



I PRO 335  
Design of a Stadium

**Final Report**  
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## 1. Introduction

IPRO 335 or Capstone Design pursued designing an advanced and economical Public Stadium. Capstone Design's primary focus was to apply new methods in design derived through researching the most recent modifications to standardized codes and breakthroughs in technology. This course has already produced building designs for large-scale projects ranging from an airport terminal to an office building. Several professional disciplines were required to complete this unique and superior structure including architecture, civil (structural/nonstructural) engineering, electrical engineering, and mechanical. This semester, Capstone Design's senior undergraduate and graduate students continued to strive toward a Public Stadium with the most innovative and creative architectural and structural designs. All objectives necessary to successful completion of this project will be pursued in the future.

## 2. Background

IPRO 335 or Capstone Design is an opportunity to CAE students to demonstrate what we have learned at IIT. This course had produced different types of building designs ranging from an airport terminal to an office building. Even though this course is required for CAE students, all disciplines are required in order to create a complete product including architectural, civil (structural/nonstructural), electrical, and mechanical engineering. The primary focus is to apply the new methods in design on original projects produced by IIT architectural students.

The private firms or municipal governments might be possible customers or sponsors for the projects depending on the focus of the design. For our design, a private firm would be the most interested in reviewing the project. Nevertheless, many societies/organizations are involved from the respective members' fields like AIA, ASCE, AISC, LEED, etc. Our goal in designing the most advanced and economical structures requires us to research for recent modifications to standardized codes and breakthroughs in technology.

A professional atmosphere is necessary in order to maintain order. Formal procedures used in everyday companies are implemented to facilitate changes on the project. Communication becomes the most important factor for successfully completing the required tasks. Few ethical issues may arise most of them related the professional procedures.

## 3. Purpose

The expected results of IPRO 335 are to advance the design of the stadium focusing on the integration of work between the different project teams in order to create a well designed building. The communication between these different teams hinges the projects success and completion. Each team has its own set of

goals in order to ensure the further development of the semester project. The work carried out by each team communicated to architectural team will guaranty the success of our semester goal.

### Architectural Group

The process of examining, understanding, and ultimately redesigning or furthering the existing the design is the primary focus of the architectural team. An important task for the architectural team is completing the necessary design element to allow for the other groups to complete their work. The architectural team has been split into two sub categories to manage most appropriately the tasks laid before them.

#### **Interior and Concourse Design-**

Meant to focus on the design the bulk of the interior space on the building furthering the programmatic design started by the last semesters architects. This team strives to utilize LEED standards, as well as, create a design to deal with the security measures in public meeting spaces. The team will be creating floor plans as well as diagrams to demonstrate their progress in the aforementioned areas.

#### **Landscape and Exterior Design-**

Meant to focus on the development of the exterior envelope and handling a comprehensive site plan addressing several primary issues. The envelope will be developed with respect to sustainable design techniques and LEED standards. This will also test the ascetic at a large scale of these practices. A primary focus is also being placed on the development of a comprehensive landscape design. This is to handle a means of egress as well as greening of urban space. The completion of site plans and exterior elevations with emphasis on materials and specifications will be this teams primary deliverable.

#### **3-D Visualizations and Walkthrough-**

Focus on creating a 3-d model for creating a walk through to most accurately portray the outcome of the work and material selection for the building. High lighting concepts of design and engineering in an animation is primary output.

### Civil Group

Analysis of the preexisting structure previously designed will be a jumping off point for this semester's comprehensive analysis and design. The tasks have been split into two primary objectives but the team will be participating in all aspects of the work.

#### **Seismic Design of Stadium-**

Designing of the stadium for earthquake loading, assuming the stadium is located in the New Madrid earthquake zone. Detailed design of critical

connections, also a dynamic response of the stadium will be performed on SAP 2000 (or equivalent software).

#### **Drainage system for site-**

Design of drainage system includes calculations of runoff, sewer and catch basin design, and integration with the plumbing design with the non-CAE students. Students will also integrate the drainage system with any pre-existing systems located near the site.

### **Electrical Group**

Starting by doing preliminary research of the how commercial and sports electrical systems are designed. We will be using reference books provided by both the instructor and from the library. Then we will calculate the individual loads and the total load of the stadium and then choose the proper transformer. After choosing the transformer we will design a basic distribution system for the stadium.

#### **Lighting Design Team-**

This team will be selecting the most suitable fixtures for each area of the stadium. Then we will calculate the number of fixtures and luminance levels for the interior and exterior areas of the stadium. After deciding on the number of lights we will give the Electrical System Design Team the calculations of the lighting loads.

#### **A/V Team-**

This team will start by selecting a main screen for the stadium and associated mounting hardware. The video equipment needed to drive this screen will then be selected, followed by the integration of an audio system as time allows.

### **Mechanical Group**

Starting with analyzing drawings and calculations from last semester we will calculate and create appropriate systems as to maximize energy efficiency and environmental design. To handle the different components of the project we have divided in to teams handling different areas of this vast project.

#### **HVAV systems for underground parking-**

For the implementation of the HVAC systems in the underground parking garage, the amount of air exchanged will need to be researched and calculated. Design and calculation of each component in the system documented and presented. Meeting EPA standards and striving for maxim energy efficiency will ensure the designs success in improving air quality inside and outside the building.

### **High efficiency plumbing design-**

The basic load requirements and designing a new plumbing system that reduces water use by at least 50%. Focus on low flow toilets and faucets, using storm water storage systems, on-site filtering and reuse of waste water.

## **4. Research Methodology**

In today's world it's necessary to design or to update all structures to meet new codes in order to maintain the highest standards of safety. From an engineering perspective, the primary goal is the general welfare of society at the most economical cost, on that basis project designs compete to meet these two objectives. Our task for this semester is to design a competitive design for a new stadium that will meet the desired criteria using the most recent technology available backed by the methods of planning and designing learned at IIT.

The design of a stadium is an enormous challenge due to the time constraint to complete it in less than sixteen weeks, for that reason we are picking up last semester's work and continue with the basic design. An embedded problem that appears from this decision is the need of time to become acquainted with the design. However, we are able to fulfill all the tasks that were not completed last semester and accomplish a better-quality design. Five teams had been created to target the necessary tasks that a design project requires which are: architectural, civil, electrical, management, and mechanical. Each team is required to complete their duties according to their fields. For all teams except management, the plan of action will be as follows: Research is the initial step to select the best approach in designing the stadium, and then calculations will be the ongoing tasks for the rest of the semester. Management team is responsible to coordinate the other four teams and remind/meet the deadlines drawn by the project plan schedule and the IPRO office. Management team will also be responsible to provide the required materials, arrange meetings, delegate tasks not expressly designated, contacting advisors and faculty, and generate IPRO deliverables. This team is composed by the team leaders from the other four design teams.

## **5. Assignments**

### **Architectural Group**

For the rest of the semester the architecture group will set aside the old project plans and work on coordinating its work with the rest of the IPRO team to finish the design. Making sure that quintessential decisions get made in time in order for other processes to move forward is its foremost concern. Adapting the design to work with the systems being completed by other groups as well as providing aid to groups who need graphic expertise will be the teams main role moving into the presentation stage of the semester.

**Interior and Concourse Design**(Artur & Arkadiusz)-

Focus on the design the interior space on the building furthering the design of the interior space. Selecting materials and meeting all code requirements will be a focus as the design work is finished. The team will finish floor plans and sections for the clearest understanding of the building.

**Landscape and Exterior Design** (Natalie & Sarah)-

Focus on the development of the exterior envelope and a landscaping plan. A redesign of the parking garage surface as well as egress will be inputted into the comprehensive landscape design. Completing drawings of the elevations of the building and creating comprehensive drawings of landscaping will be the main focus for the remainder of the semester. There will also be a continued communication between the mechanical and civil teams will be integral for the completion of the project.

**3-D Visualizations and Walkthrough** (Drew)-

Focus on creating a 3-d model for creating a walk through to most accurately portray the outcome of the work and material selection for the building. High lighting concepts of design and engineering in an animation is primary output.

**Civil Group**

Analysis of the preexisting structure previously designed will be a jumping off point for this semester's comprehensive analysis and design. The tasks have been split into two primary objectives but the team will be participating in all aspects of the work.

**Seismic Design of Stadium** (Jorge, Julio)-

Designing of the stadium for earthquake loading, assuming the stadium is located in the New Madrid earthquake zone. Detailed design of critical connections, also a dynamic response of the stadium will be performed on SAP 2000 (or equivalent software).

**Drainage system for site** (Gerardo, Chi Hang)-

Design of drainage system includes calculations of runoff, sewer and catch basin design, and integration with the plumbing design with the non-CAE students. Students will also integrate the drainage system with any pre-existing systems located near the site.

**Electrical Group**

For the remainder of the semester the Electrical Group will be focusing on completing calculations and hardware selection based on code requirements. Working closely with the architectural group will be an important part of accomplishing the remaining tasks this semester.

**Lighting Design Team** (Nathan, Sushma, Scott)-

After completing a Lighting design format based on zonal cavity method the lighting design team will calculate the total number of required fixtures and ultimately calculate the load for the stadium design. Working with the architecture team for assistance with auto-CAD as well as approval of lighting fixtures will ultimately result in success.

**A/V Team** (Keith)-

This team will start by selecting a main screen for the stadium and associated mounting hardware. Calculation of the required loads will then be calculated and equipment will be sized and placed working with the architectural team.

**Mechanical Group**

Working to meet the code requirements in conjunction with other design teams will be the most important aspect of completing all design goals.

**HVAV systems for underground parking** (Tim)-

This team will focus on the calculating of the basic loads in the system so that the Electrical team can finish their requirements. Also the calculating of the fan size and speed of rotation required for the air exchange per hour and finishing the air exchange calculations for the other parking garages will allow for the equipment with the highest efficiency to be chosen. Additionally the designing of the basic ducting system in the garage will complete the requirements laid down in the code.

**Building Energy Modeling** (Zander, Harshill)-

The focus is to develop a more complete building model for energy analysis and estimating the energy use of the stadium. An energy modeling program, development of the building model and estimation of expected heating and cooling loads for several different types of heating or cooling systems will be selected for presentation.

## 6. Obstacles

**Architectural Group**

The architectural Group is under constant stress due to the rest of the IPRO's dependence on the decisions being made. A constant communication has been required also tailor making the schedule to fit the other groups needs into their own process.

**Interior and Concourse Design**(Artur & Arkadiusz)-

Understanding and modifying last semester plans has been the greatest challenge. This group has undergone issues dealing with the column grid that need to be established for the Civil group to complete its primary design. Also dealing with the code requirements has been an extensive challenge. Design of the egress is a complex thing and this group has had to unite the work with the landscape group in order to create a functioning building.

This group has done all of this through diligence and hard work. They have communicated well with the Architect of Record and facilitated the progress of the IPRO thus far this semester. They also have been very adaptive to the responses and work of other. Meeting deadlines when ever a different group requires a change in there current tasks.

### **Landscape and Exterior Design** (Natalie & Sarah)-

The landscaping team had the responsibility of positioning the new building on the site, working out the new parking, redesigning the landscape, and being very green in the whole process. We had very little problems positioning the building on the site to suit the traffic flow of the area, except for accommodating the small plot of land in the SE corner of the site of which there were existing buildings. We did have problems positioning the building so that it would have proper vehicular access, emergency vehicle access, and emergency egress. The parking was a little more difficult to solve just because of the shear volume required, and also the requirement presented to us by the professors that the parking all be underground.

### **3-D Visualizations and Walkthrough** (Drew)-

This group has been barred from being able to begin work due to the dependence on both of the other architecture teams to complete their design work and since that progress has been slowed all of the rendering and animation work will be completed in the later part of the semester.

#### **Drew- Architect of Record**

He has faced the coordination of all aspects of the IPRO facilitating and meeting with each individual group to help them understand their design roles. Additionally has been plagued with late communicated responses and pushing those in different groups to complete their tasks in a timeline that allows the teams to move forward with design work. Persistence and patience have been imperative aspects to insuring that the IPRO moves forward with little to no resistance.

The most difficult obstacle that the structural team faced was completing all the structural design while the architectural design was not yet finished, though we tried to work together, certain aspects of the design had to be determined first in order to apply the loads and select member sections for the frame. New additions and modifications to the original design were drawbacks time wise even though we tried to have all calculations on MathCAD files in order to modify it more efficiently. Communication between the Structural team and the rest of the groups especially the architectural team improved as we worked on the stadium design throughout the semester.

**Drainage system for site** (Gerardo, Chi Hang)-

Several obstacles were encountered while designing the drainage system. The major setback was the entire site plan was changed towards the end making us change the entire layout of the system. We were also challenged with finding more accurate hydraulic data for use in our calculations.

## Electrical Group

The Electrical Group has dealt with learning the process of designing as this is first time these particular designs have been done by its members. Similar to the Mechanical and Civil Groups have had delays based on the coordinating information Architectural group.

**Lighting Design Team** (Nathan, Sushma, Scott)-

The greatest obstacle that we faced as a team during this project was that we did not have a complete stadium drawing at the beginning of the semester. The problem with this is that we had to change our calculations according to the changes done in the drawings. If the stadium drawings were finalized before bringing in the electrical team then the electrical team could have started immediately. Another obstacle was calculating the entire stadium power load. We were able to calculate the lighting load by the end of the semester, but we could not get the HVAC and other loads because no teams were working on those sections.

**A/V Team** (Keith)-

Hinder by architecture group for dimensions of the main screens. Additional restriction by interior detail needed for acoustics analysis.

### Mechanical Group

#### **HVAV systems for underground parking (Tim)-**

The creation of a HVAC system that meets EPA standards and that is so efficient that the system can be considered “green”.

#### **High efficiency plumbing design(Tom)-**

The first obstacle the plumbing team had to overcome was the understanding of data analysis done by the previous group. This was accomplished though, through research on the internet. A copy of the portions of the International Plumbing Code used in the data analysis would have made this process go more smoothly. Another obstacle was being the only member of the mechanical team. Perhaps in later semesters, if there are a small number of mechanical engineers, all of them can work together to finish each task. This could be done by working on HVAC for the first half of the semester, and plumbing for the second half of the semester, or some agreed upon method which involves more students working together.

## 7. Results

### Architectural Group

#### **Interior and Concourse Design (Artur & Arkadiusz)-**

This group has worked tirelessly trying to keep up with the demands being placed on them by all other groups. They finished all floor plans and fixed many of the problems originally put down by last semester’s project. A state of the art security and found a new and innovative way to address egress codes for the building where accomplished. They completed a more esthetically pleasing design and where able to up the circulatory quality of the spaces inside.

#### **Landscape and Exterior Design (Natalie & Sarah)-**

The positioning on the site was determined by the connection of two major accesses to the site; the green line CTA stop NE of the site, and the nearest exit from the interstate SW of the site. The building was rotated to approximately 60 degrees in order to align the two major openings with the pathway. We decided to leave the small plot of land on the SE of the site untouched while using the access road for it as the entry to our VIP lot and emergency vehicle access. The major parking on the site was placed in two four level underground half lots on the North and South of the main lot. The accesses to these underground lots were confined to the very North and South perimeter of the site in order to

eliminate and traffic concerns during stadium events. The green lot was placed on the East side of the building. As stated before, the access to the lot was provided by an existing road on the site. The emergency vehicles were given immediate access to the stadium from a basement level delivery door. On the West side of the building, there was provided a one-way street for deliveries, this also was dropped to the basement level. Pedestrian emergency egress was divided into 6 sets of doors. Originally, there were four that were at the apex points on the stadium. Because of the level drop for vehicular access, the east and west emergency accesses were separated into 4 smaller accesses on grade that flank the vehicular access. The main pedestrian entrances and exits for the major parking lots were placed on the main path that defines the site. The landscaping was divided into the parking, which has already been covered, water retention areas, the main walkway, and parks and gardens. There were three water retention areas planned into the site. Two small rain gardens were placed on the east side to cover run-off from the green lot and main walkway. The primary water retention was placed in the Northwest corner of the site. It is a large retention pond that doubles as a decorative fountain. The east side of the main retention pond is a retaining wall, and also planned to be a living wall, that drops down to the basement level delivery access. The main walkway ran through the three divisions on the site. As stated before, the pedestrian accesses to the underground parking garages are placed at the far ends of the pathway. Adjacent to these entrances are the vendor lots which are areas set aside to promote local independent vendors that are bound to occupy the area during stadium events. On the main site is pathway that is perforated with benches, floral troughs, trees, and of course the Michael Jordan statue that is on the current site. The parks and gardens were planted with a variety of trees with a variety of ages. This was done so that if any of the trees die or are affected by disease, the site will not be left barren. The variety of trees were planted for texture, but for seasonal reasons as well. The area has a freeze/thaw cycle, therefore deciduous trees will be bare in winter months. There were a variety of deciduous and coniferous trees planted so that the site would have full trees year round.

### **3-D Visualizations and Walkthrough (Drew)-**

This group has worked to create presentation quality work to represent the building that the group has been working on all semester.

#### **Drew- Architect of Record**

He has successfully orchestrated the completion of all groups achieving high quality product to their semester objectives.

## Civil Group

**Seismic Design of Stadium** (Jorge, Julio)-

Most of our primary objectives were completed during this semester. The two objectives were: a complete structural design accounting for the seismic loading and the drainage design for a 20year 24hr storm. The civil team was divided into two sub teams in order to address the two main objectives for this semester. The structural design started where the last semester team left off. The whole structure was analyzed taking into consideration the new modifications that the architectural team thought to be necessary. We had to revisit the truss analysis and the preliminary design due to some discrepancies that we found on how the structure was being loaded. Determination of the applicable loads was the first step for the Structural team, these included the following: Dead, Live, Snow, and Earthquake loading. It's important to mention that this design is suitable or is intended to be located at the New Madrid Seismic Zone that is around southern Illinois, Tennessee, and Kentucky. The wind calculations most of the time tend to have less impact on the design when seismic loading is taken into consideration therefore wind loads were not considered. The preliminary design took into account all gravity loads based on hand calculations, then we input the design of the frame into structural software, SAP, to take into account the Earthquake loading. Our analysis on SAP relies on the implementation of two powerful tools, the pushover analysis and the time history analysis. The Pushover analysis allows the structure to move under the earthquake loading beyond the yielding point, that means that to certain extend we are allowing the structure to fail in order to see the failure behavior and be able to design a mechanism for the structure to prevent total collapse. It's desirable for the frame that the beams or braces fail rather than the columns.

On the other hand, the time history analysis provides a recorded earthquake motion in order to test the selected frame to the earthquake loading in order to localize the weak members or connections. Both methods were used on this design due to the fact that seismic loading was

the controlling factor for most of the members and connections on the frame. Our lateral resisting design consists of cross bracing in both directions of the frame; therefore all the beam-column connections are pin connected. Under this type of loading members do not transfer bending moments. All beam members and columns are steel W sections with yielding of 50ksi; while all the braces are rectangular hollow box members better known as HSS members with yielding of 46ksi. From the SAP analysis, the desirable mechanism of failure would start with braces reaching plasticity following beams, and lastly the columns.

#### **Drainage system for site** (Gerardo, Chi Hang)-

With the given location of the site we were able to research the expected rainfall intensity for a 100 year storm with 24 hr duration. The rainfall intensity for the given location was 6 in/hr. Also the City of Chicago Sewer standards were incorporated into the design phase to see what requirements were needed. Using these standards we were able to make a site layout for drainage structures. A network of pipes was designed to carry the rainwater into the detention basin. Using the locations of these drainage structures and the areas that each drainage structure was to cover we were able to calculate the flow rate and the size requirements for each pipe. From our calculations we can see as the network increases the pipe sizes also increase to accommodate for the demand of the system. Pipe sizes used ranged from 8 inches to 30 inches in diameter. Any excess water that can not be accommodated by the retention basin will be discharged directly into city sewer system.

### **Electrical Group**

#### **Lighting Design Team** (Nathan, Sushma, Scott)-

The first thing we did was chose the fixtures to be used in our lighting calculations. Then we determined the lighting levels for each room and calculated the number of light fixtures needed in each room. The stadium will need 5963 interior lights to light up every room using the lighting fixtures we chose. The total wattage for the lighting is 332,144 Watts excluding parking. We used the zonal cavity method to calculate the number of lighting fixtures because

it was the most straightforward method available. For future teams working on this project, new lighting technologies and power efficient bulbs can replace the lighting that we've chosen.

We also choose some of the emergency lighting such as the exit signs.

#### **A/V Team (Keith)-**

Analog video system have issues with signal degradation over distances. Digital video systems require a large bandwidth. Using mpeg4 encoding in a network based video system similar to a video surveillance system solved both of these problems.

LED display systems were selected due to their energy efficiency and modularity. Stadiums have problems with reverberation due to their large size. Audio quality must be insured by doing a detailed acoustics analysis.

### **Mechanical Group**

#### **HVAV systems for underground parking (Tim)-**

In order to ensure that enough air is exchanged to meet EPA standards of health, the minimum air exchanges per hour of the garage was calculated to be 3.2. But because the value of air exchanges is constant for many garages (which is always higher than what is needed), a value of 6 was used. A higher air exchange will mean more fresh air will be entering the garage system thereby reducing the amounts of carbon monoxide due to exhaust from the cars.

Because of a correlation between air exchanges per hour and inlet wind speed, the inlet wind speed was found via tables to be 12 m/s. To ensure the best air mixture of the new fresh air, the inlet grills will be placed vertically on the side walls of the garage, and the outlet grills will be placed on the roofs of each floor.

The main duct size for the system (which will feed each individual floor branches) will be 1.5m X .550 m. Each individual duct that runs to each floor will need to be around .8m X .5m. The fans will be center fugal fans that are both efficient and quiet in their operations. These fans will be controlled with a varying fan system that speeds up or slows down the fans to ensure the minimum air exchanges per hour while lowering energy costs.

#### **High efficiency plumbing design (Tom)-**

The results are very positive; a lot of water can be conserved with simple adjustments to the plumbing design. All fixtures have been selected, and are guaranteed to conserve at least 30% water. There is possibility for more water conservation. The past plumbing team followed the International Plumbing Codes, while one source found suggested that the Uniform Plumbing Codes are more accurate and waste less water. Future plumbing teams could look into this.

Regardless, although 50% water conservation was not reached, the results are very satisfying and fitting of a green model. Introducing the storm water will bring this project closer to its conservation goal.

## 8. Recommendations

### Architectural Group

#### **Interior and Concourse Design**(Artur & Arkadiusz)-

Design of concession spaces as well as completed designs for the mechanical/electrical spaces as the other groups are able to advance their own projects. Interior finishes and colors along with accurate building details are the main areas that should be focused on in the future.

#### **Landscape and Exterior Design** (Natalie & Sarah)-

Suggested work for the next team would be the parking. The grade level VIP green lot has already been planned, but the main underground lots need to be planned for approximately 6000-8000 spaces. Volume calculations have been made, but ventilation that relates to those volumes has not been added. Emergency exits have been added, but they have not been planned out according to the car ramps or accesses. The parking needs to be laid out in accordance, and closely as possible, to the landscape/site plans already laid out. Also, the living wall on the back of the main retention pond needs to be researched and planned out more extensively.

#### **3-D Visualizations and Walkthrough** (Drew)-

More will be possible as the building design is completed at an earlier date. The addition of more members to this group would also greatly aid the amount that could be accomplished.

### Civil Group

#### **Seismic Design of Stadium** (Jorge, Julio)-

Though, most of the structural design was completed, there is still some portions that were not completed due to the lack of time, further design is required in terms of foundation design, ramp design around the stadium, and detail connection design. These issues will require a semester long project for future the group. The foundation design team will require a thorough inspection and research of the geotechnical conditions of the project site. It's important to mention that there are 206 columns and most have different loading, also the two main connections that will have to be

explored in detail, are the beam-column connection and secondly the brace column connection. The latter connection will be more critical in terms of maintaining the desirable failure mechanism. The last thing that we were unable to design is the ramp that would go around the stadium because it was a last minute modification. All these tasks remain very important to the successful design of the stadium.

#### **Drainage system for site** (Gerardo, Chi Hang)-

Future improvements can be made to the drainage system such as checking the maximum flow rate that is allowed by the city into the city sewer, as well as the design of the overflow system that drains any excess water. We also want to insure that the capacity of the system meets the demand and serviceability requirements.

### Electrical Group

#### **Lighting Design Team** (Nathan, Sushma, Scott)-

The next step for our team is to choose the elevators, and calculate its load. The power consumption of the concession area, restaurants, exterior lighting and parking garage lighting will also need to be calculated. After calculating all of these you need to add those loads and the ones from the HVAC system and choose a step up transformer(s) that will suit the load specifications. Another important part of the lighting system is the emergency lighting and back up transformers and generator systems.

#### **A/V Team** (Keith)-

Once interior detail has been established, acoustics analysis should be done on the stadium. After this is complete, determine placement for the audio speakers. The audio system should take advantage of the same network backbone used to drive the video system. After this is complete, the network backbone should be designed by determining placement for networking hardware such as switches, routers, bridges, etc.

### Mechanical Group

#### **HVAV systems for underground parking** (Tim)-

The next steps in the ventilation system will be to pick the fans in order to supply the air to the garage. In addition, the effects of thermal differences of

temperatures (which for this project were ignored) need to be calculated in order to ensure that the assumptions taken into account in the beginning of this project were correct in an engineering standpoint.

### High efficiency plumbing design(Tom)-

The next step to be taken is to implement the new water retention pond into the plumbing system. This includes selecting pumps and water filtration needed, and calculating new savings with numbers from the civil team. This will require accessing all of the information collected this year, and further consulting the IPC codes. If there is time, pumps for the system already in place need to be selected

## 9. References

### Architectural Group

Articles on commercial landscaping were used. Research on the location and plant types were used as well. Research concerning smaller aspects, such as the living wall, the green lots, the rain gardens, etc. was taken off of the internet. Codes needed were taken from the International Coding System, but more local codes might need to be addressed.

### Civil Group

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### Electrical Group

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