PENN STATE BALLPARK

University Park, Pennsylvania

AE Senior Thesis Project Summary

Spring 2006

Advisor: Dr. Michael Horman

Jason McFadden

Construction Management

Sponsored by Barton Malow Company, The Pennsylvania State University, and L. Robert Kimball & Associates.

Kimball
L. Robert Kimball & Associates
Architects and Engineers

2005—2006

Barton Malow

Jason McFadden

Construction Management Option

CPEP Website: www.arche.psu.edu/thesis/eportfolio/current/portfolios/jem358/

Medlar Field at Lubrano Park
University Park, Pennsylvania

PROJECT TEAM

Owner: The Pennsylvania State University

CM: Barton Malow Company

Architect: L. Robert Kimball and Associates

Structural Engineer: DLR Group

MEP Engineers: L. Robert Kimball and Associates

Interior Architect: DLR Group

Audio/Visual: The Sextant Group, Inc.

Signage & Graphics: Agnew Moyer Smith, Inc.

PROJECT OVERVIEW

Function: Sports Facility

Building Size: 152,194 S.F.

Location: University Park, PA

Estimated Project Cost: $30.8M

Construction Timeline: June 2005—May 2006

ARCHITECTURAL FEATURES

- 5,200 fixed spectator seating on the concourse level behind home plate, down each base line, in the outfield, and at the press/suite level.
- Home minor league and PSU locker rooms with a shared visitor locker room space.
- Separate administrative offices will be provided for each team.

PLAYING FIELD

- HUMMER Turfgrass Sand Grid Drainage System.
- By using a network of trenches and porous backfill materials, it provides a drainage system that can quickly absorb excess surface water in minutes to hours.

STRUCTURAL SYSTEM

- Typical spread and continuous footings for foundation system.
- Ordinary steel moment frames and masonry shear walls.
- Seating bowl constructed by sloping soil and pouring concrete slab-on-grade.
- Split-slab waterproofing system on the concourse level which consists of two layers of concrete with a waterproofing layer between the two layers of concrete.

MECHANICAL SYSTEM

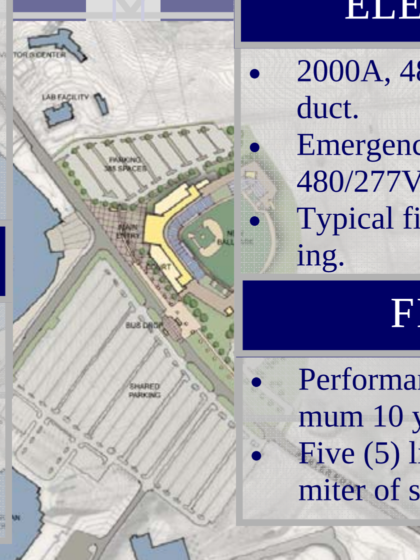
- (3) indoor air handling units; (2) roof top units
- (2) ductless split system AC units for refrigeration.
- Climate control via a VVT damper system.
- (2) 500MBH, 600 gallon gas water heaters
- (2) 20 GPM hot water re-circulation pumps.
- Combined dry and wet sprinkler system as required by hydraulic design with pendant, concealed, and sidewall heads.

ELECTRICAL SYSTEM

- 2000A, 480/277V system with a 2500A bus duct.
- Emergency Generator: 230 kW, 287.5 kVA, 480/277V
- Typical fixtures and lamps for interior lighting.

FIELD LIGHTING

- Performance based specification with a minimum 10 year life cycle cost.
- Five (5) lighting towers located around perimeter of stadium.



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ACKNOWLEDGEMENTS

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Mr. Philip Mackey	*Lighting/Electrical Candidate*
Mr. Adam Senk	*Mechanical Candidate*
Mr. Michael Vergari	*Construction Management Candidate*
Mr. Abrahm Vogel	*Construction Management Candidate*

Barton Malow Company

Mr. Forrest Brewer	*Senior Superintendent*
Mr. John Elder	*Project Engineer*
Mr. Len Moser	*Project Director*
Mr. Scott Mull	*Project Manager*
Mr. Ron Sinopoli	*Assistant Project Manager*

Bettwy Electric

Mr. Tim Bettwy	*President*

Industry Professionals Who Participated in Research Interviews

L. Robert Kimball and Associates

Mr. Charles Shaw	*Project Manager*

The Pennsylvania State University

Mr. Marv Bevan	*Project Manager (Office of Physical Plant)*
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Dr. Michael Horman	*AE Assistant Professor (construction)*
Dr. John Messner	*AE Assistant Professor (construction)*
Dr. M. Kevin Parfitt	*AE Assistant Professor (structural)*
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Dr. Walter Schneider	*AE Instructor (structural)*

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Ms. Babette Freund	*C.F.O.*

RNR Steel

Mr. Dave Edminson	*Executive*
Mr. Dale Hunt	*Superintendent*

EXECUTIVE SUMMARY

The first area of technical analysis was the structural columns that support the light fixtures design includes one (1) W14x132 columns and two (2) W14x90 columns with cross-bracing members connecting the structural bays. Because the structural steel package is on the critical path of the project and costs saving measures are often needed, I will analyze the structural columns which support the field lighting fixtures in terms of:

1. Value engineering methods to determine if an alternative structural member (ex. HSS) can be used to lessen the steel tonnage and decrease the cost while supporting the same loading.
2. Constructability methods to determine if the columns can be altered, but still achieve the aesthetic smooth appeal required by the architect.

The proposed column aesthetically looks the same as the designed members. Essentially, this method was chosen after studying the plan view of the designed column. It is apparent that the flange of the W14X132 member in the center of the tapered column does not do much structurally as depicted with a red arrow in the figure below. The alternative column design is a positive value engineering suggestion for the project. It provides an overall cost savings of $45,184.20 in labor, material, and equipment and a schedule savings of 7 days on erection of the columns.

The second area of technical analysis was proposing an electrical panel in the retail store and ticket building which is a separate building from the rest of the structure. The current design includes portions of two (2) panels which are not located within the building. One panel is 300A, 3 phase, 4 wire panel at 208V/120V for panel while the lighting is on a 225A, 3 phase, 4 wire panel at 480V/277V; both are located approximately 275' from the retail building. The proposed alternative design adds two (2) panels and a transformer. The alternative system is a positive value engineering suggestion for the project. It provides a cost savings of $8,771.38 in labor and material but most importantly the alternative system will provide the owner better electrical maintenance means during the building lifetime. Furthermore, the ease of expansion within the retail building will be much easier with the alternative system because wires and conduit do not need to be installed 275' away from the source of expansion.

The construction depth research was related to streamlining the structural steel design to construction through the implementation of computer modeling. A familiar problem in the construction industry is that a building is often designed on paper during the design phase; and then re-designed to determine "ability for construction" during the construction phase. The discussion focuses on streamlining the steel phase of a project with computer modeling along with how to take advantage of current technology to help a project team. The research methods included journal and industry article reviews, telephone interviews with steel industry professionals, and the development of a steel BIM for Penn State Ballpark. By analyzing existing practices during the steel phase of a project, a more streamline process for the steel phase of a project through computer modeling has been addressed. The above research discussion has benefited structural designers, construction managers, and steel fabrication because each entity can more effectively perform his/her job with the implementation.

Please note that all information pertaining to Penn State Ballpark is Jason McFadden's interpretation and may be different than the design and construction means and methods implemented by the project team.

SENIOR THESIS

Senior Thesis "Weight Distribution" by Breadth/Depth Study *Penn State Ballpark*					
Description	Research	Value Engineering	Constructability Review	Schedule Reduction	TOTAL
STEEL COLUMN VE	5%	25%	--	5%	35%
ELECTRICAL DIST. VE	5%	10%	5%	--	20%
STREAMLING STEEL / BIM	40%	--	5%	--	45%
TOTAL	50%	35%	10%	5%	100%

PROJECT PROPOSAL

BREADTH TOPIC #1

ANALYZE THE STRUCTURAL COLUMNS WHICH SUPPORT THE FIELD LIGHTING FIXUTRES

The *Penn State Ballpark* follows the same construction duration that has come to be accepted for sports facilities. Excavation of the 22 acre site began in June 2005 and the construction will end in May 2006 with the first game to be played in June 2006 for the minor league franchise. This means that approximately $25 million will be put in place in a twelve month time period. Furthermore, any delays in design or construction could have an immediate impact in finishing the project by May 2005.

The structural system package was released for bid in late May 2005 and bids were received by the middle of June 2005. The structural system package included 600 tons of structural steel with the interesting figure that 86 tons of that estimate was allocated to the structural columns which support the light fixtures as depicted below.

Ballpark rendering with the area highlighted which will be analyzed.

The area highlighted on the first base side is typical for the third base light fixtures as well. The design includes three (3) W14x132 columns with cross-bracing members connecting the structural bays. The overall height of the W14x132 members varies between the first and third base side because there is a sixteen (16) foot elevation difference; this is due to the fact that there is a basement level on the first base side but not on the third base side. Although the rendering appears to have the same structural support for the scoreboard in left field, this is not true. The structural supports for the scoreboard are being designed in conjunction with the scoreboard manufacturer, Daktronics Inc.

Barton Malow Company, the construction manager for the project, has developed a strong niche in the sports construction market including minor league baseball facilities. Because this project is not a design-build project with the construction manager having control of the architect, Barton Malow can only advise design changes. During the bid review period and post-bid meetings, Barton Malow suggested that these columns could be altered to support the same structural loading as well as achieve the same aesthetic look for the architect. One of the concerns proposed by Barton Malow and stated earlier was the fact that this area of the project accounted for 15% of the entire structural steel package. Furthermore, from past projects of similar size, Barton Malow has learned that the columns which support the main light fixtures of the stadium can be designed under 100 lbs/ft.

Because the structural steel package is on the critical path of the project and costs saving measures are often needed, I will analyze the structural columns which support the field lighting fixtures in terms of:

1. Value engineering methods to determine if an alternative structural member (ex. HSS) can be used to lessen the steel tonnage and decrease the cost while supporting the same loading.
2. Constructability methods to determine if the columns can be altered, but still achieve the aesthetic smooth appeal required by the architect.

In order to be able to accomplish the three (3) items listed above, I will need to first understand the design process of a structural engineer and how the design relates to the architects design intent. In order to accomplish this, I will discuss the design steps taken by a structural engineer with the professors in the structural option within the architectural engineering department at Penn State University as well as discuss the design intentions with the structural designer from DLR Group. This will allow afully understand the design requirements and intent before I begin to technically critique the field lighting structural supports on the first and third base line.

Next, I will contact Barton Malow Company and ask for information about the field lighting structural supports on past minor league baseball projects. I will need to ask for the following information when talking to them:

1. Size of the structural members in the described area.
2. Shape of the structural members in the described area.

Once I receive this information, I can begin determining possible alternatives to the field lighting structural supports. Using my knowledge of AE 401 (basic steel design), I will determine the size and shapes of the steel members needed to support the field lighting fixtures for *Penn State Ballpark*. In order to determine if the aesthetic look is affected with the alternative design, I will model alternative design in AutoCAD.

Once my technical analysis has been completed and modeled, I hope to have successfully found an alternative way to design the field lighting fixture structural supports. This will ultimately allow for cost savings in the structural steel package, but might allow for a quicker erection time in this area due to lighter and less steel members. Furthermore, I will be able to use the knowledge I have learned from performing this analysis when value engineering ideas might be needed on future projects and the project team might need suggestions in how to achieve the same look with lighter steel members.

BREADTH TOPIC #2

ELECTRICAL DISTRIBUTION ANALYSIS FOR THE RETAIL STORE AND TICKET BUILDING

The electrical system design for *Penn State Ballpark* was documented rather quickly and sent out for bid without complete design documents. When the electrical package was awarded to the responsible low bidder, a new set of electrical construction documents was released. Not only did this require the electrical contractor to submit appropriate pricing for the changes, but the construction manager also had to make the necessary planning changes for the revised electrical work. Because the electrical package was assembled quickly, there is one item that I have found to give the owner, The Pennsylvania State University, a more worthwhile facility.

As depicted below, the retail store and ticket building is separate from the rest of the structure and will be used during non-operating game times.

Ballpark rendering with the area highlighted which will be analyzed.

Within the 2000 square foot structure, there is a ticket booth area, a retail store, an office, a small mechanical room, and a storage area. The spaces contain standard electrical equipment devices including light fixtures, wall receptacles, and data outlets. All of the electrical wiring for this area is designed to be run overhead through the canopy structure and into the building. Because there is no underground raceway conduits designed for this area, there is an added labor cost for running all wires through the canopy along with extra material cost for running the wires to the required panel board. Furthermore, by not designing an electrical panel within the building, electrical maintenance could become an issue. If an electrical problem arises, the maintenance crew must find an electrical panel that is not near the retail store and ticket building.

Because of the issues named above, I have decided to design an electrical panel located within the building. The current panel which is not located within the building is 300A, 3 phase, 4 wire panel at 208V/120V for panel while the lighting is on a 225A, 3 phase, 4 wire panel at 480V/277V. In order to design a new panel, I will determine all of the connected loads with the appropriate electrical design factors for lighting, receptacles, and mechanical equipment. I will also provide underground raceways to the help minimize the wires that travel through the canopy area. Lastly, I understand before beginning the electrical calculations that two electrical panels will be required and a step-down transformer will be needed for the electrical receptacles and track lighting in the area. Furthermore, I will provide a cost-benefit analysis between the designed system and the proposed re-design to help determine the value of using an alternative system.

CONSTRUCTION DEPTH RESEARCH

STREAMLINING THE SUPERSTRUCTURE DESIGN & CONSTRUCTION THROUGH COMPUTER MODELING

1. **Chapter 1: Introduction**
    a. In July 2005, the General Services Administration (GSA) announced that all new projects requiring their funding will need to include a building information model (BIM) as part of the project proposal.
        i. The term BIM is a relatively new term in the industry, but in the past has been noted as a project model or multi-dimensional (MD) modeling.
        ii. Essentially a building information model is a materialized 3D model meaning that everything in the building is drawn with its true properties. An example of this is with an exterior masonry wall. A typical 3D model would just draw the dimensions of the wall, whereas a BIM details the wall with its brick façade, air barrier, sheathing, studs, etc. for the wall properties.
        iii. The GSA's requirement with a BIM needed for all of their future projects is a new approach to project design and delivery. In the past, many projects have been designed in three dimensions, but have not included the object properties which would make it a BIM.
        iv. Computer aided project development has been in the industry for quite some time, however implementing it has been a hardship. Many owners, architects, and construction managers have not seen the value that these models can bring to a project mostly due to initial costs and time to develop the models.
    b. On-going Construction Industry Problems:
        i. Duplication during the steel sequence continues to be a problem in the industry. The structural engineer designs the steel structure for the building and then the structural steel contractor, upon award, re-designs the building through steel shop drawings. Because of the need to produce these shop drawings, steel cannot begin fabrication until six to eight weeks after an award is made to the steel contractor and shop drawings are approved.
    c. This research proposal will focus on a BIM of the superstructure for *Penn State Ballpark*. The goals and objectives of this research are to answer the following questions:
        i. Can the construction industry reduce the waste in the steel shop drawing process through implementing building information modeling?
    d. By analyzing existing practices (shop drawings and coordination) during the steel phase of a project, I will propose a more streamline process for the steel phase of a project.

2. **Chapter 2: Background/Literature Review**
    a. Currently, there has been a lot of research devoted to computer aided design/construction research. Most of this research is based on project case

studies and not how to effectively implement computer aided models on a construction project.

b. Most projects are documented with a 3D model which is made during the preconstruction phase of a project. These models are used to develop a rendering of the project which is mainly used for marketing purposes. Unfortunately, these models are 3D models and not building information models. Furthermore, these models are very rarely taken from the design phase of a project and implemented in the construction phase.

c. During the summer of 2005, I began my initial study of building information modeling. My research paper was tilted, “Integrating Building Models In the Construction Workplace,” and documented some of the current practices with computer modeling within the industry.

    i. The most valuable information received during the research timeline were the responses to a series of survey’s I sent to architects/engineers, owner representatives, and construction managers. The survey’s asked a series of questions relating to implementing a 3D and 4D model on the project and the value that each can bring to a project.

d. Many industry members are interested in implementing new technology on a project, but either do not know how or cannot afford the cost and time associated with developing a model. Some trades in the industry already implement 3D models to assist with pre-fabrication of systems with the steel trade being at the top of the list in terms of implementing technology.

3. Chapter 3: Objectives and Methods

a. Problem Statement

    i. Duplication of structural design delays fabrication of structural members and is a problem that affects each project in the construction industry.

b. Specific Measurable Objectives

    i. Review literature and understand current practice.
    ii. Develop a solution to implement a Structural BIM on a project.
    iii. Test and validate proposed solution.
    iv. Leave ideas for future research.

c. Methods

    i. First, I will read articles documenting projects that have implemented building information modeling and understand how the research was performed.
    ii. Next, I will find any articles relating to the shop drawing sequence of a project in order to see if there is already documented waste in this process.
    iii. Then I will find any articles relating to the steel fabrication of a project and any known documented problems that may exist.
    iv. Through building information modeling during the design phase, the time invested during the shop drawing phase can be decreased and coordination between steel material fabricators can be more easily achieved.

        (1) I will make a building information model of the superstructure sequence of the project using Autodesk Revit Structure 2. This program has all of the structural members and shapes that are in the current steel manual including joists and decking which will allow me to produce an accurate model.
    v. I will then obtain a copy of the CIS/2 modeling standards which describe means of information transferred between steel computer software.
    vi. Once the computer model is made, I will contact steel industry organizations, structural engineers, steel contractors, steel detailers, and construction managers and discuss with them the items that are needed to go from design to fabrication.
    vii. By documenting the problems found in the shop drawing process, I can propose an alternative means and methods to the structural design and approval phase of a project.
    viii. Lastly, I will describe the overall affect of implementing a BIM for the structural sequence through a case study project and document the value of such a model for fabrication and design coordination.

d. Expected results / outcome / benefits
    i. In developing a BIM of the superstructure for *Penn State Ballpark*, I will be able to address better techniques in going from steel design to fabrication stage of a project. Furthermore, I will be able to address better coordination techniques between steel suppliers.
    ii. This research project will help me identify current problems and time constraints associated with the steel/structure phase of a project and allow me to suggest alternative methods to beginning the construction of a steel structure.
    iii. Because the steel phase of a project is often on the critical path, any time that might be able to be saved could result in a quicker delivery of the entire project. This research will benefit structural designers, construction managers, and steel fabricators as well as leave ideas for continued research in streamlining the design to construction of the structural sequence.

e. Timeline
    i. January 2006
        (1) Read articles about current BIM projects, studies performed with the steel sequence, and any articles with current fabrication practices.
        (2) Develop a BIM of *Penn State Ballpark's* superstructure.
    ii. February 2006
        (1) Contact steel contractors and discuss questions proposed above.
        (2) Analyze the results of the study.
    iii. March 2006
        (1) Summarize and document results of study.
    iv. April 2006
        (1) Present results of study to construction industry members.

SUMMARY AND CONCLUSIONS

The structural analysis proved that an alternative column design could be used and is a positive value engineering suggestion for the project. It provides an overall cost savings of $45,184.20 in labor, material, and equipment and a schedule savings of 7 days on erection of the columns. Through this analysis several advantages were noted including added waterproofing and easier electrical cable installation to the power the field lighting fixtures. The only noted disadvantage with the alternative column design is that the additional welding expertise to fabricate a "custom" column could limit the amount of steel fabricator's willing to bid the work. By performing this analysis, I was able to successfully provide an alternative design and satisfied the goals associated with the analysis. This analysis is a valuable tool for a construction manager to be able to discover. An understanding of the cost and benefits to changing a structural column can help identify alterations of future projects.

The electrical analysis proved that an alternative system is a positive value engineering suggestion for the project. It provides a cost savings of $8,771.38 in labor and material but most importantly the alternative system will provide the owner better electrical maintenance means during the building lifetime. Furthermore, the ease of expansion within the retail building will be much easier with the alternative system because wires and conduit do not need to be installed 275' away from the source of expansion. This analysis is a valuable tool for a construction manager to be able to utilize when providing value engineering suggestion to an owner. An understanding of the cost and benefits to modifying an electrical system can help identify alterations of future projects. Overall, the alternative system is a very positive electrical value engineering suggestion for the owner and will provide positive effects during the building operation.

The construction industry research topic regarding streamlining the steel design and construction through computer modeling proved to be very information and worthwhile. From interview discussions with steel construction industry professionals, there are several challenges to implementing this technology. These challenges include contract language, design development and management, technology, communication with project team members, and the issuing of hard copy (paper) drawings. With the stated challenges, a proposed method to addressing the challenge is expressed. A case study with the *Penn State Ballpark* project examined the effects a BIM could have on a better delivery on the design and expediting the steel shop drawing duration with a building information model supplied by the structural engineer. By analyzing existing practices during the steel phase of a project, a more streamline process for the steel phase of a project through computer modeling has been addressed. The research discussion has benefited structural designers, construction managers, and steel fabrication because each entity can more effectively perform his/her job with the implementation.