AEI Team #04-2013

February 22, 2013

Structural System Design

ASCE | STUDENT COMPETITION

Our one true aim is to enhance the quality of the communities we work with through innovative ideas and an integrated design approach

Ingenuity | Quality | Enjoyment | Integrity

1 Introduction

Project Requirements The challenge of this project is to address the design issues that must be considered for the structural systems of an Elementary School to be located in the urban setting of Reading, PA. As shown in Figure 1, Reading is a city in southeastern Pennsylvania with a population of approximately 88,000; making it the fifth largest city in the state of Pennsylvania. According to the 2010 census, Reading has the largest share of citizens living in poverty in the nation at approximately 33%.[1] The team must respond to the environment and setting in which this project takes place, and provide a school that enhances the entire community. Per the AEI competition rules, this submittal addresses the following:

Figure 1 - Location of Reading, Pennsylvania (Image courtesy of www.city-data.com)

1. Construction and design issues related to a high-performance building that meet the needs of both the school district and community. In the Energy Independence and Security Act of 2007[2], section 401, a high performance building is defined as follows:

> *The term 'high-performance building' means a building that integrates and optimizes on a life cycle basis all major high performance attributes, including energy conservation, environment, safety, security, durability, accessibility, cost-benefit, productivity, sustainability, functionality, and operational considerations.*

2. As requested by the school board, the new building is to achieve LEED certification under the LEED 2009 for Schools New Construction and Major Renovations[3].

3. A budget is provided for the school district for the design and construction of the project focusing on both the short term and lifecycle cost-benefits of the design solution. See the Construction Management submittal for details on the budget for this project.

The submitted program for the new Elementary School provides creative solutions for a natatorium and 24-hour clinic open to the community, a multi-purpose space, and a green roof. This submittal narrates the design process and results of the foundation, gravity, and lateral systems of the structure. As requested by the competition guidelines, the design addresses emerging technologies by creating adaptable spaces that may change use in the future. The design also addresses security concerns that would arise with the sharing of student and community spaces. In anticipation that the school will be used as an emergency shelter facility, the building was designed as Category IV occupancy.

Project Goals Before beginning the design process, the team developed one central goal: *to create an innovative, high-performance environment in a way that stimulates involvement in both education and the community.* To achieve this main goal, detailed project goals were developed to guide the design process and major team decisions. These three project goals are Functionality, Efficiency and Appeal which interact around the ultimate goal Community as illustrated in Figure 2.

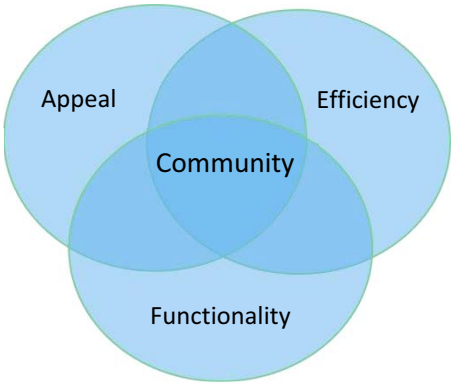

Figure 2- Project goals

The first goal was to design all building systems and components to best serve their specific functions within the building. This was achieved by breaking down the building into smaller packages which have distinct, unique and identifiable functions which drove the design of the building systems within each package. The structure was involved in every package, although many of the specific functions of the structural systems overlapped between packages. The team defined the most critical roles of each of these packages, and made sure to revert back to this definition whenever design issues or questions came about. These ideas were manifested in the design goal of functionality.

The next goal was to create a building which is affordable and long lasting, allowing the community to get optimal use out of the building. This was achieved by designing and engineering building systems which will best serve the building's inhabitants over an extended period of time. Analysis of all systems using life cycle cost assessments and sound engineering judgment also led to the accomplishment of this goal. These ideas were manifested in the design goal of efficiency, which was an important factor considered when choosing building materials and a foundation system.

The third and final goal was to create an iconic building design which attracts people to it both inside and out of the community. By creating this icon, students, families and faculty will be more inclined to be a part of this positive learning environment. This was achieved by creating a visually appealing and comfortable environment that accommodates all occupants. These ideas were manifested in the design goal of appeal. This goal to create an iconic building was the driving factor behind the design of the structural system for the natatorium.

Project Goals To achieve the project goals stated above and develop an innovative design for the structural system of the elementary school, the team made extensive use of Building Information Modeling (BIM). Organization, planned deliverables, and tracking progress were also extremely important in the success of the team as a whole. These ideas resulted in the team developing a BIM Execution Plan, which defined how exactly BIM tools would be used throughout the project. Table 1 outlines how various BIM tools were used in the design of the structural system. For details on the BIM Execution Plan, refer to the Project Delivery Goals section of the Integration submittal.

Table 1- BIM software uses

Symbol	Software	BIM Applications
	Bentley RAM	Gravity and Lateral System Design
	ETABS	Lateral System Design
	Autodesk Revit	3D Modeling, Coordination with MEP
	Autodesk Navisworks	3D Coordination, 4D Modeling

As decisions on the design of the structural system were finalized, elements were added to a Revit model central file which include architecture, topography, mechanical systems, and electrical equipment along with the structure. This model was then imported into Navisworks where a series of clash detections were run throughout the duration of the project in order to identify problem areas and possible construction issues. Independent of the Revit model, RAM and ETABS models were developed for load analysis and the sizing of members.

To illustrate the entire process and proposed solutions for the project, the remaining sections of this submittal include a specific objective for various structural elements, a list of design criteria that were considered, a narrative description of the design process, and the resulting systems chosen.