A BIM-ENABLED INTEGRATED DESIGN APPROACH FOR AN ATHLETIC FIELD/PARKING GARAGE FACILITY AT THE WPI CAMPUS

by
G.F. Salazar, S.O. Alvarez, & M.L Gomez,

Worcester Polytechnic Institute, Worcester, MA;
January 10, 2014
What is in a word, BIM & PDS

• Cooperation
  • Working Together for a common benefit (Intersection of goals)
  • Lonely BIM, Hollywood BIM
  • Design-Bid Build, CM, DB

• Collaboration
  • Working Together for Achieve shared goals
  • Social BIM,
  • DB, CM, IPD “ish”

• Integration
  • Process of making whole
  • Intimate BIM
  • True IPD
In late October 2011, WPI made a decision to build a $20 M dollar, 536 cars one-story Parking Garage project with a rooftop Athletic Field on artificial turf for soccer, field hockey, lacrosse, rugby, and softball uses.

The project was delivered under a contractor-led design build system. The parking area was completed and occupied in January 2013 whereas the playing fields were substantially completed in the summer of 2013. BIM modeling was used by the contractor but it was not part of the contractual requirements for the project.
Study Objectives

Use BIM methodology to better understand potential benefits in Design-Construction Integration, looking into

- Design time reduction
- Design changes
- Enhancing communication and coordination during the design and construction stages of the project
Conduct a parallel simulated exercise

**ACTUAL PROJECT**

**DESIGN**
- Contractor’s BIM model
  - 2D Design, Cost & Schedule

**CONSTRUCTION**
- Progress observation
- Progress observation
- Progress observation
- Progress observation

**SIMULATED STUDY PROJECT** (as intended)

- BIM EXEC PLAN
- BIM MODEL, LOD 300
- ISSUE IDENTIFICATION
- ISSUE ANALYSIS
- ISSUE ASSESSMENT
- RESULTS
- CONCLUSIONS

G. Salazar, S. Alvarez, M. Gomez
Conduct a parallel simulated exercise

ACTUAL PROJECT

DESIGN
CONSTRUCTION

Contractor’s BIM model
2D Design, Cost & Schedule
Progress observation
Progress observation
Progress observation
Progress observation

BIM EXEC PLAN
ISSUE IDENTIFICATION
ISSUE ANALYSIS
ISSUE ASSESSMENT
RESULTS
CONCLUSIONS

WPI

SIMULATED STUDY PROJECT
(as conducted)

BIM MODEL, LOD 300
BIM Model
Model Granularity

- Imported (IFCs) from TEKLA Precast BIM Model
- Model created at LOD 300
- There are 2621 objects in the model
- Contractor original schedule has 238 activities
- Contractor Original Estimate has 24 Bid Packages
- 5D Model has 78 Activities and 16 Bid Packages
5D View Model

BIM Model for Parking Garage-Rooftop Fields, Models by S. Alvarez & M. Gomez 2012-2013

G. Salazar, S. Alvarez, M. Gomez
BIM Study Execution Plan

1. Identify BIM uses and key deliverables and constraints of the selected project.
2. Map the actual design development process of the selected project.
3. Define a BIM-enabled Integrated Design approach suitable for the selected project.
4. Simulate the actual process as an alternative BIM-enabled Integrated Design Process while creating a BIM model with Level of Development (LOD) 300 based on the key deliverables and constraints mapping.
Design Deliverables & Constraints

• *Owner constraints.* Restrictions imposed by the owner through the architectural program.

• *Code constraints.* Constraints prescribed in the applicable building codes that clearly restrict the design of the deliverable.

• *Design constraints.* Constraints not regarding any official code but the by the ethics and practices in the design.
Table 1.
Athletic Field/Parking Garage Project
Deliverables and Constrains

<table>
<thead>
<tr>
<th>Deliverables</th>
<th>Owner Constrains</th>
<th>Code Constrains</th>
<th>Design Constrains</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schematic Design</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design Development</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parking Layout</td>
<td>+ Minimum of 600 parking spaces</td>
<td>+ Setback of 50 ft to Park Av</td>
<td>+ Allocate the space occupied by the concrete structure and not affecting number of parking spaces</td>
</tr>
<tr>
<td>Field layout</td>
<td>+ Church space sharing arrangement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concessions/Storage/Lockers Layout</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field Pad</td>
<td></td>
<td>+ Drainage stormwater flow rate</td>
<td>+ Weight of the grading for drainage</td>
</tr>
<tr>
<td>Spectator Services</td>
<td>+ Allocate temporary bleachers, sound systems, and scoreboards.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entrances</td>
<td>+ Provide access to field of the maintenance vehicles.</td>
<td>+ Avoid disturbance of traffic on Park Ave and Salisbury St.</td>
<td>+ Access provided on Park Ave should be according to Park Ave Image.</td>
</tr>
<tr>
<td>Foundations</td>
<td>+ Restriction on number of testing booms at early stage</td>
<td></td>
<td>+ Provide safety on all access, specially in the stairs towers.</td>
</tr>
<tr>
<td>Landscaping</td>
<td>+ Restriction on number of testing booms at early stage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lighting</td>
<td>+ Sustain Control</td>
<td></td>
<td>+ Luminic Pollution to Park Av</td>
</tr>
<tr>
<td>Safety and Security</td>
<td>+ Surveillance system</td>
<td>+ Surrounding Protection Net</td>
<td>+ Fire protection</td>
</tr>
<tr>
<td>Cost Estimating</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scheduling</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Construction Documents</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shop Drawings</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Site & Project Access
Deliverable: Site & Project Access

Owner Constraints:
• Provide access to the field for the maintenance vehicles.
• Set conditions for the future construction of the bridge to Harrington building.

Code Constraints:
• Avoid disruption of traffic on Park Ave and Salisbury St.
• Provide access to firefighter vehicles

Design Constraints:
• Access provided on Park Ave should be designed to preserve/blend with Park Ave Image.
• Provide safety on all access, specially in the stairs towers.
Mapping the Process (Observations from Project Team Interactions)
BIM Execution Plan

- BIM Execution Plan – Level 1

- BIM Execution Plan – Existing Conditions Modeling

- BIM Execution Plan – Design Review Process
BIM Execution Plan – Level 1 (Phases)
BIM Execution Plan – Existing Conditions Modeling

Reference Information

Process

Information Exchanges

BIM Execution Plan: Existing Conditions Modeling
Project: Athletic Field/Parking Garage

Function

- Site Information
- Existing Conditions

- Identify the existing conditions of the site
- Layout of the site conditions

- Establish Information Exchange Requirements
- 3D Model of Existing Conditions
- Validate Accuracy of 3D Model of RC
- Integrate Model with CAD
- End of the Model

- Information of the Site Topography
- Information of the Existing Conditions
- Arch Model

- 3D Model of the Existing Conditions
BIM Execution Plan – Design Review Process
Workflow Issues Analysis

a) Issues detected due the use of BIM Models [Red]

b) Issues caused by lack of systematic checks of the program assumption [Blue] and,

c) Issues that could have been solved during reviews [Green].
Workflow Issues Analysis
Workflow Issues Analysis (existing conditions)
Workflow Issues Analysis (design review)
<table>
<thead>
<tr>
<th>Date</th>
<th>Issue</th>
<th>Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/13/11</td>
<td>An alternative ramp adjacent to the southeast end of the garage was discussed (Aesthetic and functionality of the bridge)</td>
<td>With the 3D BIM model of the Parking Garage and Existing Conditions, would be easy to visualize the aesthetics and functionality of the future bridge related with the REC Center and the Harrington Gym</td>
</tr>
<tr>
<td>3/8/12</td>
<td>Construction issues on the precast joints of the corner spandrels panels and pilasters to support the roof of the access stairs. (2D drawing vs 3D structure model)</td>
<td>3D model would be helpful to analyze the different solution for the precast joints and pilasters of the access stair. At the same time, with the architectural and structural model (generated with the architectural model as reference) inconsistencies between 2D drawings would be avoided</td>
</tr>
<tr>
<td>03/15/12</td>
<td>Still to define pilaster and posts support on the corners stairs (roof)</td>
<td></td>
</tr>
<tr>
<td>3/22/12</td>
<td>Differences were found on the levels between the structural BIM model and Design Drawings. Design drawings do not reflect the lowering of the gravel grade height decided weeks ago</td>
<td>With the architectural and structural model (generated with the architectural model as a reference) inconsistencies between the models and the 2D drawings would be avoided</td>
</tr>
<tr>
<td>3/29/12</td>
<td>Discussion about the retaining wall needed on some parts of the perimeter to contain foundation backfill</td>
<td>With the 3D BIM model of the Parking Garage and Existing Conditions, would be easy to visualize the aesthetics and site requirements of the Parking Garage</td>
</tr>
<tr>
<td>4/12/12</td>
<td>Concerns about the aesthetics of the real view of the service door (for gator) at the Park Ave (2D drawing not reflecting this issue)</td>
<td>With the 3D BIM model of the Parking Garage would be easy to visualize and communicate the aesthetics and functionality of the Parking Garage</td>
</tr>
</tbody>
</table>
## Issues Caused by Lack of Systematic Check of the Program Assumption (Blue)

<table>
<thead>
<tr>
<th>Date</th>
<th>Issue</th>
<th>Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/6/11</td>
<td>Bridge height is an issue as relates to the potential turnaround area for buses. Height required will be 13-2 to 13-6</td>
<td>All Bridge issues are considered as a part of a lack on the follow up on the program assumptions. It is important that the project and design team always note the program assumptions of the project during the reviews and if any change is made on the model. Because of that, it is considered that BIM team would decided to take into account the future bridge for the Parking Garage design, since the beginning and would work in tight collaboration and communication as the Integrated Design definition says.</td>
</tr>
<tr>
<td>11/3/11</td>
<td>WPI requested the access for the firefigther vehicle</td>
<td></td>
</tr>
<tr>
<td>11/17/11</td>
<td>WPI requested to add the development of the bridge design on the 2 level layout</td>
<td></td>
</tr>
<tr>
<td>12/16/11</td>
<td>Trustees ask to prepair the parking garage design for future bridge construction</td>
<td></td>
</tr>
<tr>
<td>03/29/12</td>
<td>Discussion about the preparation of the main stair to receive in the future the bridge to connect Harrington building. (levels do not allow firefighter truck passing under the bridge)</td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td>Issue</td>
<td>Assumptions</td>
</tr>
<tr>
<td>------------</td>
<td>------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>09/15/11</td>
<td>VHB ... to consolidate 2 WPI curb cuts to one</td>
<td>It would be easy to make a “simple” changes using the schematic 3D model during the review, so the team can visualize, in a schematic way, the functions and operations of the Parking Garage related with the spacial requirements.</td>
</tr>
<tr>
<td>09/22/11</td>
<td>WPI requested a storage room for snow blowers that would have a garage door on it to allow vehicular access</td>
<td>With the 3D model of the Parking Garage, the review and communication of these schemes would be lighter, specially for WPI representatives, whom would have a better and faster understanding of the design proposals for the ingress and egress of the Park Av.</td>
</tr>
<tr>
<td>11/3/11</td>
<td>WPI requested a second parking level option</td>
<td>It would be easy to make a 2nd level of the Parking Garage or any other “simple” change using the schematic 3D model during the review, so the team could visualize how the Parking garage is going to look, specially for the high related with Park Avenue and Higgins side.</td>
</tr>
<tr>
<td>11/10/11</td>
<td>WPI preferred the option with internal ramps and requested to modify the selected option to provide 2 way ramps</td>
<td>Is important to mention that this changes are considered to be done in a schematic way (only for visualization purposes) during the reviews and then in more detail.</td>
</tr>
<tr>
<td>3/2/12</td>
<td>Some issues were detected to access the field with a turf vehicle.</td>
<td>The Functionality of the Parking Garage related with the transit of the turf vehicle, would be easy to visualize, understand and simulate using the 3D model.</td>
</tr>
<tr>
<td>03/15/12</td>
<td>New proposal of the main entrance, is moved one bay to south, and completely outside the parking garage</td>
<td>In addition, the aesthetic would be easy to visualize with the 3D BIM model.</td>
</tr>
<tr>
<td>4/12/12</td>
<td>Discussion on the proposed access the field with a turf vehicle. Turning ratio restrictions</td>
<td>The Functionality of the Parking Garage related with the transit of the turf vehicle, would be easy to visualize, understand and simulate using the 3D model.</td>
</tr>
</tbody>
</table>
BIM model use to select alternative designs
(one level of parking)
BIM model use to select alternative designs
(one level of parking)
BIM model use to select alternative designs (two levels of parking)
BIM model use to select alternative designs (two levels of parking)
WebCam/Window 4D

August 2012             September 2012             October 2012             November 2012

December 2012           February 2013             April 2013               June 2013

G. Salazar, S. Alvarez, M. Gomez
Conclusions

• Identified advantages that could be derived from the incorporation of a BIM-based design approach into the project following the systematic implementation of a BIM Execution Plan.

• Highlighted the benefits of building a BIM model in detecting design related issues before and during construction.

• Developed a highly Integrated 5D Model that incorporates the site and underground conditions of this facility that could be used to assist in long term Operation & Maintenance.

• Developed a better understanding & granularity control when LOD 300 is used.

• Explored the practical and educational implications of using BIM models in different aspects of the design and construction process at WPI.

• Future Quantitative Analysis of Workflow