around. Cars would enter the site and head left to park. Some cars parked in front of the trailers the entire duration of the project.

For Superstructure Site Plan See Appendix C.2

The second site layout plan demonstrates where everything was placed for the majority of the project. The materials were placed in the same areas as before. After the parking lot was paved, there was plenty of area for everybody's cars. During this phase you can see the traffic direction became stricter, which eventually helped keep the path as a one-way traffic area.

Research: Implementation of Software for Steel Buildings

An important issue facing the construction industry today is the implication of building information modeling (BIM) to projects. It is a growing technology and is not being implemented in the present time as much as it could be. If this software is used more often it can lead to better quality buildings and quicker turnovers.

Problem Statement:

What are the benefits of implementing BIM software into construction projects, particularly with steel lead times? Concrete is often used on a project, when considering lead time, over steel. If BIM can be used to lessen steel delivery lead time, it can be used more frequently than concrete.

Research Goal:

BIM is a growing technology and it is getting past its beginning stages of progression. The goal is to speak to a company who has used BIM for its structural steel erection and to explain how it has helped them speed up the process. Research will be done on other case studies to prove how it has helped speed up the design and lead time process. BIM shall also be incorporated in Plaza East to prove its advantages. Owners and contractors will be the audience and the benefactors of this research.

Research Steps:

Research for this project will begin with reading and reviewing of the subject matter given to me from Bob Lipman and Chuck Eastman. Bob Lipman has vast data on steel from his research and projects he has worked with. After the information is obtained, it will be summarized and put into the outcome. Further use of the model will include steel/concrete take offs for comparison and load testing.

Expectations:

During this process multiple case studies should be found to prove how BIM software has helped with the design process of steel. Also a superstructure of Plaza East will be made in Revit to incorporate the advantages in value engineering and work sequencing. If goals are met and if money for the project is saved, a summary of the research will be presented.

Outcome:

Building Information Modeling (BIM) is sweeping the construction industry and making a big difference. BIM can be used to help with coordinating MEP, visualizing a model, calculating take offs, and the list goes on. Many companies have used such models for so many project activities; one of the more interesting uses is taken from steel design.

When implementing CIMSteel Integration Standards/Version 2 (CIS/2) protocols for Electronic Data Interchange (EDI) a single model can be carried through the entire project. But, what exactly is CIS/2? CIS/2 is not a program or a function or language exactly. It is a translator or a bridge to help software programs to communicate. CIS/2 is endorsed by the American Institute of Steel Construction (AISC) and recognized by International Alliance for Interoperability. This process helps structure steel projects save time, money and get steel on site faster. It can be normal for a design engineer to use a physical model of a building to transpose information to 2D drawings. Through EDI this entire paper process is completely disregarded.

When one looks at this new type of software it raises questions about interoperability in the construction industry, specifically on steel construction. Interoperability relates directly to both the exchange and management of electronic information, as well as comprehend and integrating information across multiple software systems. Back in 2002, The National Institute of Standards and Technology (NIST) did a study of cost inefficient interoperability in commercial, institutional and industrial facilities. The results showed inefficient interoperability increased new construction costs by $6.18 per sq ft as well as operations and maintenance costs by $0.23 per sq ft. In total, inefficient interoperability cost the construction industry more than $15.8 billion in 2002. The three types of interoperability costs included: avoidance, mitigation, and delay. Avoidance costs include redundant computer systems and IT support staffing and inefficient business process management. Mitigation costs include manual reentry of data and RFI management. Delay costs include labor for idled employees. Another NIST study found that losses of $6.73 billion on 1.1 billion sq ft of construction came from lack of interoperability in 2004.

Below (**Table 2**) is the costs of Inadequate Interoperability by the Stakeholder Groups, by Life-Cycle Phase (in $millions)

Stakeholder Group	Planning, Engineering, Design Phase	Construction Phase	O&M Phase	Total
Architects and Engineers	$1,007.2	$147.0	$15.7	$1,169.8
General Contractors	$485.9	$1,265.3	$50.4	$1,801.6
Specialty Contractors/Suppliers	$442.4	$1,762.2	---	$2,204.6
Owners and Operators	$722.8	$898.0	$9,027.2	$10,648.0
All Stakeholders (Total)	$2,658.3	$4,072.4	$9,093.3	$15,824.0

Table 2

CIS/2 is a set of standards that allows a wide variety of design and construction software to seamlessly communicate with each other. It goes far beyond the current CAD formats to transfer information. When using CIS/2, the software incorporates information including loads, end member reactions, and connection types. The development of CIS/2 enables the structural engineer, detailer, and steel fabricator to reduce the time required to convert designs to fabricate components, improve quality control standards, and reduce cost. When importing directly from one computer to the other, engineers can be assured the design will not be changed when put into fabrication and the fabricator knows that the files received from the structural engineer are accurate. This is a great way to reduce design errors, which results in significant costs. This carries on into the erection process, which helps eliminate costly erection problems that come from fabrication errors. These problems can really delay a schedule.

Virtual Reality Modeling Language (VRML), developed by the NIST, is used to make 3D models which can be made to facilitate a paperless project. Bob Lipman, who heads the NIST's CIS/2 to VRML mapping explains, "VRML provides a 3D visual representation of a CIS/2 file. It allows users to visually verify a steel structure down to the bolts and welds to see what works and what doesn't." Lipman further went on to explain how they can link electronic versions (PDF) shop drawings to the appropriate steel members, and because VRML is viewable through the web browsers, multiple parties can view the 3D model and the shop drawings simultaneously, without the need for commercial software licenses. Imagine how much faster that can be without using the snail mail process of paper drawings.

CIS/2 can offer most value when it is used as early as possible in the design process, but it also helps to minimize schedule and cost impacts that can happen later in design. Because the design process happens so quickly, the architect and engineer have much more time to pass the drawings back and forth to refine everything to be 100% accurate. This is because the computers that transfer every bit of information eliminating manual reentry. When a model is updated it will show that update immediately to all trades able to see it. When this is done a timestamp is added to the model to show which version is the latest version.

In order to show how well the software works the original process of design is broken down as follows. Architects will present a conceptual idea to the structural engineer, who would design the structure using a structural analysis program. He would prepare design documents and send them to a fabricator. The fabricator would then do a full take off **by hand** to determine the amount of material needed for the structure. This process would be checked and double checked in order to be sure the shop bill accounts for all the materials. This process took about a week when it was done manually. This is more than a one person process also, so it isn't just 40 hours of work but up to 80 or 120 hours at a minimum. With interoperability this process takes hours. They can send files by noon and receive a bill from the fabricator by 3 o'clock.

Another feature, to save time, offered by CIS/2 is "multiples" method for counting steel more efficiently. Multiples can be calculated by the fabricator's software system. Mill material is normally rolled and stocked between 40 and 60 feet long, so you have to multiply to get the best cost when you purchase mill material. "That means if you need three 18 ft beams, you don't order those exact pieces—order one 55 ft piece and cut it to length in the shop. All those calculations use to be done by hand."

The facts, along with time and money savings, speak for themselves. The Glen Oaks campus in New York is the largest public-school construction project done by the New York School Construction Authority (NYSCA). It is located in Queens adjacent to the Cross Island Parkway. The site includes three separate schools: two grammar/middle schools and a high school. The middle schools are both four-story, 1000-ton steel frames, each about 125,000 sq. ft. The high school is a six-story, 1,500-ton steel frame, about 225,000 sq. ft. The plan was to get the three simultaneously built in 18 months. Using RAM Structural System software, CIS/2, and SDS/2 improved their steel delivery by 2 to 3 weeks. The erection process went at a rate of 700 tons and 100,000 sq. ft. of deck per month.

Chicago's Soldier Field had a $365-million makeover which was paperless. A paperless project of this scale was never before seen in the US, but this is what it took to meet the time restraints. The project needed to be gutted and reconstructed in 4 to 6 months less than a normal National Football League stadium project takes. Steel erection finished after 5 months, two weeks ahead of schedule. They started in January and around September the project was 75% complete and they were on budget.

This last case study is the renovation of Presbyterian Hospital in Albuquerque, NM. The project used 1,200 tons of structural steel to add 150,000 sq. ft to the building. Additional square footage for more rooms for patients and three stories were built on top of an existing four-story building. This entire process was to be done while the hospital was kept fully operational. Design began in September 2001 and in four months construction began. The upgrades were to be completed by July 2003. Using CIS/2 to translate the 3D model of the project to the SDS/2 detailing software saved much time. It would have taken hundreds of hours to recreate the model in SDS/2. Referring to the technology the fabricator was quoted saying, “We saved at least a couple of months as a result.”

This goes to show how much time and money can be saved using 3D models, CIS/2, and SDS/s software. More owners every year should be trying to implement this step into their design process. Doing so will not only save them time and money, but give them an extra layer of accountability to the process. “It can force collaborating firms to be more forward in explaining the projects costs.” NIST did a study and found that about 85% of owners/operators in the capital facilities industry are largely uninformed on the issues related to project cost. They must rely on the integrity of the people working for them: architect, engineers, and general contractors. They must rely on them to keep projects in specified budget.

You can see that adding on this new technology can add an increase to the structural engineer’s fees. However, the money and time saved on the project through schedule reduction, detailing and fabricating costs can more than offset these additional fees.

Conclusion:

There is no apparent reason not to have this technology added to all new and upcoming projects. A problem exists in the fact that not many people know about this technology or use it. I am trying to do my part and help by putting this knowledge out there, using the three case studies listed above. Getting three schools finished in 18 months and increasing steel delivery by 2 to 3 weeks is a significant success for a project of such size. Chicago’s Soldier Field needed to be gutted and reconstructed in 4 to 6 months less than a normal National Football League stadium project takes. Along with steel erection finishing 2 weeks ahead of time, shows another success. And last and certainly not least, the Presbyterian Hospital in Albuquerque, NM having a fabricator quoted saying they saved several months on the project points to another success.

In knowing that these projects saved so much time, and that the software helped remove confusion between contractors, subcontractors, superintendents, etc., I can see how this could have helped on Plaza East. Every Thursday the project team had team meetings to go over progress, confusing drawings and/or specifications. This technology could have helped solve over half the questions generated during these meetings just by having the up-to-date electronic copies of the buildings.

When I worked up in York, PA at ATI we had problems with the erectors and precast beams staying in place after the embed welding. The erectors had to come back the following day to fix it, which pushed back the mullion and window installations. This set off an ongoing delay of the mockup which ended up lasting almost 4 to 4 ½ months longer than it was suppose to. With this new technology no one will be out of the loop again and problems such as this can be resolved before they become a greater nuisance. I'm not saying the mockup would have been exactly on time. They had other problems with it that did not involve the erection process; but, those first few delays did not help the situation. It is time to move forward in this industry and by going paperless can be a very helpful first step, not just for certain individuals, for everyone in the industry.

A 3D model was in progress of being made for Plaza East, but the post tensioning of the girders combined with slabs proved to be more over my head than anticipated. In short, the model was then scrapped and the 3rd Analysis, which was to be my structural, had to be changed. I planned on using my new 3D model that was created in Revit Structural to be placed into RAM. Using RAM I was going to then test new roof loads of my building, and to also possibly test to see if steel would have been more cost efficient.