	SOUT	08A
1350	Form/Place Stair Landing -03A - Basement	5	17	20OCT05A	14NOV05A	BASE	03A
1460	Elevator Machine Room Rough- 14A - Basement	15	73	20OCT05A	03FEB06A	BASE	16A
1325	Install Roof Stairs	2	6	24OCT05A	31OCT05A	STRU	05A
1440	Electric/ Fire Alarm Rough-in- 16A Mech / Electr	8*	7	24OCT05A	01NOV05A	MECH	16A
5036	Fab & Del Millwork	60	53	24OCT05A	10JAN06A	STRU	06A
2640	Install Windows - North	5	5	25OCT05A	31OCT05A	NORT	08A
1930	Finish Drywall - 2nd flr	10	9	25OCT05A	04NOV05A	SECO	09A
1480	Insulate/Hang Drywall- 09A - Basement	3	3	31OCT05A	02NOV05A	BASE	09A
1892	Owner Pull Telecommunicatios 2nd flr	10	6	31OCT05A	07NOV05A	SECO	99B
1642	Owner Pull Telecomunication 1st Flr	10	8	31OCT05A	09NOV05A	FIRS	99B
2570	Install Alum. DFH - East	5	12	31OCT05A	16NOV05A	EAST	08A
2790	Complete CW/Install Alum. DFH - West	2	22	31OCT05A	01DEC05A	WEST	08A
1470	MEP Inspections Mech / Elect Rms	1	1	01NOV05A	01NOV05A	MECH	15C
3200	Site Prep- East & North Sides	5	4	01NOV05A	04NOV05A	IMPR	02A
1490	Finish Drywall- 09A - Basement	5	10	02NOV05A	16NOV05A	BASE	09A
3400	Site Prep- West & South Sides	5	6	04NOV05A	14NOV05A	IMPR	02A
3250	Site Concrete- East & North Sides	10	9	04NOV05A	17NOV05A	IMPR	03A
5324	Owner Award Signage	10	3	07NOV05A	09NOV05A	STRU	10A
2305	Install Plywood - Attic	5	9	07NOV05A	18NOV05A	ATTI	07A
1680	Finish Drywall - 1st flr	8*	8	09NOV05A	21NOV05A	FIRS	09A
3452	Final Paving	1	1	10NOV05A	10NOV05A	IMPR	03A



Start Date 23FEB05
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Early Bar
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Critical Activity

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GILBANE (BT08)

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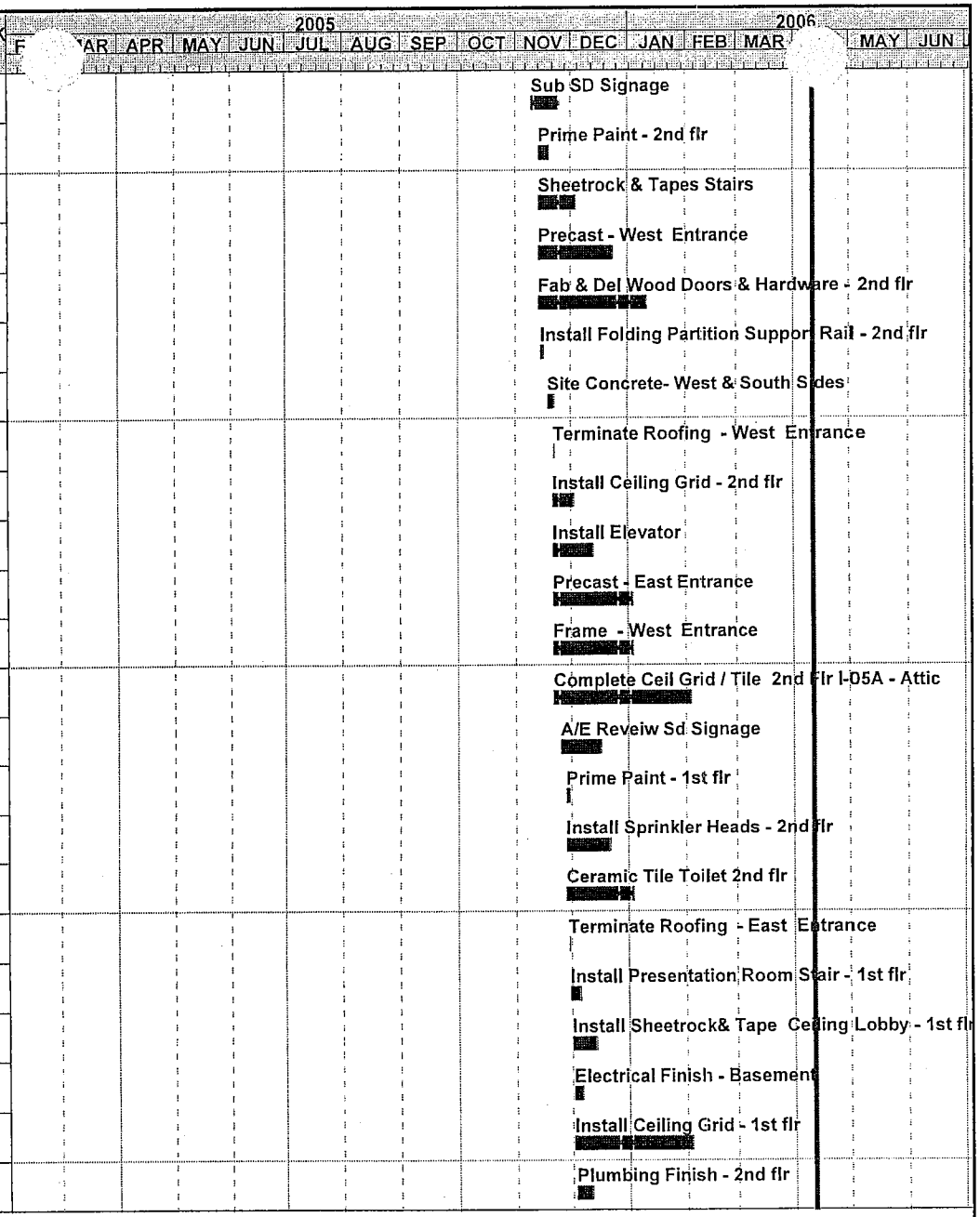
Activity ID	Activity Description	Orig Dur	Actual Duration	Early Start	Early Finish	BDPK	BDPK
5326	Sub [illegible] ignage	10	9	10NOV05A	24NOV05A	STRU	10A
1940	Prime Paint - 2nd flr	5	5	14NOV05A	18NOV05A	SECO	09D
1685	Sheetrock & Tapes Stairs	10	14	14NOV05A	03DEC05A	FIRS	09A
3805	Precast - West Entrance	5	29	14NOV05A	23DEC05A	CANC	04A
1934	Fab & Del Wood Doors & Hardware - 2nd flr	30	39	14NOV05A	10JAN06A		09A
1972	Install Folding Partition Support Rail - 2nd flr	1	1	15NOV05A	15NOV05A	SECO	09A
3450	Site Concrete- West & South Sides	2	2	18NOV05A	21NOV05A	IMPR	03A
3840	Terminate Roofing - West Entrance	1	1	21NOV05A	21NOV05A	CANC	07A
1945	Install Ceiling Grid - 2nd flr	5	9	21NOV05A	02DEC05A	SECO	09A
1993	Install Elevator	15	15	21NOV05A	12DEC05A	SECO	14A
3800	Precast - East Entrance	5	29	21NOV05A	03JAN06A	CANC	04A
3810	Frame - West Entrance	3	29	21NOV05A	03JAN06A	CANC	09A
2025	Complete Ceil Grid / Tile 2nd Flr I-05A - Attic	3	52	21NOV05A	03FEB06A	SECO	09A
5328	A/E Reveiw Sd Signage	10	16	25NOV05A	16DEC05A	STRU	10A
1690	Prime Paint - 1st flr	5	2	28NOV05A	29NOV05A	FIRS	09D
1955	Install Sprinkler Heads - 2nd flr	5	18	28NOV05A	21DEC05A	SECO	15B
1942	Ceramic Tile Toilet 2nd flr	3	25	28NOV05A	03JAN06A	SECO	09B
3845	Terminate Roofing - East Entrance	1	1	29NOV05A	29NOV05A	CANC	07A
1634	Install Presentation Room Stair - 1st flr	5	4	30NOV05A	05DEC05A	FIRS	05A
1800	Install Sheetrock& Tape Ceiling Lobby - 1st flr	10	9	01DEC05A	13DEC05A	FIRS	09A
1520	Electrical Finish - Basement	3	3	02DEC05A	06DEC05A	BASE	16A
1695	Install Ceiling Grid - 1st flr	5	44	02DEC05A	03FEB06A	FIRS	09A
1980	Plumbing Finish - 2nd flr	5	5	03DEC05A	10DEC05A	SECO	15C



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Appendix F – List of Activities Submitted by CE3020 Students

GROUP 1 DOM Construction Inc.

task_code	wbs	task_name	target_drtn_hr_cnt
Activity ID	**CSI Code**	**Activity Name**	**Original Duration(d)**
10		START SCHEDULE	1
1000	16050	Electric Relocation Work- Phase 1-16A	3
1020	16050	Shutdown #1- 16A	1
1030	16050	Electric Relocation Work- Phase 2-16A	5
1100	02200	Erect Fence/Prep Site/Erosion Control- 02A	4
1060	16050	Shutdown #2- 16A	1
1070	16050	Energize New HV Loop- 16A	1
1050	03100	Place Concrete for New Ductbank- 16A	2
1130	03100	Form/Place/Strip Balance of Footings- 02A	3
1110	02200	Exc. Bsmt/Prep for Found Footings- 02A	5
1080	02050	Demo Ductbank/MH- 02A	2
1090	02200	Backfill/Restore Grade- 02A	1
1210	05100	Steel Shops Submitted	1
1220	05100	Steel Shops Approved/Returned	10
1115	05520	Deliver Anchor Bolts/Embeds- 05A	1
1126	02450	Prep for Balance of Footings- 02A	3
1122	02600	Install Sewer Line- 02A	15
1120	03100	Form/Place/Strip Basement Footings- 03A	3
1150	03100	Form/Place/Strip Basement Walls- 03A	4
1153	07100	Partially Dampproof & Insulate Foundation	4
1160	03100	Forms/Place/Strip Balance of Walls- 03A	8
1225	05100	Fabricate Steel	41
1124	02600	Install Water Line/Tap- 02A	15
5012	05300	Sub Shp Dwgs	10
5402	14200	Sub SD Elevator	10
1170	15700	Install U/G Ductwork- 15B	5
1175	02200	Backfill Int. Fnd. Walls & U/G Duct- 02A	2
5042	07500	Sub Roofing EPDM Shp Dwgs	10
5052	07300	Sub Roofing Slat Shp Dwgs	10
5062	08500	Sub Windows Shp Dwsg	10
5072	08900	Sub Curtain Shp Dwgs	10
5370	08050	Arch Compl Door Schedule	10
5082	09250	Sub Drywall Shp Dwgs	25
5092	06100	Sub Struct Studs / Dens Shp Dwgs (Dens sub)	11
5112	10651	Sub Folding Part Shp Dwgs	11
5102	09550	Sub Act Ceil Shp Dwgs	41
5122	09100	Sub FEC Shp Dwgs	41
5212	06400	Prep Millwork Bid Pkg	6
5022	05520	Sub Stair Shp Dwgs	15
5412	15700	Mechanical Coordination Duct mech Ppg/Pimg	10
5000	04200	Fab & Del Brick	55
5014	05300	A/E Review Deck Shp Dwgs	5
1155	02200	Partially Backfill Basement Walls- 02A	1
1177	02200	Excavate for U/G Plumbing- 02A	2
1230	05520	Survey Anchor Bolts	2
5016	05300	Fab & Del Deck	2
5372	08100	Prep Frames / Hardware Bid Pkg	10
1180	15400	Install U/G Plumbing- 15B	10

5064	08500	A/E Review WindowsShp Dwgs	10
5074	08900	A/E Curtainwall Shp Dwgs	10
5044	07500	A/E Review EPDM Shp Dwgs - rejected	15
5054	07300	A/E Review Slate Shp Dwgs	10
1196	07100	Install Dampproofing/Insulation- 03A	2
5214	06400	Bid Period Millwork	15
5374	08100	Bid Drs / frames / Hardware	15
5001	04200	A/E Review Precast SD	10
1198	02200	Backfill/Rgh Grade Foundation & Site- 02A	3
1183	03302	Prep/Place Basement SOG- 03A	4
5024	05520	A/E Review Stair Shp Dwgs	10
1204	02200	Prep Site for Steel	6
1202		President's Inauguration/Commencement	1
5414	15300	Sprinkler Coord	14
5416	16050	Electrical Coord	14
5076	08900	Fab & Del West Curtainwall	83
5066	08500	Fab & Del Windows	93
1185	03302	Prep/Place Main SOG- 03A	5
5084	09250	A/E review Drywall Shp Dwgs	10
1240	05100	Steel Delivery	1
1351	15700	Set AHU/Mechanical Room Equipment- 15B	5
1260	05100	Erect Basement Steel	3
5342	12600	Prep Aud Seating Bid Pkg	12
5132	09600	Prep Flooring Bid Pkg	15
5182	09900	Prep Painting Bid Bkg	15
5026	05520	Fab & Del Stairs 1 & 2 MAIN STAIRS	38
5311	10400	Owner Clarify Signage Bid Pkg	53
1270	05100	Erect First Floor Steel	5
1275	05100	Erect Second Floor Steel	5
5376	08100	Eval & Recom Award Drs/Frames/Hardware	5
5216	06400	Eval & Recom Award Millwork	8
1277	05100	Erect Attic Steel	3
5045	07500	Resubmit EPDM Shp Dwgs	5
5056	07300	Fab & Del Slate Roofing	30
1280	05100	Erect Roof Steel	10
1255		WPI Reunion Weekend	1
1290	05300	Install Roof Decking	5
5378	08100	Owner App Award Drs/Frames/Hardware	2
5384	08100	Award Aud Drs/ Frames/Hardware	1
1340	02200	Backfill/Prep Landing-02A	5
1318	05100	Install Precast Supports / Adjust	9
5096	05500	Fab & Del Exterior Studs / Dens	10
5386	08100	Sub SD Drs/Frames/Hardware	24
1380	15500	Mechanical Rough-in-15B-Mech RM	77
1295	05300	Install First Floor Deck/Studs	1
1297	05300	Install Second Floor Deck/Studs	1
1300	05300	Install Attic Deck	4
1298	15700	MEP Slab Prep First Floor	2
5222	06400	Owner App Award Millwork	2
6094	06100	A/E Structural Studs / DensShp Dwgs	10
5114	10651	A/E Folding Part Shp Dwgs	10
1299	03300	Prep/pour First Floor SOD	5

5047	07500	A/E Review EPDM Shp Dwgs	5
5002	03400	Fab & Del Precast	25
5344	12600	Bid Period Aud Seating	17
2190	06100	Stock Insulation, Densdeck & Plywood- 09A - Attic	1
5224	06400	Award Millwork	1
1302	15700	MEP Second Floor SOD Prep	2
5086	09250	Fab & Del Drywall	14
5104	09510	A/E Act Ceil Shp Dwgs	10
5134	09600	Bid Period Flooring	18
5184	09900	Bid Period Painting	22
5032	06400	Sub Millwork Shp Dwgs	15
1304	03300	Prep/Pour Second Floor SOD	2
5420	15950	MEP Coordination Signoff	5
2490	06100	Inst 1st & 2nd Flr/Gable Ext. Studs/ Sheath -East	14
5046	07500	Fab & Del EPDM Roofing	40
1390	15700	Heat Rough-in- 15B - Mech / Elect room	68
1400	15400	Plumbing Rough-in- 15B - Mech / Elect room	66
5422	15500	Fab & Del Duct - 2nd flr	27
5116	05520	Fab & Del Folding Part Rail	150
5117	05520	Fab & Del Folding Part Wall	10
1577	09100	Layout 1st floor and Top Track	2
5404	14200	A/E Review Sd Elevator	10
3090	07700	Install Roof Drains & Vents - Roof	3
5027	05520	fab & Del Basement Stair	25
5392	08100	Fab & Del Drs/Frames/Hardware	15
2520	04200	Install 1st & 2nd Floor Brick & Precast East	27
5418	15950	A/E review MEP Coordination (for record)	5
2900	06100	Install 1st & 2nd Floor Studs & Sheath - South	8
2600	06100	Install 1st & 2nd Floor Studs & Sheath - North	8
5105	09550	Re-Sub Act Ceil Shp Dwgs	10
5388	08100	A/E Review Sd Drs / Frames / Hardware	10
1445	16300	Deliver/Install Switchgear- 16A Electric Rms	1
5406	14200	Fab & Del Elevator	131
5186	09900	Eval & Recom Award Painting	5
5346	12600	Eval & Recom Aud Seating	5
1835	15400	Overhead Heat Pipe - 2nd flr	10
1580	15500	Overhead Ductwork - 1st flr	15
1590	15400	Overhead Heat Pipe - 1st flr	16
5136	09050	Eval Award	5
1860	06100	Install Interior Studs and Frames - 2nd flr	10
1885	15400	Plumbing in-Wall Rough - 2nd flr	4
2546	04200	Install Gable-End Brick & Precast - East (Br dne)	9
2700	06100	Inst 1st & 2nd floor/Gable Studs & Sheath - West	9
2770	04200	Install Gable-End Brick & Precast - West	17
1375	06100	Install Stud Walls/Door Frames- 09A - Basement	3
2715	16050	Electric Shutdown Switchgear	2
1630	06100	Install Interior Stud Walls/Door Frames - 1st flr	8
1855	15300	Overhead Sprinkler - 2nd flr	10
2720	04200	Install 1st & 2nd Floor Brick & Precast West	15
3100	07600	Install Roof Sheathing - East - Roof	3
1503	05520	Install Stairs - basement	18
6000	05520	Submit Sketch Ladder & Handrail - 05A - Attic	3

6010	07300	Fab & Del Slate Infills North	124
3110	07600	Install Rood Sheathing - North	3
2610	04200	Install 1st & 2nd Floor Brick & Precast - North	17
5192	09900	Owner App award Painting	2
5348	12600	Owner App Award Aud Sealing	2
5107	09550	A/E Review Re-Sub Act Ceil Shp Dwgs	10
1840	15400	Overhead Plumbing - 2nd flr	3
1600	15400	Overhead Plumbing - 1st flr	5
1924	08500	Install Plastic in Windows - 2nd flr	5
3130	07600	Installation of Sheathing - South	3
5194	09900	Award Painting	1
5354	12600	Award Aud Seating	1
5124	09100	A/E FEC Shp Dwgs	10
1636	15400	Plumbing In-Wall Rough - 1st flr	5
1620	15300	Overhead Sprinkler - 1st flr	10
1360	05520	Install Stairs/Areaway Grates-05A basement	12
1850	16050	Overhead Electric - 2nd flr	5
1663	15700	Insulate Duct & Piping - 1st flr	5
2910	04200	Install 1st & 2nd Floor Brick & Precast - South	8
1610	16050	Overhead Electric - 1st flr	10
1661	09100	Frame Chases - 1st flr	2
1921	09100	Frame Chases - 2nd flr	2
2005	05520	Sub SD Ladder & Handrail - 05A - Attic	107
5142	09600	Owner App award Flooring	2
5144	09600	Award Flooring	1
5196	09900	Sub SD Painting	10
5146	09680	Sub SD Vct	10
5156	09680	Sub SD Carpet	10
5166	09300	Sub SD Slate	10
1890	16100	Electrical In-Wall - 2nd flr	10
1895	16800	Fire Alarm In-Wall - 2nd flr	5
1900	16300	Control In-Wall - 2nd flr	5
1920	15700	Insulate Duct & Piping - 2nd floor	5
2270	15700	Mechanical Rough-in-14A - Attic	19
3180	07700	Install EPDM - Pit & Balcony	5
5034	06400	A/E Review Millwork Shp Dwgs	10
1410	15300	Sprinkler Rough-in- 15B - Mech/Elect Rms	104
1905	09100	Build Elevator Shaft - 2nd flr	5
1465	10200	Install Areaway Louvers- North	2
3140	07300	Install Slate Shingles- North	5
5356	12600	Sub SD Aud Seating	10
1450	09100	Build Elevator Shaftwall- 09A - Basement	3
1285	05520	Install 1st Floor Stairs & Rails	5
1640	16100	Electric In-Wall Rough - 1st flr	5
1922	09250	Sheetrock Chases - 2nd flr	5
5033	06050	Select Wood Veneer Leed Certification	5
5198	09900	A/E Review Sd Painting	10
2291	16300	Del Main Transformer	23
1645	16300	Control In -Wall Rough - 1st flr	5
1647	16800	Fire Alarm In-Wall Rough - 1st flr	5
5106	09550	Fab & Del Act Ceil Grid	96
5110	09550	Fab & Del Act Ceil Tile	96

1664	09250	Sheetrock Chases - 1 st flr	5
2755	08900	Install Partial Curtainwall- West	7
3190	07200	Temp Dry In Full Roof	0
1910	15950	MEP Inspections - 2nd flr	1
1305	05520	Install 2nd Floor Stairs & Rails	5
5148	09680	A/E Review Sd Vct	10
6158	09680	A/E Review Sd Carpet	10
5168	09300	A/E Review Sd Slate	10
5202	09900	Fab & Del Painting	84
5126	09100	Fab & Del FEC (Avail)	30
1660	15950	MEP Inspections - 1st flr	1
1650	09100	Build Elevator Shaftwall - 1st fl	7
5358	12600	A/E Review Sd Aud Seating	10
1925	09250	Insulate/Hang Drywall - 2nd flr	5
3150	07300	Install Slate shingles- North	5
2280	15400	Plumbing Rough-in - Attic	10
2290	16050	Electrical Rough-in - Attic	10
2550	08500	Install Windows - East	15
3170	07300	Install Slate Shingles- South	5
5163	09680	Fab & Del Custom Carpet 1st flr	84
5152	09680	Fab & Del Vct (Avail)	30
5162	09680	Fab & Del Carpet	30
3160	07300	Install Slate Shingles-West	5
3248	03050	Site Concrete- Mock-up Approved	3
2780	08500	Install Windows - West	10
1670	09250	Insulate/Hang Drywall - 1st flr	5
2300	09100	Install & Densdeck - Attic	15
2950	08500	Install Windows - South	5
1350	03050	Form/place Stair Landing -03A - Basement	5
1460	14200	Elevator Machine Room Rough- 14A - Basement	15
1325	05520	Install Roof Stairs	2
1440	16800	Electric/Fire Alarm Rough-in- 16A Mech/ Electr	8
5036	06400	Fab & Del Millwork	60
2640	08500	Install Windows - North	5
1930	09250	Finish Drywall - 2nd flr	10
1480	09250	Insulate/Hang Drywall- 09A - Basement	3
1892		Owner Pull Telecommunications 2nd flr	10
1642		Owner Pull Telecommunications 1st flr	10
2570	08100	Install Alum DFH -East	5
2790	08100	Complete CW/Install Alum DFH - West	2
1470	15950	MEP Inspections Mech / Elect Rms	1
3200	02200	Site Prep- East & North Sides	5
1490	09250	Finish Drywall- 09A - Basement	5
3400	02200	Site Prep- West & South Sides	5
3260	03100	Site Concrete- East & North Sides	10
5324	10400	Owner Award Signage	10
2305	06100	Install Plywood - Attic	5
1680	09250	Finish Drywall - 1st flr	8
3452	02700	Final Paving	1
5326	10400	Sub Signage	10
1940	09900	Prime Paint - 2nd flr	5
1685	09250	Sheetrock & Tapes Stairs	10

3805	03400	Precast - West Entrance	5
1934	08200	Fab & Del Wood Doors & Hardware - 2nd flr	30
1972	10651	Install Folding Partition Support Pail - 2nd flr	1
3450	03100	Site Concrete- West & South Sides	2
3840	07400	Terminate Roofing - West Entrance	1
1945	09500	Install Ceiling Grid - 2nd flr	6
1993	14200	Install Elevator	15
3800	03400	Precast - East Entrance	5
3810	09100	Frame - West Entrance	3
2025	09500	Complete Ceil Grid / Tile 2nd Flr 1-05A - Attic	3
5328	10400	A/E Review Sd Signage	10
1690	09900	Prime Paint - 1st Flr	5
1955	15300	Install Sprinkler Heads - 2nd flr	5
1942	09300	Ceramic Tile Toilet 2nd flr	3
3845	07400	Terminate Roofing - east Entrance	1
1634	05520	Install Presentation Room Stair - 1st flr	5
1800	09250	Install Sheetrock & Tape Ceiling Lobby - 1st flr	10
1520	16050	Electrical Finish - Basement	3
1695	09500	Install Ceiling Grid - 1st floor	5
1980	15400	Plumbing Finish - 2nd flr	5
1950	15700	Install D's - 2nd Flr	5
1692	09300	Ceramic Alum Exterior Entrance Doors	3
2572	08100	Install Alum Exterior Entrance Doors	5
1985	16050	Electrical Finish - 2nd flr	5
1700	15700	Install RGD's - 1st flr	5
1705	15300	Install Sprinkler Heads - 1st flr	5
1970	09600	Install Flooring - 2nd flr	10
1960	09500	Flood Ceiling Tile - 2nd flr	5
5172	09300	Fab & Del Slate to Customs	0
2015		Remove Wd Ladder from Rm 2nd Flr 1-05A - Attic	1
1915	08800	Install Glass Handrail - 2nd flr	3
1995	10980	Install Specialties - 2nd flr	10
2020	05300	Install Deck @ Attic 2nd Flr 1-05A- Attic	1
2260	05520	Install Ladder & Handrail -05A- Attic	5
6002	05520	Fab & Del Ladder & Handrail-05A- Attic	10
1505	05520	Install Stair Handrails - Basement	3
1965	06200	Install Millwork - 2nd flr	5
2650	07300	Install Slate Infills North	3
1935	08200	Install Wood Doors & Hardware - 2nd flr	5
1710	09500	Flood Ceiling Tile - 1st flr	5
1973	10651	Install Folding Partition Wall - 2nd flr	1
5332	10400	Fab & Del Signage	60
1805	06200	Install Wood Paneling in Lobby- 1st flr	7
1722	09300	Install Slate Flooring - 1st flr	5
2960	07300	Install Slate Infills - South	5
1686	08200	Install Wood Doors / Hardware - 1st	5
3825	09100	Frame - East Entrance	3
1790	09700	Install Fabric Panels - 1st flr	3
1795	06200	Install Wood Paneling in Lobby- 1st flr	3
5359	12600	Gilbane Release Aud Seating (Stain Color)	5
1975	09900	Final Paint - 2nd flr	5
1716	06200	Install Millwork - 1st flr	5

1990	15900	Mechanical Finish - 2nd flr	5
5362	12600	Fab & Del Aud Seating	0
2010	05520	Install Stair Rails	29
3815	16500	R.I. Lights - West Entrance	1
3820	08400	Densglass - West Entrance	5
3830	16500	R.I. Lights - East Entrance	1
3835	08400	Densglass - East Entrance	5
1720	09600	Complete Flooring - 1st flr	4
1725	09900	Complete Paint - 1st flr	3
3700		Fire Marshall Inspect Building	1
3705		test & Balance Building - Bldg	6
1997		Punchlist - 2nd flr	3
1740	15900	Mechanical Finish - 1st flr	2
1807	12600	Install Presentation Room Seating - 1st flr	2
1730	16050	Electrical Finish - 1st flr	3
1727	10400	Install Signage in Building	4
1750	12400	Install Mecxho Shades - 1st flr	5
1815	01046	Final Clean - 1st flr	5
3710		Commissioning Building	6
3722		Flush Building	10
2000	01046	Final Cleaning - 2nd flr	5
3715		Substantial Completion C of O	5
3860	07400	Ballast Roofing - East Entrance	1
2013	09500	Complete Attic Insulation	6
2011	12500	Owner Furniture	10
3720		WPI Move - in	38
3600	03700	Place Exterior West Slab	3
1830	15500	Overhead Duct 2nd flr	10
1833	15700	Fab & Del Valves Heat Pipe - 2nd flr	4
3120	07600	Install Roof Sheathing - West	12
5173	09300	Slate Clear Customs & Deliver	5
2012	06400	Furnish & Install Plam Top	5
3821	09200	Plaster - Both Entrance	5
3650	02900	Landscaping & Brick Paving	20
2735		WPI Occupy Building	0
1811		Building Dedication	0

Appendix G – Reduced List of Owner's Activities by CE3020 Students

WBS Code	Item Description	Estimated Time Duration (Work days)
	Project Milestones	
	Project Starts	
	Design Kick-off Meeting	
	Design Completed	
	Foundation Completed	
	Building Enclosed	
	Final Inspection & Approval	
	Substantial Completion C of O	
	Flush Building	
	Project Ends	
010	**Project Management**	
	Develop Work Plan	6
	Form Project Team	6
	Building Permits	30
	Move In, Erect Fence, Erosion Control	6
	Procure Contractor's Bids	90
	Handover	7
	Punch List & Move	14
010	**Design**	
	Structural Design	40
	Storm-Water Design	8
	Sanitary Sewer Design	8
	Architectural Design	60
	On-Site Utilities Design	8
	Mechanical Systems Design	10
	Electrical Systems Design	21
020	**SiteWork & Excavation**	
	Backfill/Restore Grade	1
	Excavate Bsmt/Prep for Found Footings	8
	Install Sewer Line	15
	Backfill Int. Fnd. Walls & U/G Duct	3
	Install Water Line/Tap	15
	Excavate for U/G Plumbing	2
	Backfill/Rgh Grade Foundation & Site	3
	Prep Site for Steel	6
	Backfill/Prep Landing	5
	Final Paving	1
	Landscaping & Brick Paving	20
030	**Concrete (incl formwork, reinforced steel)**	
	Form/Place/Strip Balance of Footings	6
	Form/Place/Strip Basement Walls	12
	Prep/Place Basement Slab On Grade	4
	Prep/Place Main Slab on Grade	5
	Prep/pour First Floor Slab On Deck	5

	Prep/Pour Second Floor Slab On Deck	5
	Form/place Stair Landing Basement	5
	Site Concrete- all Sides	12
	Place Exterior West Slab	3
034	**Precast Concrete**	
	Fab & Del Precast	25
	Precast - Entrance	10
040	**Masonry**	
	Fab & Del Brick	55
	Install 1st & 2nd Floor Brick & Precast East	27
	Install Gable-End Brick & Precast - East (Br dne)	9
	Install Gable-End Brick & Precast - West	17
	Install 1st & 2nd Floor Brick & Precast West	15
	Install 1st & 2nd Floor Brick & Precast - North	17
	Install 1st & 2nd Floor Brick & Precast - South	8
050	**Metals**	
	Fab & Del Deck	2
	Fabricate & Deliver Steel	42
	Survey Anchor Bolts	2
	Erect Steel Frame	16
	Erect Roof Steel	10
	Install Deck/Studs	2
	Install Roof & Attic Decking	9
	Install Precast Supports / Adjust	9
	Fab & Del Stairs 1 & 2 MAIN STAIRS	38
	fab & Del Basement Stair	25
	Install Stairs - basement	18
	Install Stairs Building	30
	Fab, Del & Install Ladder & Handrail-- Attic	15
	Install Stair Rails	32
060	**Carpentry**	
	Fab & Del Millwork	60
	Install Millwork	10
	Install Wood Paneling	10
	Install Plywood - Attic	5
070	**Roof & Moisture Protection**	
	Fab & Del Slate Roofing	30
	Fab & Del EPDM Roofing	40
	Fab & Del Slate Infills North	124
	Dampproof & Insulate Foundation	6
	Install Roof Sheathing	15
	Install Slate Shingles	12
	Install EPDM - Pit & Balcony	5
	Terminate Roofing Entrance	2
	Install Slate Infills	8

080	**Doors & Windows**	
	Fab & Del Drs/Frames/Hardware	15
	Fab & Del West Curtainwall	83
	Fab & Del Windows	93
	Fab & Del Wood Doors & Hardware	30
	Install Windows	25
	Install Wood Doors / Hardware	10
	Install Plastic in Windows - 2nd flr	5
	Install Curtainwall	10
	Densglass Entrance	8
	Install Alum Exterior Entrance Doors	5
	Install Alum DFH -East	5
	Install Glass Handrail - 2nd flr	3
090	**Finishes**	
	Fab & Del Exterior Studs / Dens	10
	Fab & Del Drywall	14
	Fab & Del Painting	94
	Fab & Del Act Ceil Grid	96
	Fab & Del Vynil Tile, FEC	30
	Fab & Del Custom Carpet 1st flr	84
	Install Exterior Studs/ Sheath	20
	Install Interior Studs and Frames	25
	Sheetrock Chases	8
	Build Elevator Shaft	15
	Insulate/Hang Drywall	15
	Install & Densdeck - Attic	15
	Fnish Drywal	20
	Prime Paint	13
	Install Ceiling Grid	10
	Install Sheetrock & Tape Ceiling	20
	Install Flooring - 2nd flr	10
	Frame Entrance	6
	Ceramic Tile Toilet	3
	Install Slate Flooring - 1st flr	5
	Flood Ceiling Tile	9
	Final Paint	8
	Complete Attic Insulation	5
100	**Specialties**	
	Fab & Del Folding Partition Wall & Rail	150
	Install Folding Partition Support Wall & Rail	3
	Fab & Del Signage	60
	Install Signage in Building	4
140	**Elevator**	
	Fab & Del Elevator	131
	Install Elevator	15
	Elevator Machine Room Rough- 14A - Basement	15
150	**Mechanical**	

	MEP Slab on Grade Prep	15
	MEP Second Floor Slab On Deck Prep	4
	Install Roof Drains & Vents - Roof	3
	Fab & Del Duct	27
	Overhead Ductwork	25
	Overhead Plumbing, Sprinkler, Heat Pipe	25
	Plumbing & Mechanical Rough-in Mech / Elect room	77
	Plumbing in-Wall Rough	9
	Heat Rough-in Mech / Elect room	68
	Mechanical & Plumbing Rough-in Attic	29
	Sprinkler Rough-in Mech/Elect Rms	104
	Mechanical & Plumbing Finish	7
	Install Sprinkler Heads	10
160	**Electrical**	
	Electric Relocation Work	8
	Overhead Electric	15
	Electrical In-Wall	15
	Control In-Wall	10
	Fire Alarm	15
	Electrical Rough-in - Attic	10
	Electrical Finish	12
	Del Main Transformer	23
	R.I Lights Entrance	3
	Electrical Coordination	14

Appendix H – "Visualizing Construction" Website

Visualizing Construction

The Bartlett Center: From Start to Finish

An Architect's Rendering

A Glimpse at the newest addition to WPI's Campus

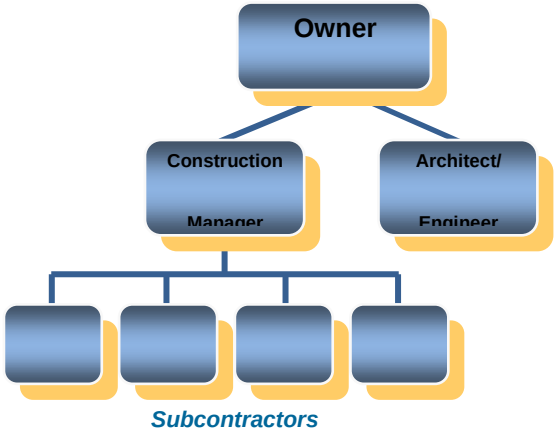
The Bartlett Center, WPI's first "Green Building" was inaugurated on the 10th of June as its newest admissions building. Designed by Childs Bertman Tseckares Inc. (CBT), the construction of the Bartlett Center followed U.S. Green Building (USGB) guidelines using local building materials and increasing recycling of construction materials. Being a "Green" building, not only does it make the Bartlett Center's existence environmentally friendly, but also reduces its operation costs while providing its employees a safer work surrounding.

Some of its visible advantages being a "Green" Building is that 'the open area on the site equal to the footprint of the building, the design introduces substantial new green space to the campus, while the removal of the asphalt paving reduces the heat island effect and decreases the rate and quality of storm-water run-off. Facing the general east/west direction it takes optimum advantage of day-light while simultaneously using a 'portico' for shade, mitigates rising temperatures within.

To learn more about the two story, 16,589-square-foot, silver LEED rating Bartlett Center, visit the link on the left panel. To see the phase by phase process of the construction of the Bartlett Center, click on "Visualize" Construction

Construction Entities

Owner
Architect/Designer
Construction Manager
Contractor



SubcontractorOwner: The owner, as can be seen in Fig 1: Construction "Food-Chain" is at the top of the "food-chain". The owner is not only the financier of the entire project, but importantly plays the role of defining the scope of work that needs to be done. Depending on the type of project (Design-Build, Design-Bid-Build, etc. See next section) the owner may opt for any of the following entities that play an essential role in the successful completion of the owner's project.

Architect/Designer: Once the owner has defined the scope of work (for example, for a 3 bedroom, 2 bathrooms residential home), the owner hires an architect or a designer who is an entity involved in the art of planning, designing and overseeing the construction of buildings, or more generally, the designer of a scheme or plan. The architect/designer molds the owners scope of work into a physical, constructible solution complete with drawings and specifications tailored to the owner's specifications.

Project Manager: As discussed before, the project manager plans, budgets, co-ordinates, monitors and controls the operational contributions of property professionals, and others, in a project in accordance with a client's objectives in terms of quality, cost and time. The project manager takes over the responsibility of handing over the project to the owner within the deadline giving "time, cost and quality" special importance.

Contractor: A general contractor is defined as such if it is the signatory as the builder of the prime construction contract for the project. A general contractor is responsible for the means and methods to be used in the construction of the project in accordance with the contract documents. These contract documents usually include the contract agreement including budget, the general and special conditions and the plans and specification of the project that are prepared by a design professional (Architect/Designer). A general contractor usually is responsible for the supplying of all material, labor, equipment, (engineering vehicles and tools) and services necessary for the construction of the project. To do this it is common for the general contractor to subcontract part of the work to other persons and companies that specialize in these types of work.

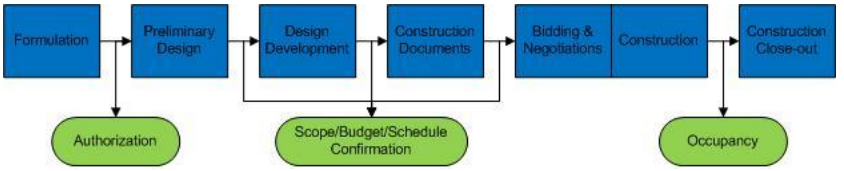
Subcontractor: Subcontractors may be large organizations or small business owners, but they all have one thing in common: work specialization. These entities focus on a certain type of skilled profession ranging from elevators, sprinklers, iron-works, steel fabrication to bathroom tiles, electrical switches and furniture. Once the subcontractor enters a contract, it is the subs job to deliver the end product as specified in the contract with all the necessary close-out documents and deliverables such as include but are not limited to attic stock, special warranties, and keys.

TheConstruction Process

Construction on the Bartlett Center began on the 23rd February 2005 and continued for a period of one year and three months to be handed over to WPI on 1st June 2006.

In this project, Worcester Polytechnic Institute was the Owner, while Gilbane Construction Co. and Childs Bertman Tseckares Inc. (CBT), Boston were the Construction Managers (CM and Architects, respectively. (Click on any of the terms to get an explanation of each in left panel.)

The Bartlett Center project was delivered using the Construction Management @ Risk System. Before construction could actually begin, there are a lot of pre-construction phases that have to be taken into account; the entire process can be summarized as shown below:



There were many phases in the construction of this facility, many of which are typical of construction of various types of structures: Pre-Construction phases through Close-out. These steps are listed below in the form of links which will discuss each step in detail, walking through the schedule, percentage of work complete, list of tasks involved in each step linked to the CSI code and with a discussion of each step with a video or picture demonstration as well. These steps can be navigated by clicking on the links below (These links will be available on every page hence forth for easy navigation):

Pre-Construction Phases
Mobilization
Steel Frame
Landscaping
Construction Schedule
Excavation
Ext. Walls/Roofing
Finishing/Punchlist
Bartlett Ctr. Schedule
Foundation
Int. Walls/Mech./HVAC
Close-out

Top

[Scope](#)
[Schedule](#)
[Budget](#)

Scope: 'The project scope is the written summation of the purpose of a project, the intended result of a project, a description of the physical items to be constructed, and the expected deliverables/responsibilities of the project participants. The project scope addresses the method and approach to be utilized to satisfy the project requirements within a specified time period for a given amount of money.'

Schedule: The required time to produce the end product as described under the scope of the project. All tasks that are involved in getting the job done have to be performed in a sequence, as the precedence chart illustrates, and the time required perform all tasks according to specifications is known as the project schedule.

Budget: This is an estimated cost to complete the project. The project costs depend on several variables including (mainly): labor rates, material rates, risk management, plant (buildings, machines, etc.), equipment, and profit. The expected total to perform all these tasks is generally referred to as the budget.

Pre-Construction Phases

Preconstruction phases include but are not restricted to the following activities:

Formulation: Formulation consists of identifying the scope, schedule and budget for the proposed project. The scope is generally identified by a sketch prepared by the architect/designer. Once the scope has been identified the plans are evaluated and the projects total cost is estimated. The schedule is similarly planned and estimated. The scope, schedule and budget information is summarized for (after the active involvement and approval of) the owner.

Preliminary Design: This is the initial phase of the design process. The agreed upon scope, schedule and budget of each project is defined during the formulation process, all of which are refined as more details about the project are received. It will be the PMs responsibility to keep these three parameters in focus when making decisions regarding the project design. In order to achieve a successful project, the design team must get input from, and coordinate with, a number of different entities such as engineers, accountants and superintendents with regular meetings with the owners, QA/QC, architects and project managers as the project moves along. All changes made to design have to be approved by the owner.

Construction Documents: This is a phase where design is finalized and all necessary documents to "seal the deal" are organized. The main emphasis of this phase is to verify that all the information is on the drawings and in the specifications so that the project can be bid for construction. Clarity and completeness is key to avoid costly changes while in construction. All bonds, permits and other construction documentation such as drawings, project manuals, general conditions, specifications etc are refined and outlined and finalized for construction to begin.

Project completion-o-meter:

0% 2% 100%

Pre-Construction	Mobilization	Excavation	Foundation	Steel Frame	Ext.Walls/Roof	Int.Walls/Mech./HVAC	Landscaping	Finishes/Punch-List	Close-Out

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Close-out

Direct Costs
Indirect Costs

Direct Costs:

Overhead

→ Material takeoff

→ Pricing Material & Equipment

→ Construction Equipment

→ Labor

→ Special Conditions

→ Government Furnished Materials

→ Sampling & Analysis Costs

→ Transportation & Waste Disposal

→ Environmental Management

Conditions

The more accurate the estimates, the more prepared the owner will be for expected expenses, hence, fewer the consequences on the schedule.

Indirect Costs:

'The indirect costs may be included as part of the code of accounts for a project. One method to estimate the indirect costs is to assign a cost to each cost account. This must be based on the size and type of contract and could be a lengthy list. This method requires a great deal of experience and a working knowledge of the construction firm's experience.'

Construction Schedule

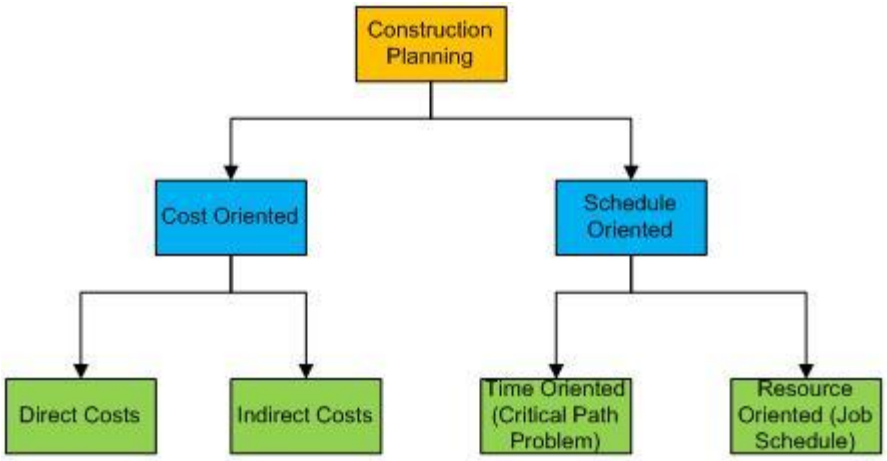

Fig. 2

Construction planning is a fundamental and challenging activity in the management and execution of construction projects. It involves the choice of technology, the definition of work tasks, the estimation of the required resources and durations for individual tasks, and the identification of any interactions among the different work tasks. A good construction plan is the basis for developing the budget and the schedule for work. Developing the construction plan is a critical task in the management of construction, even if the plan is not written or otherwise formally recorded. In addition to these technical aspects of construction planning, it may also be necessary to make organizational decisions about the relationships between project participants and even which organizations to include in a project.

Figure 2 simplifies the breakdown of the dependent variables that play a role in the development of a construction schedule. These variables are broken down into two main categories that deal with the two critical elements involved in the smooth running of a project: Cost Oriented and Schedule Oriented variables.

Cost Oriented Variables: In simple words, this is just a matter of buying and selling. When a project is constructed, excluding property costs, resources and raw material constitute for almost a hundred percent of the costs. Without sufficient capital these resources such as labor, steel, concrete, HVAC, etc (direct costs as per specifications) cannot be acquired. To determine precise details of an estimate the direct costs and indirect costs must be calculated.

Schedule Oriented Variables: Once work activities have been defined, the relationships among the activities can be specified. Precedence relations between activities signify that the activities must take place in a particular sequence. Numerous natural sequences exist for construction activities due to requirements for structural integrity, regulations, and other technical requirements. Figure 3 illustrates a simple example of a precedence relation:

Fig. 3

Similarly, a more complex precedence relationship involving a more complex network of activities can be established. Primavera and Gantt Charts are effective tools used to plan, organize, direct, control and budget a project effectively.

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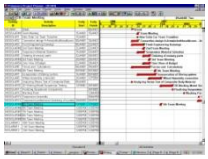
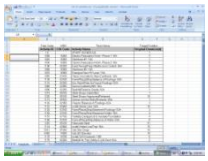
Excavation | Foundation | Steel Frame | Ext.Walls/Roofing
Int.Walls/Mech./HVAC | Landscaping | Finishing/Punchlist | Close-out

Files
(click file to open externally)

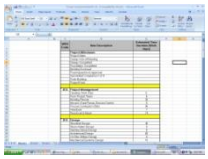
Original Primavera Systems schedule (PDF)



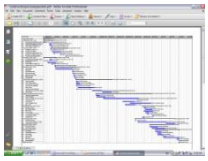
Activities by CSI division (approx. 350) & duration (XLS)



Summation of Activities by WBS codes (approx. 140) & item description (XLS)



Gantt Chart (List simplified from a multiple page schedule to a one page construction agenda - PDF)



Gantt Chart phase by phase (Mobilization thru Close-out - PDF)

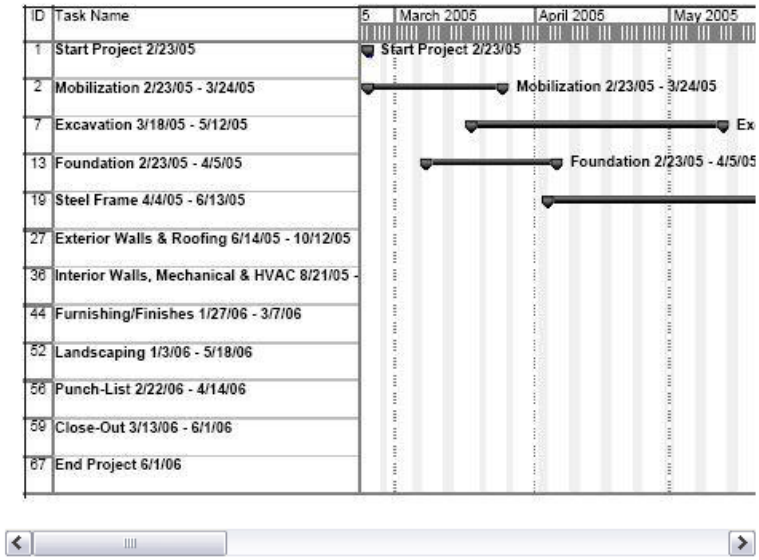
Bartlett Center Schedule

Construction on the Bartlett Center began on the 23rd February 2005 and continued for a period of one year and three months to be handed over to WPI on 1st June 2006. The schedule for this project is an elaborate precedence relationship flow chart of complex construction operations intertwined, working independently or simultaneously, produced by using Primavera (a widely used scheduling program), one activity following another with construction equipment and labor operating accordingly.

Engineers, accountants and superintendents follow this <Primavera schedule (PDF)>, where a list of activities to be completed, roughly 350 in Bartlett Center's case, can be broken down by its CSI division (www.icces.org) with its respective duration. Hence, the list of activities can be reduced to a summation of activities sorted by WBS Code (click here - new window - for example for WBS construction technique), with each and every item description as shown here (Each file can be found on the left panel - FILES - Click here).

Similarly, the complex schedule can be simplified by connecting, essentially, the same series of tasks together, to break it down phase by phase, and distributing activities into categories by mobilization through close-out, as listed on the main page (left pane). **From the next slide onwards, the construction schedule timeline will be demonstrated using the same methodology. Click here** (new window) **for the simplified Gantt Schedule listing activities.**

(Click here to interact with the Gantt Schedule for overviews on subtasks/activities involved in each task as shown below) - opens in new window



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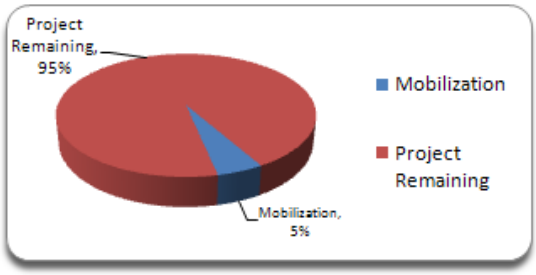
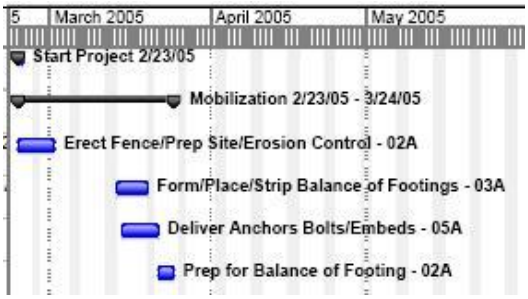
Mobilization Schedule Overview



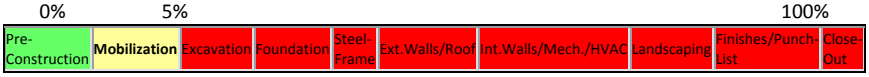


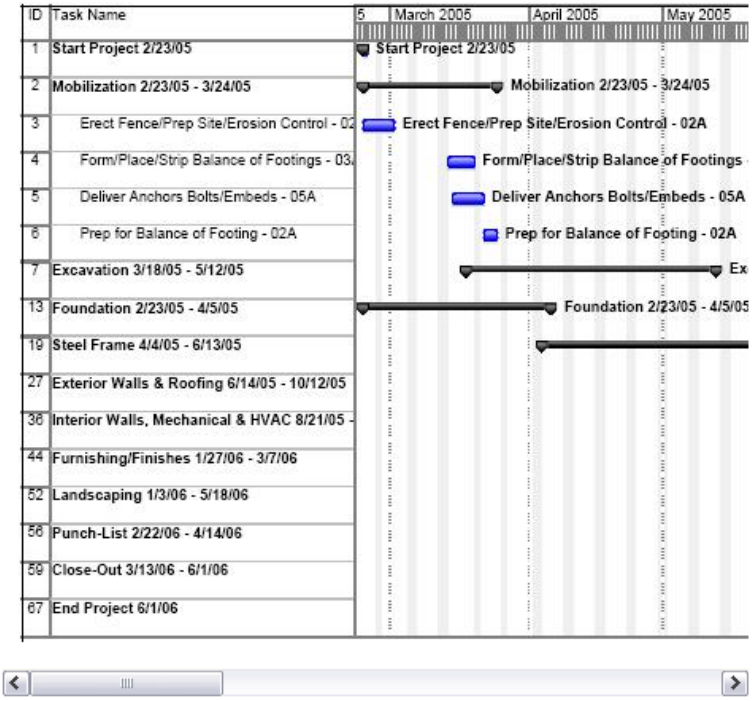
ID	Description	Start	Finish	BDPK
1030	Erect Fence/Prep Site/Erosion Ctrl	3/9/05	3/14/05	02A
1130	Form/Place/Strip Balance of Footings	3/14/05	3/18/05	03A
1115	Deliver Anchors Bolts/Embeds	3/22/05	3/22/05	05A
1126	Prep for Balance of Footing	3/22/05	3/24/05	02A

Mobilization

Mobilization is the planned act of transporting and establishing resources for the project, required and specified as per the contract. Mobilization shall include all activities and associated costs for transportation of contractor's personnel, equipment operating and maintenance costs, and operating supplies to the site; establishment of offices, buildings, and other necessary general facilities for the contractor's operations at the site. Some examples of construction equipment are lifting cranes, hoisting engines, back hoes, dump trucks, dozers, etc.

Project completion-o-meter:





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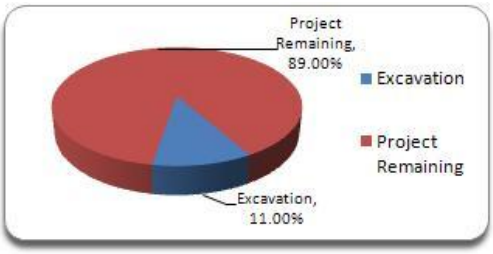
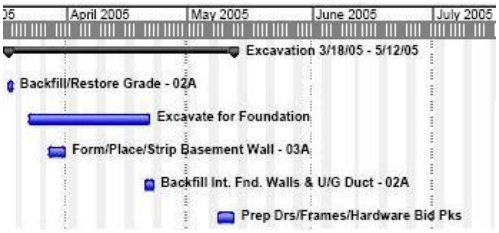
Excavation Schedule Overview



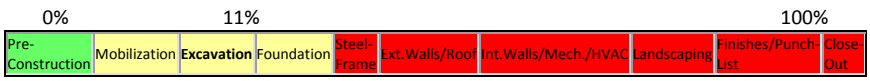


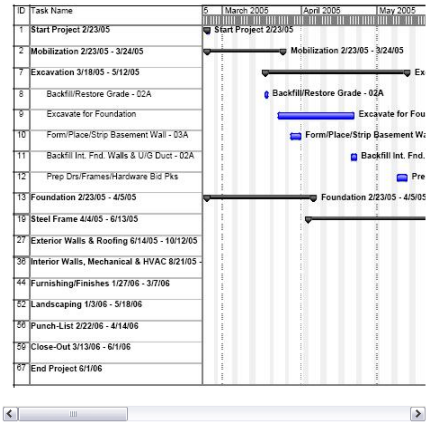
ID	Description	Start	Finish	BDPK
1090	Backfill/Restore Grade	3/18/05	3/18/05	02A
1130	Excavate for Foundation	3/23/05	4/21/05	02A
1150	Form/Place/Strip Basement Wall	3/28/05	3/31/05	03A
1175	Backfill Int. Fnd. Walls & U/G Duct	4/21/05	4/22/05	02A
5372	Prep Drs/Frames/ Hardware Bid Pks	5/9/05	5/12/05	08B

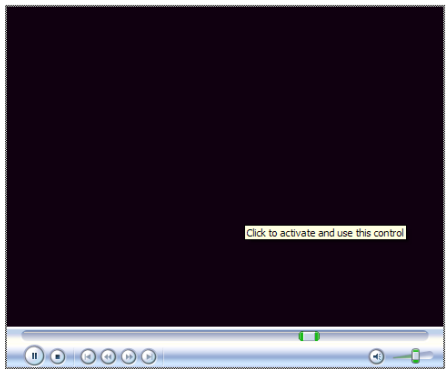
Excavation

This is the systematic 'digging-up' of soil at the location of the proposed structure. The entire skeleton of the structure that supports the dead-load of the components of the building, the live-load when it is inhabited, snow-loads, wind-loads and earthquake under different climatic circumstances, all depend on one thing: the foundation. Excavation equipment are chosen carefully for optimum performance within budget to cut costs and keep on top of the schedule. Soil bores are taken, and samples analyzed to determine the type of foundation required, and accordingly, the site is excavated and soil disposed off appropriately to make room for the concrete foundation that will be placed in its stead. Plans and drawings are double checked to be careful about pre-existing conduits to avoid damage to existing conditions. The Excavation in the Bartlett Center faced many obstacles due to restricted space in an active college environment. Large excavation equipment and machinery was a big problem in the confined space where hindrances in the everyday processes could be afforded.

Project completion-o-meter:







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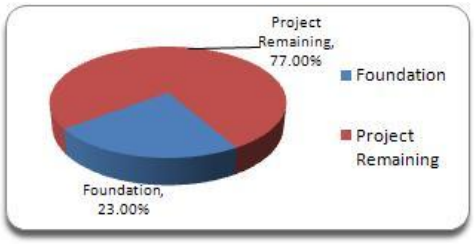
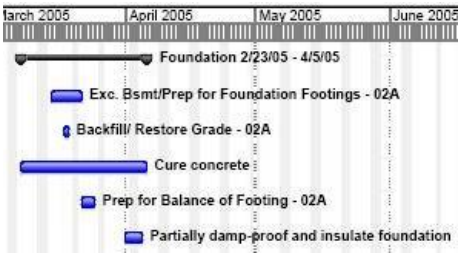
Foundation Schedule Overview



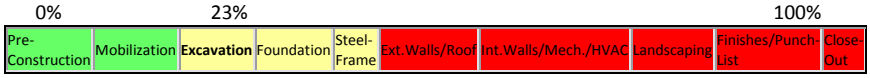


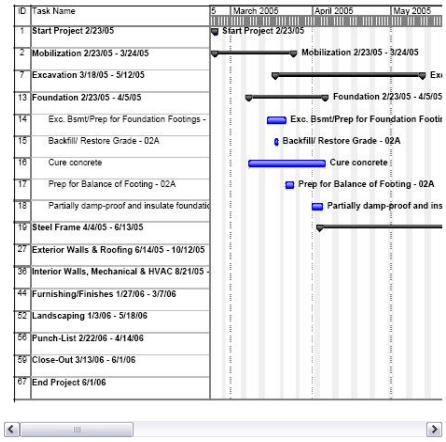
ID	Description	Start	Finish	BDPK
1110	Exc. Bsmt/Prep for Foundation Footings	3/15/05	3/21/05	02A
1090	Backfill/ Restore Grade	3/18/05	3/18/05	02A
	Cure concrete	3/8/05	4/5/05	03A
1126	Prep for Balance of Footing	3/22/05	3/24/05	02A
1153	Partially damp-proof and insulate foundation	4/1/05	4/4/05	03B

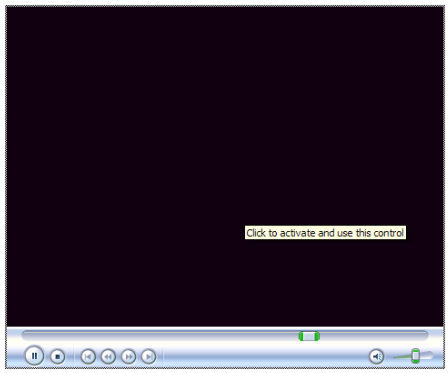
Foundation

Excavation and Foundation Development usually go together. Once excavation is complete, forms are placed to form the walls of the foundation and braced with shoring to make ready for the concrete pour. Depending on the type of foundation and according to specifications, concrete of specific strength and quality is transported by a fleet of concrete-mixing trucks. Each batch is tested on site for air content and slump. This is essential because if the foundation fails, the consequences could prove catastrophic. The foundation is carefully cured, and climatic controls are put in place for effective curing to achieve maximum desirable concrete strength.

Project completion-o-meter:







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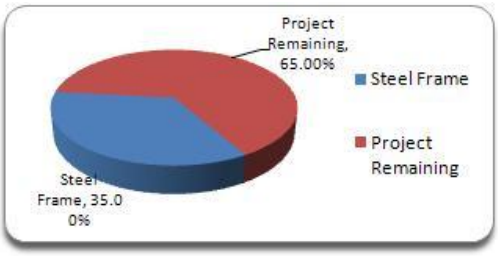
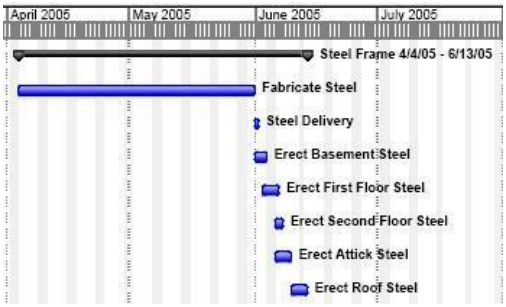
Steel Frame Schedule Overview



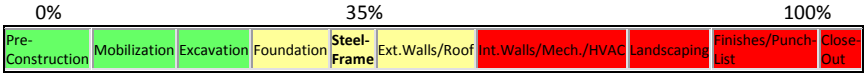


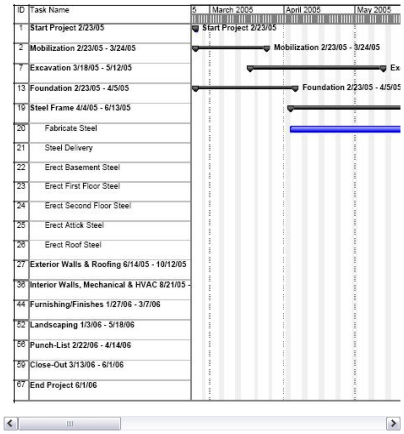
ID	Description	Start	Finish	BDPK
1225	Fabricate Steel	4/4/05	5/31/05	05A
1240	Steel Delivery	6/1/05	6/1/05	05A
1260	Erect Basement Steel	6/1/05	6/3/05	05A
1270	Erect First Floor Steel	6/3/05	6/6/05	05A
1275	Erect Second Floor Steel	6/6/05	6/7/05	05A
1280	Erect Roof Steel	6/10/05	6/13/05	05A

Steel Frame

Once the foundation is tested and approved for further construction, a silent celebration is in order because this is the point of construction where the project starts to take shape. As mentioned before, the steel frame structure of any project can be thought of as the structural skeleton, holding walls, floors and ceilings together to protect its inhabitants against inclement weather and providing a safe work environment for its employees. The Bartlett Center, as many buildings like its size, are framed with steel columns and beams. These columns and beams are designed before the procurement stages begin where the thickness and strength of these columns and beams are determined by the stresses they will carry. The weight they support must successfully transfer to the foundation below without buckling keeping the structure in equilibrium. Not only is the fabrication of the steel frame important to the structural stability of the building but the connections used to tie these columns and beams together play just as big of a role. Framework is costly and dangerous as construction moves from the first floor to the second, scaffolding and man-lifts are used to place heavy beams and girders above ground level increasing the risk of workers on site. After the steel frames have been erected, the floor decks are poured with concrete and rough roofing installed.

Project completion-o-meter:





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Finishing/Punchlist
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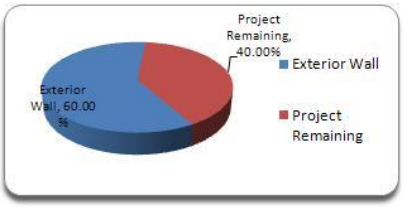
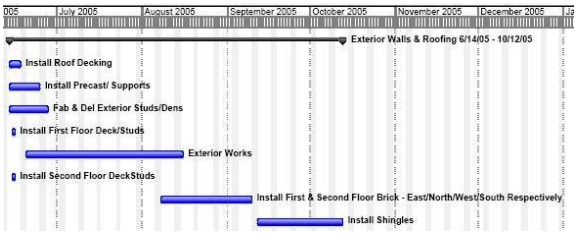
Foundation
Int.Walls/Mech./HVAC
Close-out

Exterior Wall & Roofing Schedule Overview



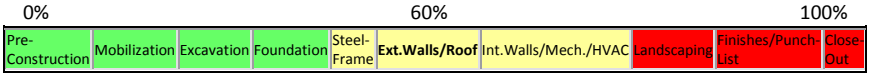


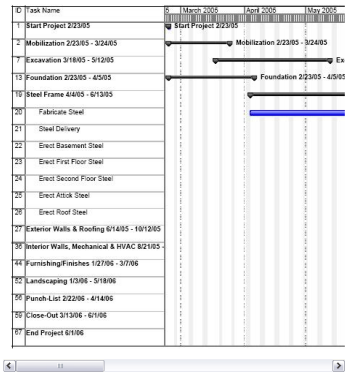
ID	Description	Start	Finish	BDPK
1290	Install Roof Decking	6/14/05	6/17/05	05A
1318	Install Precast/ Supports	6/14/05	6/24/05	05A
5096	Fab & Del Exterior Studs/Dens	6/14/05	6/27/05	09A
1295	Install First Floor Deck/Studs	6/15/05	6/15/05	05A
	Exterior Works	6/20/05	8/15/05	
1280	Install Second Floor DeckStuds	6/15/05	6/15/05	05A
2520	Install First & Second Floor Brick - East/North/West/South Respectively	8/8/05	9/9/05	04A
3140	Install Shingles	9/12/05	10/12/05	07A

Exterior Walls & Roofing

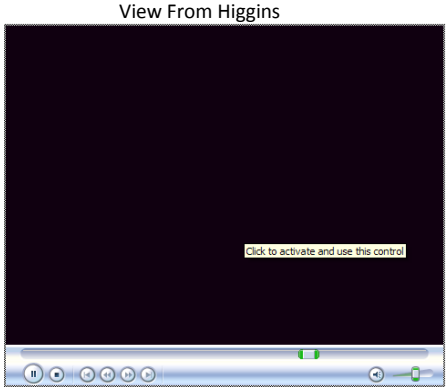
Exterior wall is the barrier between the inside and outside of the building. Over centuries, architecture has progressed into a new era where new ways to create an aesthetic facade to make a structure look magnificent, or in Bartlett Center's case, to make it blend into its surroundings, giving it a more 'old-school' academic appearance. Once the framing is complete, exterior walls are developed using concrete blocks, insulation, mortar and brick. The function of an exterior wall is more than that of keeping animals and unwanted elements of nature out, vents are designed to encourage air circulation and to help dissipate moisture within the air spaces. Flashing, weeps and insulation is used to keep the interior of the structure at a constant level without any leaks of any sort, keeping moisture out. The brick is laid by hand by masons, usually using scaffolding as the wall progresses higher, leaving gaps as per drawings for windows and doors. This is a meticulously tedious job as it is important to assure its functionality as well as its appearance. Roofing plays a similar role, it can be thought of as an exterior wall on the ceiling of the entire structure, using insulation and a combination of waterproof materials to help keep moisture (critically from snow and rain) out and provide shelter to its inhabitants. Bartlett Center's ten foot ceilings allow light to penetrate the interior spaces, where a double-height reception area acts as a natural chimney to pull air through the building for better circulation.

Project completion-o-meter:





View From Higgins



View From Harrington

<< Back

Interior Walls, Mechanical & HVAC - Next >>

Pre-Construction Phases | Construction Schedule | Bartlett Ctr. Schedule | Mobilization
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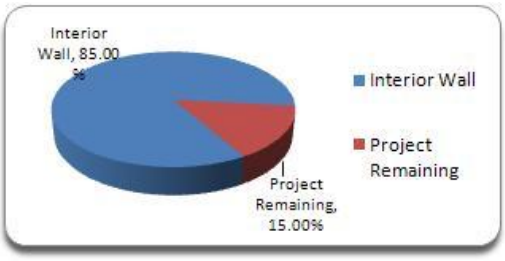
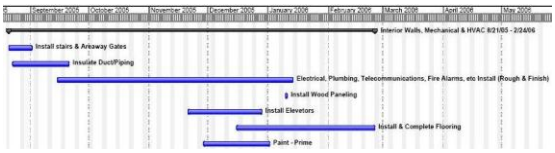
Ext.Walls/Roofing | Int.Walls/Mech./HVAC | Landscaping
Finishing/Punchlist | Close-out

Main Page Survey Picture Gallery Bartlett Center IQP Report

Interior Walls, Mech. & HVAC Schedule Overview





ID	Description	Start	Finish	BDPK
1360	Install stairs & Areaway Gates	8/21/05	9/1/05	05A
1663	Insulate Duct/Piping	8/23/05	9/20/05	15C
1640	"Electrical, Plumbing, Telecommunications, Fire Alarms, etc Install (Rough & Finish)	9/15/05	1/13/06	16A
1934	Install Wood Paneling	1/10/06	1/10/06	09A
1993	Install Elevetors	11/21/05	12/28/05	14A
1280	Install & Complete Flooring	12/16/05	2/24/06	05A
2520	Paint - Prime	11/29/05	1/1/06	04A

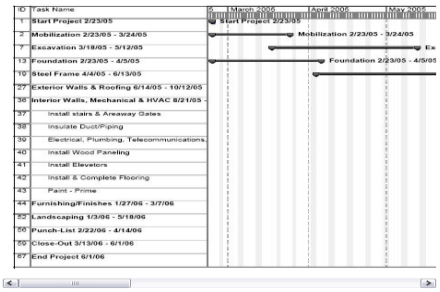
Interior Walls, Mechanical & HVAC

Once the exterior walls are assembled, windows and doors are installed and the interior of the structure can be focused on. Fire retardants are sprayed onto every inch to help prevent fire outbreaks. As per owner specifications on drawings, partitions are framed by spacing between the exterior walls to form rooms. The bare ceilings are attached with shelves and vents to support heating, air conditioning and ventilation systems, as well as sprinkler systems and continuous electrical wiring to be fed to every electrical outlet and switches in every room as specified by the electrical section in the specifications. The walls are insulated and either side plastered for a rough finish, forming walls. Mechanical and HVAC systems may be planted either in the attic or the basement, where heaters, ventilation systems, electrical systems, water boilers, etc are powered from to circulate either commodity to specified outlets in every room. bathroom fixtures are attached and all rooms are brought to a rough finish making sure every fan, light, tap, drain works.

Project completion-o-meter:

0% 85% 100%

Pre-Construction	Mobilization	Excavation	Foundation	Steel-Frame	Ext.Walls/Roof	**Int.Walls/Mech./HVAC**	Landscaping	Finishes/Punch-List	Close-Out



Click on thumbnails for larger pictures - hit 'Back' on your browser to go back to page)


Roof installation

Installation of the roof is a milestone completion regarding the exterior structure of the building


Doors & Windows

Once the exterior is complete, doors and windows are installed to seal off the interior for dust and thermal control


Interior Wall Frames

The skeletal structure of the interior walls are framed as per drawings, outline rooms


Electrical

Over head racks are installed on the ceilings to weave electrical wiring inside the building to each room


Plumbing

Plumbing piping, connections and conduit are laid out as per drawings


Electrical & Telecommunications

All relevant cables and wiring that have been run through the walls and ceiling racks are bundled neatly before walls and false ceilings can be installed


Piping Insulation

Water and plumbing related piping, and other critical carriers are insulated to prevent freezing and thermal deflections in winter months


Stairs and Floor carpentry


Stairs and Floors

Rough stairs and floors are installed, which are finished as the project progresses


HVAC

Ducts and vents used for air conditioning and heating and air circulation are installed for optimum performance


Frame Reinforcement

All wiring and cables are neatly tucked into the frames and adjustments are made and frames reinforced


Mechanical

Mechanical equipment to drive generators, pump air conditioners and heaters, water systems and telecommunication hardware are installed in the attick and inspected thoroughly


Electrical Panels


Panels/Main frames

The electrical, mechanical, HVAC and telecommunication systems are connected and installed, and the main operatory panels are installed to confirm functionality


Wall Insulation

The interior partitions are stuffed with insulation for decreasing thermal conductivity and to prevent drastic thermal changes during harsher climates, maintaining the inside temperature at optimum levels

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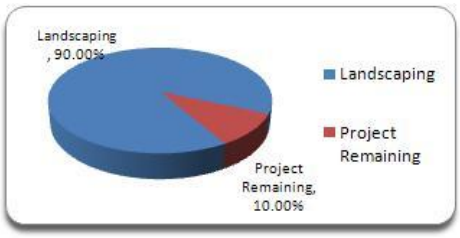
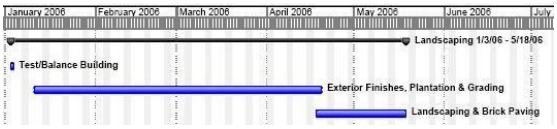
Landscaping - Next >>

Pre-Construction Phases | Construction Schedule | Bartlett Ctr. Schedule
Mobilization | Excavation | Foundation
Steel Frame | Ext.Walls/Roofing | Int.Walls/Mech./HVAC
Landscaping | Finishing/Punchlist | Close-out

Landscaping Schedule Overview



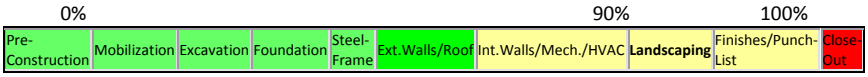


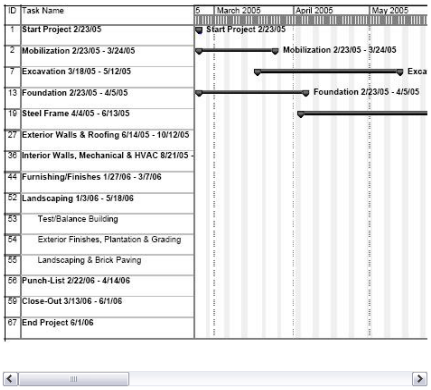
ID	Description	Start	Finish	BDPK
3705	Test/Balance Building	3/1//06	3/1//06	99E
3708	"Exterior Finishes, Plantation & Grading"	1/11/06	4/19/06	
3650	Landscaping & Brick Paving	4/18/06	5/18/06	02B

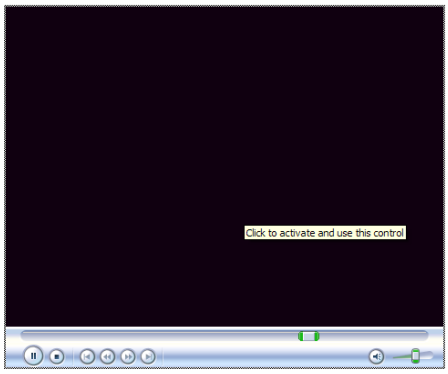
Landscaping

Landscaping is an art of transforming the project's exterior surroundings to quite literally, a sight for sore eyes. This task refers to any activity that modifies the visible features of the project milieu and may range from living elements such as trees, to landforms, elevations and bodies of water, to structural enhancements that help blend the structure in with its surroundings eliminating construction messiness. In the Bartlett Center's case, landscaping was kept in mind while the structural exterior such as entrance stairs, side-walks and walk ways were poured, and the process slowly progressed as the project was fenced in for safety reasons, continuing through until the project was at the finishing stages.

Project completion-o-meter:







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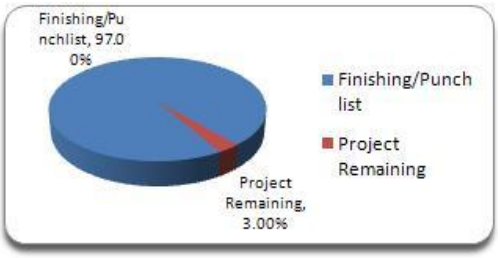
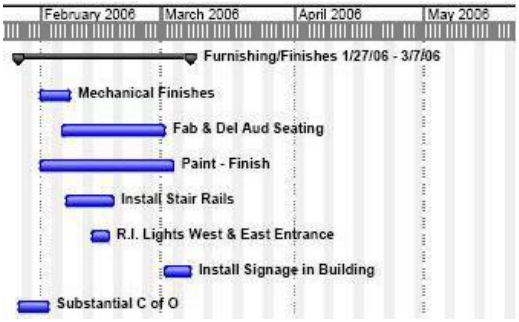
Finishes/Punch-list Overview





ID	Description	Start	Finish	BDPK
1110	Exc. Bsmt/Prep for Foundation Footings	3/15/05	3/21/05	02A
1090	Backfill/ Restore Grade	3/18/05	3/18/05	02A
	Cure concrete	3/8/05	4/5/05	03A
1126	Prep for Balance of Footing	3/22/05	3/24/05	02A
1153	Partially damp-proof and insulate foundation	4/1/05	4/4/05	03B

Finishes/Punch-list

This is the stage where the final inspection of construction work is conducted. The start of of closing out of the project begins near the end of a project, when the contactor requests a final inspection of the work. Before completion of the project, various equipment, electrical systems, and mechanical systems must be ready for testing and approval by the construction manager. A punch **list** is prepared listing all items that need to be completed or corrected. To develop this punch list, the field inspection personnel must carefully review their daily inspector's log to note all work items which have been entered that require corrective actions. The punch list is generally a list of tasks, or"to-do" items organized for the completion of a project.

Acceptance of the work and final payment to the contractor must be done in accordance with the specification sin the contract documents. Substantial completion of a project is the date when the construction is sufficiently complete in accordance with the contract documents so that the project can be used for the purposes intended. [1]

Project completion-o-meter:

0% 97%

100%

Pre-Construction	Mobilization	Excavation	Foundation	Steel-Frame	Ext.Walls/Roof	Int.Walls/Mech./HVAC	Landscaping	**Finishes/Punch-List**	Close-Out

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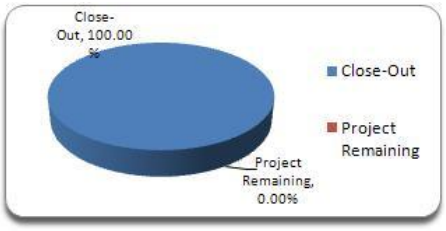
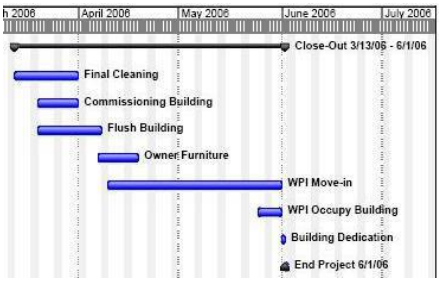
Finishing/Punchlist
Bartlett Ctr. Schedule
Foundation
Int.Walls/Mech./HVAC
Close-out

Close-Out Schedule Overview





[1] Oberlender, Project Management for Engineers and Construction. 2000

Close-Out

Construction management involves a number of steps that have to be processed before the project is finished. These steps include engineering study, final design, construction contractors, construction, and close-out, etc. Completing a project does not only comprise of the construction phase, there are other phases necessary to carry out a project. Contractually, construction management firms are required to perform paperwork and other type of administrative tasks before handing the project to the owner. That process is identified as close-out.

Furthermore, the close-out process for a construction project is the final stage before handing the project to the owner. The process includes the following items:

• Final Inspection (Certificate of Substantial Completion) • Punch List • Certificate of Occupancy • Guarantee/Warranty • Clean-up • Lien Releases	As-Build Drawings • Disposition of Project File • Call Backs • Disposition of Project File • Keys • Attic Stock • Owner's Manual

The final inspection is completed when the CM requests the owner's representative to visit the site in order to check the final work of the project. This is done after the project manager checks all the punch list items, which is a "to-do" list of items, still left after majority of work has been completed, and ensures that all the work has been completed. Upon the acceptance of work, a Certificate of Substantial Completion is issued by the CM and approved by the owner. The Certificate of Occupancy is issued after that by the state/city hall approving the building. At this point, the project can be used for its intended purposes and only minor items remain to be finished. The guarantee period is usually one year after completion of construction. The CM also submits guarantee/warranties for all equipment, machines and work done by subcontractors. The owner can request a lien release or a payment bond indicating that all subcontractors and laborers have been paid. A Lien is a hold on property for the benefit of someone whose work improves the property. [1]

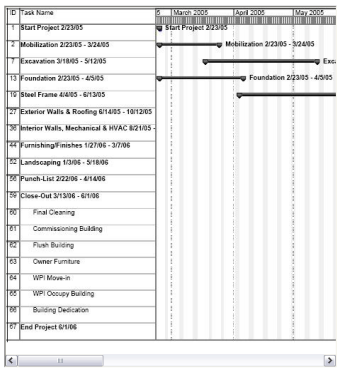
Another important part of close-out is the delivery of attic stock and keys from the subcontractors to the owners. This can be a lengthy process depending on the size of the project. Attic stock includes but is not limited to: gypsum boards, tiles, carpet, etc. The CM is also required to hand over record files and as-built drawings, prepared by all the subcontractors on the work they completed, to the owner at the end of the project. Close-out involves engineers, accountants, project managers, and the primary owner. It is a lengthy and important process in the construction management industry.

Close-out is often a time consuming process where nobody wants to take responsibility, thus, the CM must insure that there is a responsible party for each of the items involved in the close-out phase of the job. Good construction managers ensure that the close-out process starts as soon as project work commences, making sure that the subcontractors and all parties involved in the project close-out when they finish their work.

Project completion-o-meter:

0% 100%

Pre-Construction	Mobilization	Excavation	Foundation	Steel-Frame	Ext.Walls/Roof	Int.Walls/Mech./HVAC	Landscaping	Finishes/Punch-List	**Close-Out**



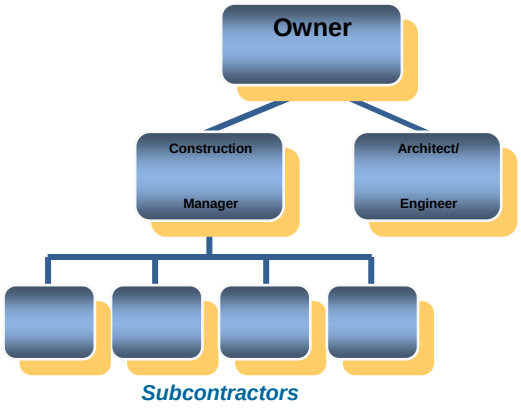
[<< Back - Finishing/Punchlist](#) [Picture Gallery - Next >>](#)

Pre-Construction Phases | Construction Schedule | Bartlett Ctr. Schedule
Mobilization | Excavation | Foundation
Steel Frame | Ext.Walls/Roofing | Int.Walls/Mech./HVAC
Landscaping | Finishing/Punchlist | Close-out

Main Page Survey Picture Gallery Bartlett Center IQP Report

Picture Gallery Options

Picture Gallery



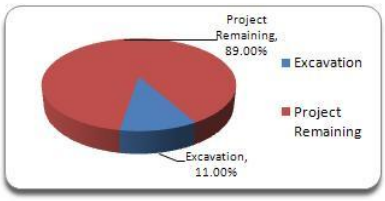
Construction entities hierarchy.

Relationship between Scope, Cost & Time

<< Back to Close-out **Main Page >>**

Summary Page on Bartlett Center Schedule page

Excavation Schedule Overview



Videos:

Excavation
Foundation
Steel Frame
Ext. Wall (Har)
Ext. Wall (Hig)
Int. Wall

Landscaping

Click here to Go Back (Close Window)

CSI List

CSI Division Number:

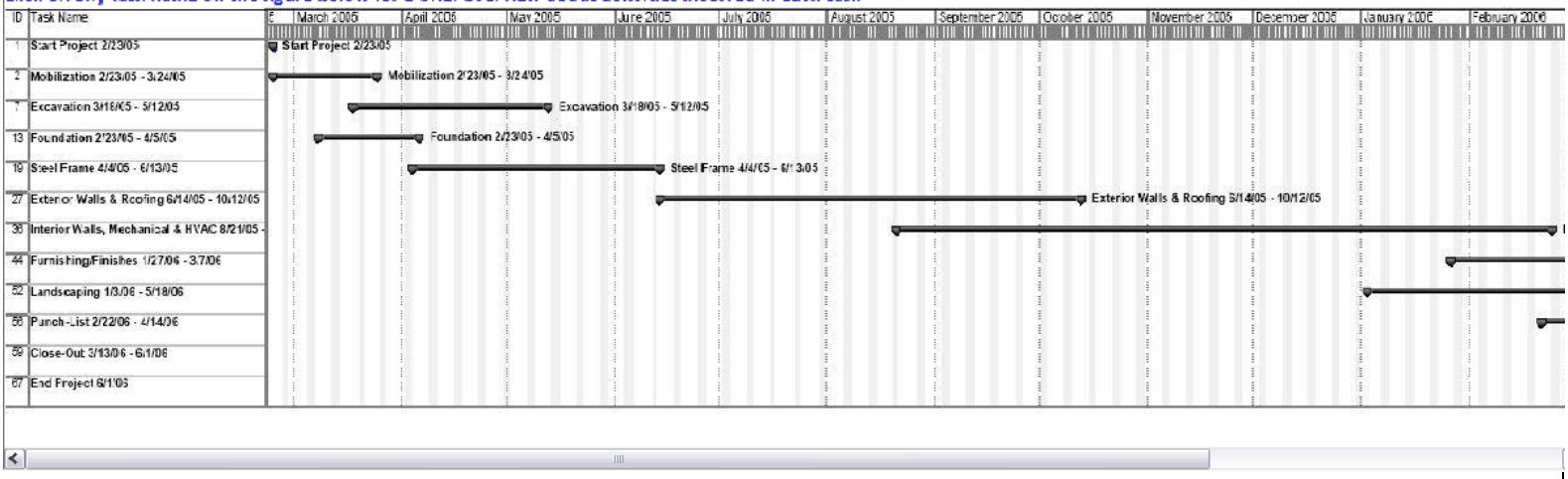
1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16

Division 01 — General Requirements

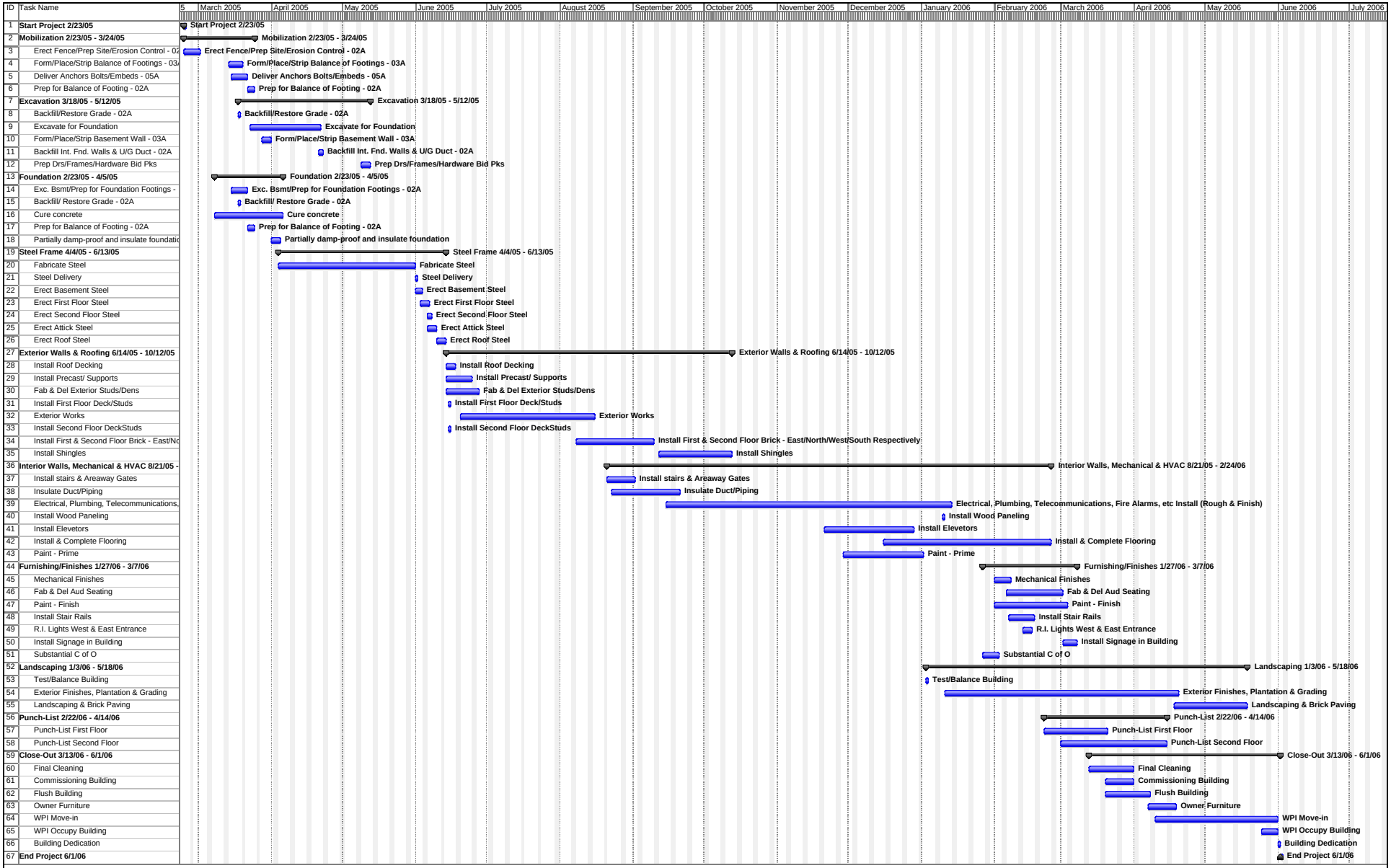
01410 - Testing Laboratories

01420 - Inspection Services

Click on any task name on the figure below for a brief overview about activities involved in each task



Appendix I – New Simplified Gantt chart Schedule (Publisher)


ID
Task Name
5
March 2005
April 2005
May 2005
June 2005
July 2005
August 2005
September 2005
October 2005
November 2005
December 2005
January 2006
February 2006
March 2006
April 2006
May 2006
June 2006
July 2006
1 Start Project 2/23/05
2 Mobilization 2/23/05 - 3/24/05
3 Erect Fence/Prep Site/Erosion Control - 02
4 Form/Place/Strip Balance of Footings - 03
5 Deliver Anchors Bolts/Embeds - 05A
6 Prep for Balance of Footing - 02A
7 Excavation 3/18/05 - 5/12/05
8 Backfill/Restore Grade - 02A
9 Excavate for Foundation
10 Form/Place/Strip Basement Wall - 03A
11 Backfill Int. Fnd. Walls & U/G Duct - 02A
12 Prep Drs/Frames/Hardware Bid Pks
13 Foundation 2/23/05 - 4/5/05
14 Exc. Bsmt/Prep for Foundation Footings -
15 Backfill/ Restore Grade - 02A
16 Cure concrete
17 Prep for Balance of Footing - 02A
18 Partially damp-proof and insulate foundatio
19 Steel Frame 4/4/05 - 6/13/05
20 Fabricate Steel
21 Steel Delivery
22 Erect Basement Steel
23 Erect First Floor Steel
24 Erect Second Floor Steel
25 Erect Attick Steel
26 Erect Roof Steel
27 Exterior Walls & Roofing 6/14/05 - 10/12/05
28 Install Roof Decking
29 Install Precast/ Supports
30 Fab & Del Exterior Studs/Dens
31 Install First Floor Deck/Studs
32 Exterior Works
33 Install Second Floor DeckStuds
34 Install First & Second Floor Brick - East/No
35 Install Shingles
36 Interior Walls, Mechanical & HVAC 8/21/05 -
37 Install stairs & Areaway Gates
38 Insulate Duct/Piping
39 Electrical, Plumbing, Telecommunications,
40 Install Wood Paneling
41 Install Elevetors
42 Install & Complete Flooring
43 Paint - Prime
44 Furnishing/Finishes 1/27/06 - 3/7/06
45 Mechanical Finishes
46 Fab & Del Aud Seating
47 Paint - Finish
48 Install Stair Rails
49 R.I. Lights West & East Entrance
50 Install Signage in Building
51 Substantial C of O
52 Landscaping 1/3/06 - 5/18/06
53 Test/Balance Building
54 Exterior Finishes, Plantation & Grading
55 Landscaping & Brick Paving
56 Punch-List 2/22/06 - 4/14/06
57 Punch-List First Floor
58 Punch-List Second Floor
59 Close-Out 3/13/06 - 6/1/06
60 Final Cleaning
61 Commissioning Building
62 Flush Building
63 Owner Furniture
64 WPI Move-in
65 WPI Occupy Building
66 Building Dedication
67 End Project 6/1/06
Project: Project_Initial_Timeline
Date: Sat 10/6/07
Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External MileTask
Split
Page 1

Appendix J – Bourque – Morais Website Template

Excavation

Foundation

Steel Frame

Exterior (Wall)

Windows & Doors

Roofing

Site Work

(Owner)

(Construction Manager)

(Architect)

Additional Pictures
Interior Pictures

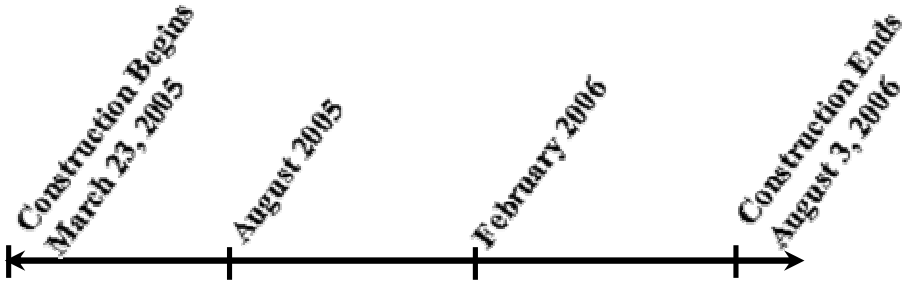
Survey:

http://www.surveymonkey.com/s.asp?u=838053255728

STEEL FRAME

The Steel Frame can be an exciting stage because it the first step in construction where progress can be seen above ground. The Bartlett Center, as many buildings like its size, are framed with steel columns and beams. These columns and beams are designed before the procurement stages begin. The thickness of these columns and beams are determined by the stresses they will carry. Not only is the fabrication of the steel frame important to the structural stability of the building but the connections used to tie these columns and beams together play just as big of a role. Although exciting, framework is costly and dangerous. When framework is being placed in a multiple story building, there is scaffolding needed to hold up the workers and the steel frame, the higher the story is, the expensive it becomes. As the cost goes up with height so does the danger.

Video Clip: Steel Frame



3/23/05-5/12/05	**EXCAVATION**
3/30/05-5/3/05	**FOUNDATION**
5/31/05-6/14/05	**STEEL FRAME**
6/11/05-7/11/05	ROUGH ROOFING
7/11/05-9/12/05	EXTERIOR (WALLS)
9/3/05-10/6/05	FINISH ROOFING
10/28/05-11/20/05	WINDOWS & DOORS
3/23/05-8/3/06	SITEWORK ——————————————————————————— SITEWORK

Excavation

Foundation

Steel Frame

Exterior (Wall)

Windows & Doors

Roofing

Site Work