EXECUTIVE SUMMARY

KGB Maser is pleased to present the team's year-long senior capstone thesis project for AE482. Over the course of the year, the team has collaboratively assessed the current Millennium Science Complex building design and targeted areas where the team could explore design enhancements through integrated project deliver and building information modeling platforms. The KGB Maser team consists of a student from each discipline within Architectural Engineering at Penn State. Each discipline came into the IPD/BIM thesis with sufficient background in building information modeling programs. Together, KGB Maser has analyzed engineering systems of the Millennium Science Complex using BIM software in an IPD environment. Specifically, the team made efforts to analyze the façade, optimize energy performance, and redesign the structure to attempt to save cost of the building.

The existing façade consists of a pre-cast panel system sized to span each 22'-0" bay. The brick veneer wraps around the approximately 27-inch deep reveal to eight feet of window wall. The windows are separated vertically by a louvered overhang that reaches out to the plane of the pre-cast panels. Team members dissected daylight delivery, structural integrity, indoor environment, and constructability to achieve a cost-effective alternative to the existing façade composition. Through substituting a triple-pane glazing for the existing double-pane glazing, reducing the depth of the panel flanges, and optimizing the overhangs for daylight and indoor environment, the team is able to reduce mechanical operating costs by 1.5%. Additionally, the dimming system in public perimeter zones saves 6.97% in automated areas. The flange thickness reduced to 15.75" resulting in $243,932 savings in estimated construction costs.

The next phase of KGB Maser's analysis aims to reduce energy consumption through optimizing the mechanical distribution system. Research in ASHRAE Journal articles and Labs21 design guides has shown that chilled beam application in a laboratory facility can produce substantial savings in operating costs. The chilled beam redesign was applied to the whole building with the use of single enthalpy wheel and enthalpy-sensible wheel air handling units. The system was sized in response to façade design changes and the resulting electrical system implications were assessed. Annually operating costs are 14.1% less than the existing VAV design. Life cycle cost analyses demonstrated that the high initial cost will be suppressed over a thirty year span. A separate study was performed to quantify energy savings for reducing fume hood face velocity. Through analysis with a computational fluid dynamics model, similar containment effectiveness was found to warrant energy savings with lower face velocities.

The expensive cantilever structure was investigated for redesign possibilities that could reduce materials and therefore structural cost. The 154 foot cantilever is supported by four main trusses whose members are controlled by stiffness rather than strength. By placing two columns underneath the intersections of these four trusses, stresses are reduced and truss members can be downsized. Bays of bracing that once resisted the cantilever's inherent overturning moment can now be removed due to different end conditions. A sculpture was added underneath the overhang to enhance the support of the cantilever and prohibit pedestrian traffic over the nano-technology labs relieve the space visually.

Through each of KGB Maser's phases of analysis, communications between team members and model sharing software needed continuous input. KGB Maser chose to continue use of Revit analytical models provided by the design team and share information across a spectrum of BIM software.

FOREWORD: INTENT AND USE OF THIS DOCUMENT

Being part of the IPD/BIM Thesis pilot program has its inherent challenges. Teamwork is a major theme throughout the duration of projects. Groups do their best to perform as a single, full-service design firm – a well-oiled machine. The challenge for IPD/BIM groups is hinged on two goals – working as a team and presenting a cohesive product that embodies the team dynamic used during the 2010-2011 academic year. Not only must each student be part of the team, but must also display knowledge and proficiency in engineering studies. The structure of this document tries to accommodate both team and individual requirements for the Architectural Engineering senior capstone thesis project.

The reader will be introduced to two binders collectively form one final report – the body and the appendices. Using two books will allow readers to consult tables, figures, drawings, and manufacturer information while concurrently examining the analysis portion of the report.

The body of the report has been divided into 5 units: IPD/BIM, Construction Management, Lighting/Electrical, Mechanical, and Structural. In no way is this document structure intended to imply disconnects in teamwork throughout the academic year. Rather, the document separates information based on topic. The reader can easily maneuver to the portion of the document they are most interested in. Supporting engineering calculations and explanations are grouped together in option-specific units to highlight discussions of teamwork and integration.

The appendices section of the final report is structured in the same fashion as the body. Each unit of the body has its associated set of appendices to support design discussions, also named and numbered by unit. Again, this format is designed to keep readers on the same naming and numbering convention between analysis and appendices so as not to become disoriented within the document.