Case Study: Google's Unique Canopy Styled Construction

Raymond A. Cuevas
California Polytechnic State University
San Luis Obispo, California

In today's rapidly changing world, builders are pushing to implement more sustainable practices and incorporate innovative techniques to integrate green practices into their structures. One of the latest examples of this push towards sustainability is seen in Google's new headquarters, Charleston East located in Mountain View, California. Combining their widely known mission to provide a positive work environment for their employees with their passion to be more environmentally friendly, Google has set out to create a Living Building with LEED Platinum certification. In order to accomplish this Google has collaborated with Bjarke Ingels Group, Heatherwick Studio, and Hathaway Dinwiddie. The data for this report was gathered through semi-structured personal interviews with project members and the research of various primary and secondary sources. Despite the challenges of constructing the unique canopy styled structure, this building will promote community and sustainability while providing a healthy and productive workspace for Google employees.

Key Words: Google, Roof Design, Solar, Sustainability, Productivity

Introduction

Since Google's establishment in 1995, they have remained at the forefront of technology and innovation. Behind the technology, Google employs over 100,000 employees and has been listed 11 times on Fortune for the "100 Best Companies to Work For". As Google continues to grow, the company decided to create a new campus known as Google Charleston East in Mountain View, California directly next to their current headquarters, Googleplex. The Google Charleston East project is the first of its kind in company history due to the fact that it will be built from the ground up. In the past, Google has limited their projects to tenant improvement (TI) meaning they refurbished older buildings into contemporary facilities. The Google Charleston East project includes 1,000,000 square feet of space that will accommodate the community and employees while providing an environmentally friendly design. The project's most discussed feature is the one of a kind canopy-shaped roof. It contains photovoltaic shingles designed to repurpose solar energy throughout the building and its unique shape also allows for rain water to be captured and recycled. The entire first floor will be open to the public to enjoy to create an environment that unites Google and the residents of Mountain View. Above all, the office layout for employees is meant to be open to provide a more collaborative and inclusive workplace for employees to adhere to Google's commitment to providing a positive work environment.

To create this one of a kind structure, Google hired Bjarke Ingels Group (BIG), Heatherwick Studio, and Hathaway Dinwiddie. BIG is based out of Copenhagen and New York with 25 offices worldwide.

Their mission is to create exciting, unordinary architecture that include contemporary “ingredients” such as leisure, working, shopping and parking (Bjarke Ingels Group, 2020). Some of their well-known projects include 8 House in Copenhagen, West 57 in New York, and the Two World Trade Center in New York City. Google hired BIG as one of the leading partners to design Google Charleston East. Heatherwick Studio is another company that strives to have a positive social impact throughout the world with their sustainable projects. Some notable projects include the Olympic Velodrome in London, EDEN in Singapore, and the Lantern House in New York. Heatherwick Studio was hired to collaborate with BIG to design Google’s newest headquarters.To carry out the vision for Charleston East, Hathaway Dinwiddie Construction Company was brought in to build the structure most likely due to their long history of building unique structures throughout large metropolitan areas in the U.S.

Due to the originality of this project, this case study will review the social and physical benefits of Google’s new headquarters through various lenses including data analysis and interviews with members that made this project possible. The gathering of this information will create new knowledge surrounding the impact of Google’s innovative workspace on its employees, community and environment.

Methodology

To obtain the best results, field research was conducted to gather the proper information regarding the construction of Google Charleston East. The field research conducted for this case study includes qualitative data gathered through personal interviews from project members and primary and secondary literature sources. Each interview was conducted in a semi-structured manner to gather exploratory and attitudinal data. The nature of the questions differed depending on the interviewees position to expand on any significant findings pertaining to the unique canopy structure.

Case Study

Construction

Structural steel is a material commonly used in commercial construction. Its high tensile strength makes an optimal material for building large and unique structures. Because of the special properties of steel, it also adds value to commercial buildings. This material can be found in malls, stadiums, and warehouses but is typically associated with high-rise buildings or bridges primarily due to its high strength to weight ratios. Incorporating steel members into building design is also beneficial for its ability to be prefabricated off site and brought onsite when it is ready to install (Sullivan & Horwitz-Bennett, 2008) which is known as the “just-in-time delivery method.” This method has been commonly adopted to save space on site, allow for higher quality members and increase project safety (Bertelsen & Nielsen, 1997).

Like most commercial structures, this building is supported by a secure concrete foundation. Google Charleston’s East has a square shaped foundation that includes four exterior walls to form the basement. In each corner, there are large reinforced concrete piers commonly known as touchdowns (see figure 1). These touchdowns require exceedingly large reinforcement to support the canopy

structure (see figure 2). Concrete is also used for the building's ventilation system by circulating air through large concrete tunnels on the west and east sides of the building.

Figure 1. This is a typical touchdown that can be found at all four corners of the building before concrete is placed.

Figure 2. This is a complete touchdown, where the canopy structure touches down onto the foundation. In this image you can also see the yellow tubenet structure and tube steel truss above the touchdown.

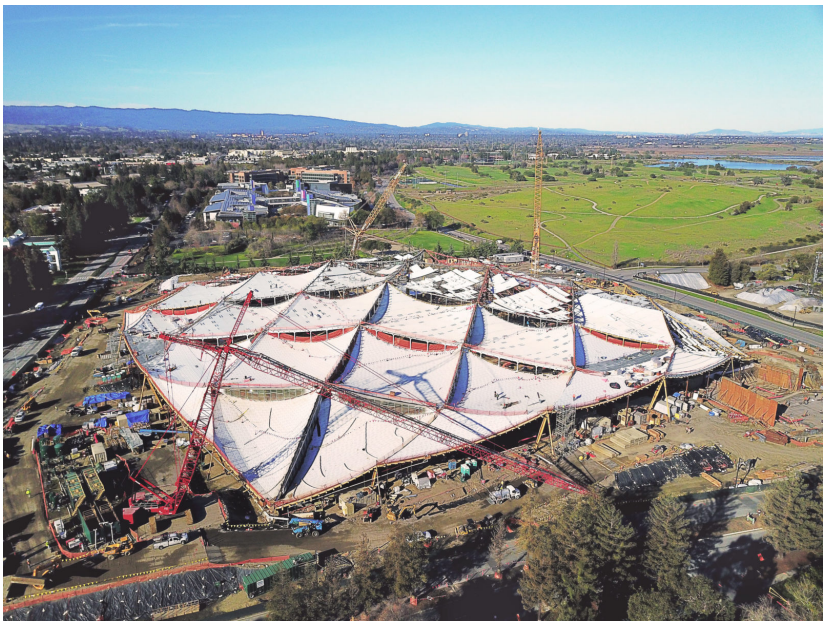

Figure 3. The canopy at the clerestory installation phase.

Without structural tube steel, the unique roof shape and high ceilings would not be possible. It comprises various square, triangular, and kite shaped roof panels referred to as sequences (see figure 3) which are built up of a complex net like tube steel structure known as the tubenet (see figure 2). There are 52 total sequences, each identified by the order of its installation.

Due to limited site space, most of the structural steel members were prefabricated offsite. Some of the larger members, such as the smiley trusses and columns had to be transported in two pieces and welded together onsite. The tube steel pieces that make up the tubenet were bolted together onsite using stanchions (see figure 4). The stanchions served as a tool that controlled the exact placement of each assembly piece. Using the stanchions, adjustments could be made on the ground instead of 50 feet in the air. This allowed for a safer, more efficient and higher quality assembly. Once completed, the panels were craned up and bolted into place on the canopy. The tubenet pieces were attached to the smiley trusses on all four sides and a column at each corner. The canopy was constructed one sequence at a time in a strategic manner which allowed it to be constructed directly succeeding the construction of the basement walls supporting it. The construction began in the southeast corner and worked its way towards the north west corner.

Figure 4. A complete tube net square getting ready to be craned into place. This image also includes a visual of the tubenet panel sitting on the stanchions.

Following the installation of the tube steel structure, the metal decking is fastened directly onto the tube net therefore creating the ceiling that occupants see when they look up. In order to water proof, fire proof and provide temperature regulation, the metal decking is covered with insulation. The next step in the roof construction process is the installation of Densdeck. The Densdeck creates a surface for the Bemo waterproofing to stick to. Bemo waterproofing is used for structures with unique shapes such as round or concave roof structures. The bemo material is used to create a moisture barrier between the exterior surface and the insulating surface above the metal decking.

Once the initial waterproofing layer is installed, the clerestory windows are installed. There are clerestory windows on every smiley truss. These windows allow natural light to enter the interior spaces of the building. Once all windows are installed, the nodes are installed. The nodes are large stainless steel bullnose shaped panels that cap the exterior corner of each square canopy panel.

After all nodes are installed, the canopy surface is ready for the photovoltaic panels or PV panels. The photovoltaic panels are placed in a shingled pattern that make the surface appear similar to a typical roof. The PV panels will cover the entirety of the canopy surface.

The exterior of the building will consist of Floor to ceiling Clerestory windows. The windows attach to the tubesteel above and concrete basement walls below.

The interior of the building will be built of structural steel platforms. The first floor will feature a concrete floor poured over metal decking. The second story is made up of split level platforms connected by ramps. These platforms will feature cross-laminated timber (or CLT) beneath a concrete deck. This allows only the CLT panels to be visible from the first floor while still having a concrete floor above.

Sustainability

Sustainability has become an essential factor for a businesses long term success. Without the implementation of sustainable practices, companies may face critique or loss of customers. Many consumers are looking to support companies that promote a smaller carbon footprint. To achieve this, companies have included more sustainable production methods, managing styles, and workplace environments. Recently, companies such as Apple, Facebook, and Nvidia have begun to implement these green techniques in their headquarters.

With new Green building certifications and challenges such as the LEED certification and the Living Building Challenge, there are now standards for building sustainable structures. LEED certification is based on credits. These credits are earned through implementing green building features. There are four levels of LEED certification, Certified (40-49 credits), Silver (50-59 points), Gold (60-79 points), and Platinum (80+ points) (Mlotek, 2014).

The Living Building Challenge is meant to highlight the most sustainable structures. The challenge has different requirements for new buildings, existing buildings, interior projects, and landscape/ infrastructure projects. The challenge is based on the execution of 20 requirements known as imperatives that are divided into 7 sections known as petals (“Living Building Challenge 4.0 Basics,” 2020). The petals are Place, Water, Energy, Health/Happiness, Materials, Equity, and Beauty. Some of the most difficult aspects of the living building challenge includes an overall net positive waste, this means reducing or eliminating the production of waste. This is a requirement that is effective throughout four phases, design, construction, operation, and end of life. This limits the project to sustainable materials and materials that can be easily recycled at the end of the building's lifespan.

These new campuses often incorporate features such as renewable energy, water efficiency, improved indoor air quality, and sustainable materials. Aside from having a positive impact on the environment, building green has also proven to be very cost-effective in the long run (“Benefits of green building,” 2020).

Google has always been one of the frontrunners in the race towards sustainability. They began with their Googleplex campus and have stepped it up a notch with their latest endeavour. Their new headquarters aims for a LEED Platinum certification and a Living Building title.

Some sustainability features included in this project are:

- Renewable energy: Photovoltaic solar roof
- Water efficiency: Control of rain water run-off with drains on roofs surface
- Natural light: Roof and exterior clerestory windows
- Alternative transportation methods
    - Bicycle parking for employees
    - Electric Vehicle charging stations
    - Bus stop terminal on-site

Community

Community connectivity is key in a large tech company's success. Creating a personal relationship with the surrounding community benefits the company and the community. Improves company's image. Give back to the community not disrupt it. Allow for space for community members to gather and spend time, make it feel like it is part of their community not an exclusive space.

Including retail space and restaurants creates jobs, helps the local economy and pulls the community into the space. Makes it more personal

This building will feature a first floor that is open to the public. There will be restaurants, retail space, and lounge areas. This will help create a personal relationship between Google and members of the Mountain View community.

Aside from helping the community by creating jobs, Google has directly helped the mountain view community by donating to small businesses during the COVID-19 shutdown.

Figure 5. This image is a rendering created by BIG that demonstrates the potential this building has to create a close knit community.

Workforce Productivity

Workspace environment is also a major factor in a company's success. Today, in such a competitive industry, tech companies are taking every step to improve their performance. Most of this increased performance comes from employee productivity. Employers are making major changes to keep their employees performing at their full potential. This includes updating their workspace (Kim et al., 2016). Natural lighting, air quality, and layout are all shown to increase productivity in the workspace.

With this new building, Google has really made it a point to create an inspiring and creative atmosphere for its employees. With the unique canopy design they were able to provide natural light to interior spaces of the building that would not typically have access to natural light. By using elevated platforms, they managed to create an open workspace that still feels private (see figure 6). The lack of fixed walls and ceilings allows for spaces to be more flexible and transformed as needed. The open spaces and high ceilings also allow for great air ventilation. Proper air circulation is extremely beneficial to employees health.

Figure 6. This is another Rendering by BIG that shows what the interior work space of the building will look like. You can see the clerestory windows in the smiley trusses allowing natural light to enter the building.

Results

Interview Information

Being such a unique project, were there any major difficulties?

Considering the large project, typical mistakes that would seem insignificant on normal projects are multiplied. For example on a typical project if you were to miss 5 nuts and bolts, it would not be such a big deal, but on this project those 5 nuts and bolts are multiplied by 10,000.

This is a structure that has never been built before, it was a challenge finding solutions as they arise. For example, when installing the tubenetting on the canopy there was a deflection in the steel that was not expected. Finding a viable solution for this issue required several mock-ups, and prototypes. Other issues such as soil contamination also created unexpected issues for the general contractor. In order to build in certain areas of the project where contaminated soil was discovered, the soil had to be removed, treated, and allowed to dry before being re-tested. This whole process could take days to weeks depending on the amount of soil.

What would you say is the most difficult aspect of participating in the Living Building Challenge?

Building green was another challenging aspect of the project. Finding materials that met the architects specifications and were made in a sustainable manner that met the sustainability requirements was extremely difficult.

Has there been a learning curve for subcontractors on the project? If so, how has this learning curve affected the scheduling process?
Although this project is very unique and unlike most other projects, one thing that remains the same is the subcontractors ability to learn as they go. Subcontractors on this project experienced a learning curve that allowed for a decrease in task durations. For example, instead of taking five days to complete a task it would take three days. This made scheduling and planning much easier as the project progressed because the task durations became more and more accurate.

How has coordination and collaboration among project members benefited this project?

Coordination between project members was a great benefit to the overall success of the project. On-site performance was greatly improved through the several meetings held throughout the week. Every morning a foreman's meeting was held to go over each tardes work for the day and where they would be working. This helped avoid any clashes between trades during the day and allowed the project to flow much easier. Another meeting held weekly was the pull-planning meeting between the foreman, superintendents, and project managers. This meeting's purpose was to keep the schedule updated on a weekly basis. Foreman would go over what tasks they accomplished the week before and what tasks they plan on completing in the week to come. This was the main way to track progress and create a schedule. Another form of coordination that proved beneficial for the project was the office set up. The main project office had a big-room set up, meaning the general contractor, architects, and engineers were all in the same building. This increases communication between team members and promotes collaboration. Working in the same space allowed all parties to get familiar with each other on a personal level. This is extremely helpful when compared to most projects where the general contractor, architect, and engineer are not so willing to help each other.

What was the most difficult part of creating the schedule and phase plan for the canopy?

Having so many subcontractors involved in the construction of the canopy was a major difficulty. Each trade was directly affected by the trade that it was following. For example, the window subcontractor could not install their windows until the waterproofing subcontractor installed their waterproofing and the waterproofing subcontractor could not install their waterproofing until the metal decking subcontractor completed their decking. When speaking in terms of scheduling this is known as the critical path.

How did site space affect the construction of the canopy?

Site space was another major issue. With so many subs onsite daily keeping everyone from getting in each other's way was not easy. With only one road that wrapped around the edge of the building there were constant traffic jams on site. This was extremely evident when installing the final clerestory windows on the interior sequences of the canopy. Being such a large building there were not very many cranes that could reach all sequences from a fixed position so a crawler crane was required to place materials on the canopy. Onsite, this crane was known as Big Red. For safety reasons, mobilizing the crane required shutting down the road onsite for the majority of the day. These mobilization days required large amounts of collaboration between all members of the project to avoid any issues.

Conclusion

This project has various benefits. The benefits outway the initial disadvantages experienced by some of the project members. All new ventures will have their difficulties. These challenges are a small price to pay for the major benefits this building will have on the environment, its employees, and the surrounding community. Google's new headquarters creates a healthy workplace for its employees through the implementation of natural lighting, open floor plans and beautiful architecture. It also improves the city of Mountain View by creating jobs and promoting a sense of community. Most importantly, this structure is able to accomplish all of this while improving the environment. Using the latest sustainable building methods, Google has managed to reduce their carbon footprint and create a building that can power itself. Providing accommodations for various methods of transportation such as bussing and cycling reduces the amount of vehicles on the road, reduces emissions, and is a very convenient alternative for employees who have to commute in traffic.

Future Research

Some future research that could be conducted is reviewing the effects of this building after some time. One could test the accuracy of the comments made in this case study regarding how beneficial this project is to the environment, employees, and community. One specific study could be analyzing the overall satisfaction of employees that work in this building compared to employees that work in other, more traditional, work spaces. This study could also review other factors such as their health, productivity, and happiness.

References

American Institute of Architects. "Figure 3." 2020. JPEG.
https://www.aiasmc.org/events/2020/05/may-27-joint-chapter-event-at-stanford-with-aiasv/

Benefits of green building. (2020). *U,S Green Building Council.* Retrieved from
https://www.usgbc.org/press/benefits-of-green-building

Bertelsen, S., & Nielsen, J. (1997). Just-In-Time Logistics in the Supply of Building Materials. *Semantic Scholar.* Retrieved from https://pdfs.semanticscholar.org/6c6c/e29483f94784ac80f428a8cbaed994a2ac60.pdf.

Bjarke Ingels Group. (n.d). About BIG-Bjarke Ingels Group. *BIG*. Retrieved from https://big.dk/#about

Cuevas, Raymond. “Figure 1.” 2019. JPEG

Cuevas, Raymond. “Figure 2.” 2019. JPEG.

Cuevas, Raymond. “Figure 4.” 2019. JPEG.

Heatherwick Studios. “Figure 5.” 2019. JPEG. Google Charleston East. https://www.architectmagazine.com/project-gallery/google-charleston-east_

Heatherwick Studios. “Figure 6.” 2019. JPEG. Google Charleston East. https://www.architectmagazine.com/project-gallery/google-charleston-east_

Kim, J., Candido, C., Thomas, L., & de Dear, R. (2016). Desk ownership in the workplace: The \ effect of non-territorial working on employee workplace satisfaction, perceived productivity and health. *Building and Environment, 2016*(103), 203-214. doi10.1016.j.buildenv.2016.04.015

Living Building Challenge 4.0 Basics. (2020). *International Living Future Institute.* Retrieved from https://living-future.org/lbc/basics4-0/

Mlotek, L. (2014). LEED Green Associate Study Guide. *Leading Green.* Retrieved from https://leadinggreen.com/wp-content/uploads/2013/12/LeadingGreen-LEED-GA-Study-Guide-v4-ed.pdf\

Sullivan, C.C., & Horwitz-Bennett, B. (2008, December 1). Steels Adds Value to Commercial Buildings. *Building Design and Construction.* Retrieved from www.bdcnetwork.com/steel-adds-value-commercial-buildings

100 Best Companies to Work For. (2020). *Fortune.* Retrieved from https://fortune.com/best-companies/2017/google/