Zach Dennin
David Foery
Erich Holtzer

EGR 343 Green Architectural Engineering: 2020 Tokyo Olympic Final Design Paper

Abstract:

The next summer Olympics will be here before we know it, and we have decided to get a jump start on preparations designing a large LEED-Platinum facility for the 2020 Olympics in Tokyo. In order to meet a Platinum certification we will be heavily focusing on certain demographic constraints, which will include topics like; site selection, land development, culture, topography, and natural habitats. Of course, we will also be thinking of inventive ways to keep this stadium as green as possible. Some ideas we've had so far are; utilizing green energy sources, like solar panels and wind turbines, and implementing a rainwater collection system. Throughout the design process we hope to adhere to the Japanese culture so that long after the 2020 Olympics is over, Tokyo can still have a long lasting environmentally friendly stadium which can be enjoyed for generations to come.

Introduction:

In deciding to choose the creation of a LEED Platinum building for the Tokyo 2020 Olympics, we set our primary objective as leaving the area surrounding our venue improved when compared to that of when we began our design. We tackled this objective on several fronts including, economical, cultural, and most importantly, environmental. In choosing an exact location, we were forced to decide on options within the city environment of Tokyo, thus setting a limitation on how environmentally friendly we could design our building. At the same time it leaves opportunities for growth of the area with regards to each of our core objectives. Our design will include ideas which can be applied around the world in other designs. Our goal with our building is to utilize the site and topography presented to us and optimize the development of the land to integrate with surrounding habitats while tying in the native culture.

Site Selection:

The specific location within Tokyo that we decided would best allow us to minimize our environmental impact is the location of the former National Olympic Stadium used in 1964, at 35°40'N, 139°42'E. In order to be more environmental with our approach we have chosen to create a major renovation on this existing stadium with a goal of reusing as many materials as possible. Additionally, the Tokyo bay is located within five miles of the stadium, as a result, we have set forth plans to help restore natural habitat in the bay. Over the past 100 years, a large amount of eelgrass has been lost in the Tokyo Bay. Eelgrass is an important vegetation to maintain as its deep roots strongly assist with the reduction of erosion in a coastal habitat (Tanaka et al. 871). As a result, we have decided to grow eelgrass within the stadium. We are preparing to collect rainwater to fill glass wall tanks, and have the eelgrass grow inside of these glass wall tanks. This will serve as a way to give back to the environment, as well as provide

both aesthetic and comfort benefits. Also, if we're left with enough money, we plan on integrating a large pond on the same property, which would also consist of eelgrass. Water is an extremely efficient material to use for thermal mass heating and cooling, and the implementation of these tanks will allow rooms to remain at a more comfortable temperature with less use of air conditioning or heating.

Land Development:

Upon our research into the current design plans for the 2020 Olympic Stadium, we have determined that 52 acres of land will be used in the creation of a new stadium. With the dimensions that we have determined for our stadium, 1400 feet by 1000 feet, our stadium would take up just over 32 acres. This amount of area would give us 1,400,000 square feet. An overestimate for the amount of area an olympic track would be 200,000 sq feet which yields us with 1,200,000 square feet to utilize for the visitors to the stadium. Based off of the expected stadium capacity of about 60,000 fans and an estimated 5,000 workers and athletes there would be an allocated 18.46 square feet per person, which is more than the recommended 16.15 square feet per person for a gymnasium, allowing a comfortable amount of space for each patron. People will be able to be spread out even more due to the multiple levels of the stadium. This extra space will allow the stadium to house special amenities such as food options and luxury boxes and various other vendors.

Not only will this stadium design give plenty of room inside the stadium it will also leave around 20 acres of leftover land to be transformed into natural gardens as well as walkways for our visitors. We will be able to utilize the excavated dirt from the stadium to assist in the landscaping surrounding the stadium as a way to both reduce cost and reuse the materials that we already have available to us. To assist in LEED credits this area will consist of meandering pathways to get away from the business of Tokyo city and the Olympics going on. These pathways will be shaded by typical Japanese trees. We plan to construct a japanese garden to assist in both the aspect of relating the culture of the nation into the construction as well as contributing to the greenery around the stadium. Centering this garden will be a large pond made from any of the water not collected by the rainwater collection system. This pond will also be home to more eelgrass which, like the eelgrass surrounding the stadium, will be transferred to Tokyo Bay following its growth.

Integration with Surrounding Land Usage:

Throughout our building process we plan on digging into the ground to ensure a flat area, giving us excess dirt from the process. This dirt will be used to alter existing floodplains and funnel water to a determined location in which we will locate a water storage tank to collect rainwater. This water will be used to fill our eelgrass tanks, water vegetation installed around and throughout the stadium, as well as supply water to restrooms. Additionally, this dirt will be used to beautify the stadium through landscaping. This dirt will allow us to build walkways around the stadium lined with trees for shading from the sun which reaches an average high of around 80 degrees Fahrenheit in summer months. We will also design slopes and valleys that

work as natural funnels that channel the water to certain areas which will have underground pipes leading to the storage tank.

Culture:

Our design will incorporate the ancient Shinmei style architecture in Japan and follows a design as shown in our architectural design drawings. This will compose our outside design, modified for a technological and environmental twist. One layer of the roof will consist of a green roof which will assist with rainwater runoff and heat island reduction. This roof would also involve solar panels on the west south and east facing sides of the building. This will allow the south facing solar panels to receive sunlight throughout the day. The east and west solar panels will receive sunlight during the early morning, and late night, when lighting from the stadium will be required the most, which will be a large part of the electrical use of the stadium. In addition to the green energy produced by solar panels there will be wind turbines on the roof similar to those on top of the stadium at Lincoln financial field (Jones 30-31). In order to add cultural significance to the turbines we are planning to have these turbines situated so that they resemble the Olympic rings. In the event that this would not provide enough power to our stadium, we would look into contacting local green energy companies to purchase green energy for the Olympic Games in a manner similar to how Elizabethtown College does.

Our last efforts into adding Japanese culture to our Olympic stadium will be with our food provided. We would like to offer our patrons traditional Japanese food from local food sources. This will also reduce the environmental effect in transporting food to the stadium and ensure that the food is fresh. This will give visitors a great experience to immerse themselves into Japan as well as try out new food and experiences all within the confines of an Olympic stadium. This will also reduce the environmental effect in transporting food to the games. There will be numerous vendor stations located around the perimeter of the stadium that are provided environmentally friendly appliances and systems to produce their products. The generated waste will be donated to the local waste to energy facility to reduce landfill.

Thermal Comfort:

Stadium spectators are exposed to thermal conditions which are dominated by the natural climate, which is not present in most indoor environments, but which needs to be considered when performing comfort studies. Keeping the viewers comfortable in our stadium was of high importance to us. However, calculating thermal comfort for an outdoor stadium is no easy task.

There are six main factors in determining thermal comfort: Air Temperature, Mean Radiant Temperature (MRT), Airspeed, Relative Humidity, Metabolic Rate (MET), and Clothing Insulation. We ended up finding an online calculator that allowed us to plug in values for each of these factors and give us results pertaining to ASHRAE standards.

In terms of Air Temperature, we found that Tokyo had an average temperature reading of 26 degrees centigrade in August of 2016. Since the summer Olympics will take place in August of 2020, we decided to use 26 degrees centigrade as our air temperature.

The MRT is defined as the uniform temperature of an imaginary enclosure in which the radiant heat transfer from the human body is equal to the radiant heat transfer in the actual non-uniform enclosure. The way you measure this is by taking the temperature of every object around you and multiply that by the angle it makes with you. Once you sum all of those values together, you divide by 360. In general, angle factors are difficult to determine, and they normally depend on the position and orientation of the person. Furthermore, this method becomes complex and time consuming as the number of surfaces increases and they have elaborate shapes. Not to mention, this is a figurative stadium that hasn't been made yet; so you can't do physical calculations even if you wanted to. Because of this, we found that we can just assume the MRT is the same as the Air Temperature. This would normally be frowned upon, but since this is an outdoor stadium it is actually quite plausible.

Airspeed is regarded to be a constant 0.1 m/s since most of the time people are measuring thermal comfort in regards to an indoor environment. Even though our stadium is outdoor, our roof is still fairly massive and would most likely restrict wind. Because of this we kept Airspeed as 0.1 m/s in our calculations.

Relative Humidity was very simple to find. We researched weather data on the month of August of 2016 in Tokyo. The average Relative Humidity came out to be 76%.

SInce this is an Olympic stadium, most of the spectators will be sitting. One Metabolic Rate (MET) = 58.2 W/m² (18.4 Btu/h·ft²), which is equal to the energy produced per unit surface area of an average person seated at rest.

The online calculator had a function that allowed us to pick what kind of clothing our figurative spectator would be wearing and provide a value with that clothing. We determined that the average spectator's outfit in August would consist of trousers, a short-sleeved shirt, socks, and underwear.

In the end, we ended up complying with the ASHRAE standard 55-2013. Not only that, but we received a PMV value of 0.34, which translates to a comfort level of somewhere in between *Neutral (0)* and *A Little Too Warm (+1).*

Lighting:

In spectator sports, lighting is very important. Without it the patrons cannot adequately see the activities on the field, especially at large distances, such as those seats that are towards the back of the stadium. During the day, the design of the building will allow enough sunlight into the stadium to illuminate the majority of the facility, excluding areas that are enclosed such as bathrooms and vendors. These areas will be lit using high efficiency LED lights that radiate in the optimum colors for visibility and comfort. At night the same types of bulbs will be used in indoor areas and other non-field spaces. The field and seats will be lit using high power stadium LED flood lights.

Infrastructure:

We plan on implementing all infrastructure accordance to the various codes International Building Code Series, including the IBC, IECC, IFC, IMC, IPC and IPMC, as well as the necessary codes in order to make our stadium specific to Tokyo's environment, considered shin-taishin. Other aspects of our infrastructure including building sizing, energy conservation, and transportation have been addressed in various sections of our final design proposal.

Topography:

After looking at the topography map, it was seen that Tokyo, is either flat, or at a lower elevation in comparison to the land around the city. As a result, we believe that our stadium is highly accessible by methods other than automobiles. In order to encourage this we will put an abundance of bike racks around the stadium, as well as advise other Olympic venues to do the same. As an additional incentive to use either mass transportation, or green transportation we will advertise that there will be no parking fees for bikes. Japan ranks sixth in the world in the amount of bicycles per capita. It has become a normal part of everyday life in Japan, thus allowing this emphasis on biking to fit directly into Japanese lifestyle (Steele 203).

We've also decided to integrate a green roof into our design. The green roof would be located on the east and west side of our stadium, that way in can get a large amount of sun each day.

LEED:

When evaluating our stadium design for LEED certification we determined that our stadium will receive 85 LEED points out of a possible 110 which would give our stadium LEED platinum status, with a buffer of 5 points. When looking at the location and transportation section we recieved 15 out of 16 points. We were able to receive 5 points for surrounding density and diverse uses due to us having more than 12 people per acre as well as more than eight types of diverse uses within half a mile of the stadium. We also received 5 points for access to quality transit due to Tokyo's metro and bus systems. Lastly, we were able to get LEED credits by adding bicycle facilities and utilizing an off site parking garage with green vehicle charging stations.

Sustainability is very important within LEED so we also focused attention on LEED points in the sustainable sites section scoring a total of 8 out of 10 possible points. This included creating an erosion and sediment control plan and site assessment of the topography, climate, vegetation, soil, and human health effects. By planting trees, gardens, and other vegetation we plan to help improve the environmental aspects. Also by incorporating the open space of a track and field facility with the open space of gardens and surrounding landscape we were able to earn additional points toward a platinum rating. In terms of rainwater management, we are building an underground water tank that is fed by collecting rainwater and channeling it to the tank.

Water Efficiency is a section of LEED we looked deeply into with a rainwater collection system. We will be able to use this water both in and out of the stadium. This will allow us to

reduce the water use. In addition, inside the stadium we will install all energy star appliances to ensure we will be using as little water as possible. These factors combined allow us to earn 9 out of a possible 11 LEED credits.

The section pertaining to energy and atmosphere allows the possibility of up to 33 LEED credits which makes it one of the most important sections to focus in on. We are able to earn 6 LEED credits by hiring a testing company to conduct experiments regarding energy use in the enhanced commissioning category. Using this data we will reduce our energy use by 35%, which would reward us with 14 LEED credits. Additionally, we are adding solar panels and wind turbines as alternative energy sources, leaving us with a total of 28 LEED credits.

In terms of our materials and resources, we plan to reuse much of the material from the original stadium at this site. We will also be recycling anything and everything that we can from the construction of the new stadium. For additional resources that are required, we will utilize numerous, local manufacturers as opposed to outsourcing to overseas contractors. This will help to support the local economy and help earn additional LEED credits.

The section regarding Indoor Environmental Quality allows the possibility of up to 16 credits. We were able to achieve 15 out of the 16 credits. We certainly earned all three credits of Daylight because it is an open top stadium. Daylight will consist of most of the lighting in our stadium. However, some indoor lighting will still be required, of course. Our one point for the Interior Lighting capabilities were covered earlier in this paper. Our one point for Thermal Comfort was also described earlier in the paper. The rest of the points we believe we achieved had to do with making sure the final stadium would have good air ventilation, using LEED compliant materials, and structuring a plan. If we were truly building a stadium, then these would all be easily attainable.

In the final section of innovation, we received 6 of a possible 6 LEED credits. In this design process we would bring a LEED accredited professional onto our team and implement the ideas discussed in this project in order to add LEED credits. Some of the major ideas discussed being the eelgrass being grown as well as used as thermal mass, composting food disposal, sending waste to a waste to energy facilities as well as many more. Throughout this design we have been able to weigh the pros and cons of different elements to incorporate on our mission to design a LEED Platinum track and field stadium for the 2020 Tokyo Olympics.

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