
AEI Team Number:
05-2014
10 Feb 2014
Innovative Construction
Report
2014 Charles Pankow Foundation
Annual AE Student Competition

Table of Contents

Executive Summary:

The Charles Pankow Foundation Design Competition challenges students to address the design, integration and construction issues that must be considered for a high performance, 30 story high-rise located in San Francisco, California. Our team plans on enhancing the quality, efficiency, and value of large building construction through our innovative construction methods, structural considerations, and building system designs. Collaboration, communication, and design methods are the key components to achieving these goals.

350 Mission is designed to be a near net zero high-rise building. Our team has created our own definition of net zero by combining multiple different definitions. *Please refer to the Integration Report for our team's definitions, goals and results.*

The goal of our team's innovative construction members is to construct a near net zero high-rise building that addresses safety, project delivery, project planning, budgeting, and scheduling through building information modeling. This goal is achieved through the architectural design and integration amongst the structural, mechanical, electrical, and construction disciplines.

The construction delivery method which will be utilized for 350 Mission will be a Design – Building delivery method. This approach is believed to be the best option for this project. An organizational chart along with further explanations has been provided in the project delivery method of this report. In this section, constructability concerns and challenges our team will need to overcome for this project are addressed.

Our innovative construction team's number one priority is the safety of the construction workers and the public. It is our innovative construction member's goal to provide and injury free site. To ensure the safety of the public and construction workers, safety plans, and strategies have been provided in the safety section of this report.

The project planning section of this report addresses the overall construction process. This section will be emphasized on the demolition, dewatering/slurry wall, excavation, superstructure and enclosure phases along with the waste management plan. The demolition phase will address the demolition of the existing building and the asbestos abatement plan of this project. The dewatering and slurry wall phase discusses the strategies which will be taken for excavating 55 feet in an area with a high water table. Three 3 Dimensional site logistics plans have been provided for each of the different phases of construction. Lastly, a waste management plan has been created to explain the removal and recycling process for this project.

An overall construction schedule was completed to determine how long 350 Mission will take to be constructed. Construction will begin February 2014 and conclude July 2017 for total schedule of 29 months. A breakdown of the schedule is provided in this section as well as in the appendix. Calculations for the durations are also available in the appendix.

A detailed estimate and general conditions estimate was completed to determine the estimate cost of 350 Mission. The estimate for this project is $137,594,704 and $10,500,566 for the general conditions estimate making the total cost to be $148,095,270. Breakdowns of these costs are provided in this section as well as in the appendix.

Building Information Modeling will be used on this project to help with the coordination between the disciplines. A Four Dimensional (4D) model will help contractors understand the phasing and sequencing of the project. This model will also be used for Three Dimensional (3D) coordination amongst the disciplines and site management. 4D modeling and 3D coordination are the key components that lead to prefabrication which will be discussed in this section.

Through the collaboration amongst structural, mechanical, electrical and construction disciplines, our innovative construction team's goal to construct a near net zero high-rise building will be achievable.

INTRODUCTION:

350 Mission is a 30 story mixed use high-rise building located in the heart of the Business District in San Francisco, CA. It will be five blocks off the Bay at the corner of Mission Street and Fremont Street across from the future Transbay Transit Center Terminal. Once construction is completed, this corner will be a highly visible and recognizable area for San Francisco.

Figure A: 350 Mission Rendering

This high-rise building can be seen in **Figure A** contains a four story entrance lobby which includes a restaurant, café, and retail space. The upper 26 levels of the building are rentable offices with a four story underground parking garage. The goal of 350 Mission is to provide a more sustainable lifestyle and work environment for their tenants.

Our team believes, through the various building systems and construction methods, this high-rise building can provide a safe and sustainable lifestyle for the tenants. The systems being implemented are a double façade, raised access floor system with underfloor air distribution, steel structural system, photovoltaic grid, and combined heat and power. These systems are integrated through collaboration and coordination amongst the disciplines.

The mission of our innovative construction team is to provide an integrated delivery amongst the structural, mechanical, and electrical disciplines to achieve a near net zero high-rise building.

PROJECT DELIVERY:

PROJECT DELIVERY METHOD

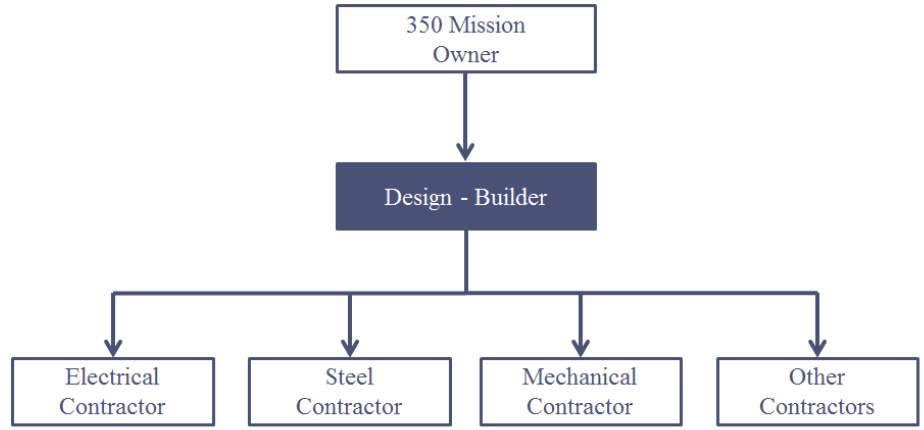

Figure B: Delivery Method (Our team represented by the dark box)

Our team will be performing a Design – Build delivery method as shown in **Figure B**. Our innovative construction team members feel this is the best option for approaching this project. In this delivery method, the Owner of 350 Mission will be actively engaged in the construction process and will only have one contract with the Design – Builder. The advantage to only having one contract is the Owner will hold less risk since most of the liability will be on the Design – Builder. This method will help improve the quality of the project. Since the architect and contractor are one entity and will be working together, the design process and procurement will be able to begin earlier. Having these two members on the same team, allows for the construction process to also begin before the designs are finalized. This will help shorten the overall construction schedule of the project. This delivery method allows for more potential cost savings since there will be close collaboration and coordination between the Design – Builder and the trades throughout the entire project. During this time, the steel, mechanical, and electrical contractors will be brought on the project early for clash detection to be conducted. This process will provide for fewer problems during construction.

Constructability Concerns

350 Mission has presented many unique constructability concerns which our innovative construction team members need to address. Some of the challenges are no work zones, site limitations, and building systems. At our team meetings, these concerns were brought up and as a team, discussed potential solutions to address these concerns. Through effective communication and collaboration amongst the disciplines, all of the challenges will be overcome.

The city of San Francisco contains many different forms of transportation. One of the popular forms is the electric buses. There are multiple electric bus lines that run past our site on a daily basis. In order for these buses to operate, there are electrical wires that run up and down the streets. These electrical wires are currently attached to the pre-existing building at three locations. Prior to construction beginning, these wires must be detached from the building and placed on temporary poles which will be located at the perimeter of the site. Communication with San Francisco Municipal Transit Authority must be conducted before relocating the electrical wires. According to the San Francisco Municipal Transit Authority, 10 feet horizontally and vertically of the wires must be clear of construction. These no work zones can be seen in **Figure C**.

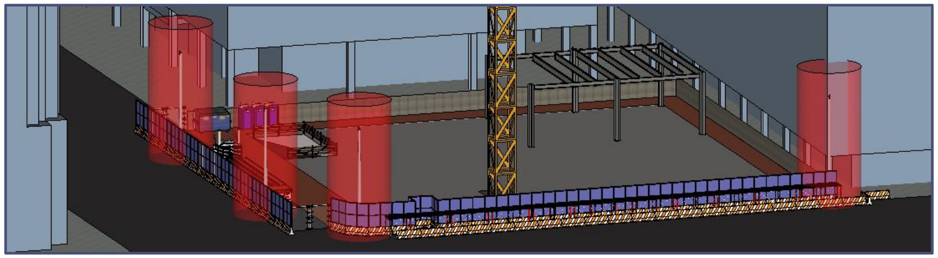

Figure C: Temporary Pole No Work Zones

The selection of the crane is a crucial decision on this project. Two concerns that will need to be addressed are the type of crane which will be most beneficial and where it will be placed on site. Since the site is small and most radii of a jib will hit the surrounding buildings, a luffing boom tower crane will be required. This crane allows for the jib to be raised which will permit for the crane to swing while clearing the surrounding buildings. The second concern is where to place the crane on site. Our innovative construction team members analyzed placing the crane either on the edge of the site or inside the building footprint. Our innovative construction team members along with our structural team members believed that the best location would be inside the building footprint because the crane creates an extra stress on the foundation walls when placed on the edge of the site. *Specifications of the crane can be viewed on Appendix Page C-2.*

During one of our team's coordination meetings, a concern that was brought to our team's attention was the amount of field welding that a high-rise steel structure contains. **Figure D** shows a typical connection for the columns. Each of the bolts will be full penetration welds. To reduce the amount of field welding, our structural team members proposed to splice the columns. Splicing the columns will allow for them to be longer and welding will not have to be done on each floor. Welding will only need to be done on the floors where the columns connect. Our structural team members designed our structure to be spliced every three floors resulting in columns of 42 feet in length. One concern our innovative construction team members had was the transportation of these columns to the site. When looking at possible routes, it became clear that the length of these

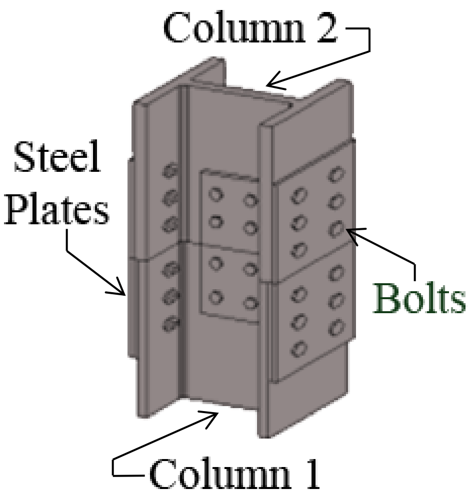

Figure D: Typical Connection for Columns

columns would be too long. Therefore, our team members worked together to achieve a solution that addressed the field welding concern and transportation concern. As a result, our structural team members designed the columns to be spliced every two floors resulting in columns of 28 feet in length. *Refer to Appendix Page C-5 for possible delivery routes to the site.*

SAFETY:

Our team's number one priority is safety. Our innovative construction team member's goal is to ensure the safety of our workforce, contractors, and the public. 350 Mission is located in a high traffic area which means extra precautions must be taken. It is our team's responsibility to implement strategies to achieve a zero accident site.

PUBLIC SAFETY

To prevent the public from entering the construction site, there will be a construction fence placed around the perimeter of the site. During the demolition phase, this fence will be a chain link fence with mesh covering. Due to site limitations, this fence allows for easy adjustments when demolition is occurring.

Figure E: Pedestrian Traffic Flow

Once the excavation phase begins, a Jersey barrier fence will be placed for the duration of the project. This fencing is a more stable fence which is needed to keep vehicles and the public from entering the site. Signs will be placed along the line of the fence to inform the public not to enter the site. The fence will also be lined with lights for visibility at night.

Since we are located in the heart of the city, there is a high flow of pedestrian traffic. During construction, the pedestrian traffic will be rerouted around the site. To accommodate for this inconvenience, temporary walk ways will be placed on Mission Street and rerouting signs will be placed on Fremont Street. In **Figure E**, the rerouting of pedestrian traffic is shown in red. A covered walkway will be placed over the Mission Street walkway to protect pedestrians from potential falling debris once steel erection begins.

CONSTRUCTION WORKER SAFETY

Safety for the work force is a major concern when dealing with a high-rise building located in a metropolitan area. To ensure the safety of the workforce, OSHA regulations will be met or exceed by all parties on this project. To enforce these regulations, our innovative construction team will have all employees/visitors attend a safety orientation before entering the job site. In addition, our innovative construction team will be implementing a safety program which will provide extra safety precautions. This safety program will include weekly safety meetings known as Toolbox Talks which will address any safety concerns that will be occurring on site that week. The Toolbox Talks will help prevent injuries from occurring by keeping employees alert. *Appendix Page C-3 has an example of a Toolbox Talk.*

Evacuation procedures will be planned to ensure the safety of the workers on site. These procedures will range from emergency weather to catastrophic events. In each of these events, the workers will have a designated safe area to go. *A list of these procedures is shown on Appendix Page C-4.*

Project Planning:

There are many challenges that will need to be addressed for 350 Mission since it is located in a metropolitan environment. One of the more difficult challenges for this project is the site limitations. 350 Mission is a small congested site which our team plans on using the space efficiently.

Demolition

Since it is unclear when the pre-existing building was constructed, our team will be developing an asbestos abatement plan as a precaution. There is a possibility of two types of asbestos our team may come across. These types are friable and non-friable. If asbestos is found, it must be tested by a lab that is certified by the California Department of Health Services to determine if it is hazardous. If it is found to be hazardous, a special crew will need to come and completely remove the asbestos. Once this has been completed, demolition of the pre-existing building can begin.

Demolition is scheduled for a two month period and will begin on the West end, moving in a clockwise direction and ending on the South end of the site. **Figure F** shows the flow of demolition and each of the different demo zones. A demolition mat will be used to keep debris from falling out of the site and entering the street. Due to site limitations, this debris will be transported to another location to be sorted and recycled. Since the pre-existing building was constructed of concrete, our team plans on recycling this material and using it as aggregate. This aggregate will be used in the concrete which will be covering the steel columns in the lobby. During the recycling process, this concrete must be tested for gypsum contaminations before being added to the admixture.

During this phase of the project, the field office will be located off-site in an adjacent building, which can be seen on *page C-5 in the Appendix*. This will allow for more adequate space on the site. One traffic lane along with street parking on Fremont Street adjacent to the site will be used during construction.

A construction fence will line the perimeter of the site which will be a chain link fence with a mesh covering at 8 feet in height.

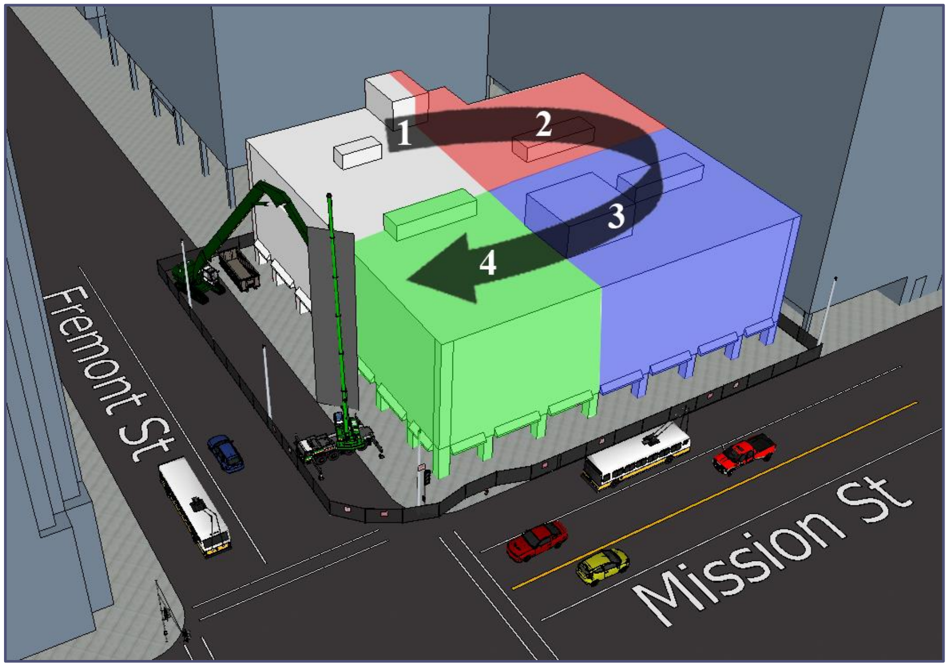

Figure F: Demolition Flow and Zone Breakdown

Dewatering / Slurry Wall

350 Mission is located five blocks from the bay which causes this area to have a high water table. A temporary construction dewatering system will need to be installed to drain and depressurize the soil so the building can be constructed below the ground water level. A deep slurry wall will be used to avoid dewatering outside the cutoff wall, which could cause excessive ground subsidence.

Steel sheet piles and internal steel bracing was considered by our innovative construction team members for the shoring system; however, there are many difficulties with using this method. Based off the Geotechnical Report, there will be a difficulty of driving the steel sheet piles through the existing fill and into the dense Colma Sand. The report also states the installation of the steel sheet piles will generate significant vibrations that could cause ground settlement and they are not sufficiently rigid to limit vertical and lateral movements. These movements could affect the surrounding structures and underground utilities. Our innovative construction team members decided that it will be safer to use a deep slurry wall since it is a more rigid method. **Figure G** shows how the slurry wall will be installed.

Figure G: Slurry Wall Installation (Chen, 2013)

Our innovative construction team will be utilizing a deep well dewatering system. Based off the Geotechnical Report, the design groundwater elevation is -3 feet and will extend to -55 feet. The groundwater level will be maintained at least three feet below the planned maximum excavation until the mat foundation is poured and cured so that it resists the hydrostatic uplift forces. This will insure that no water damage will occur during construction. The dewatering contractor will need to obtain a dewatering and discharge permit from the City and County of San Francisco for the discharge of water into the local municipal storm drain system. A fee will be charged for the disposing of construction generated water into the city's wastewater collection system.

Excavation

The excavation phase will be scheduled for a five month period and is shown in **Figure F** on the next page. In this phase of the project, the construction fence will be changed from the chain linked fence to a Jersey barrier fence. This will be a permanent fence during construction to help keep the public from entering the site. Construction delivery gates will be added to the fence for entering and exiting of delivery materials. The delivery area will be located on Fremont Street as shown in **Figure H** as the area highlighted in green. Fremont Street is a one way street which allows for easy delivery access for vehicles since the trucks can pull right up onto the site. A temporary sidewalk will be placed on Mission Street to accommodate the pedestrian traffic around the site.

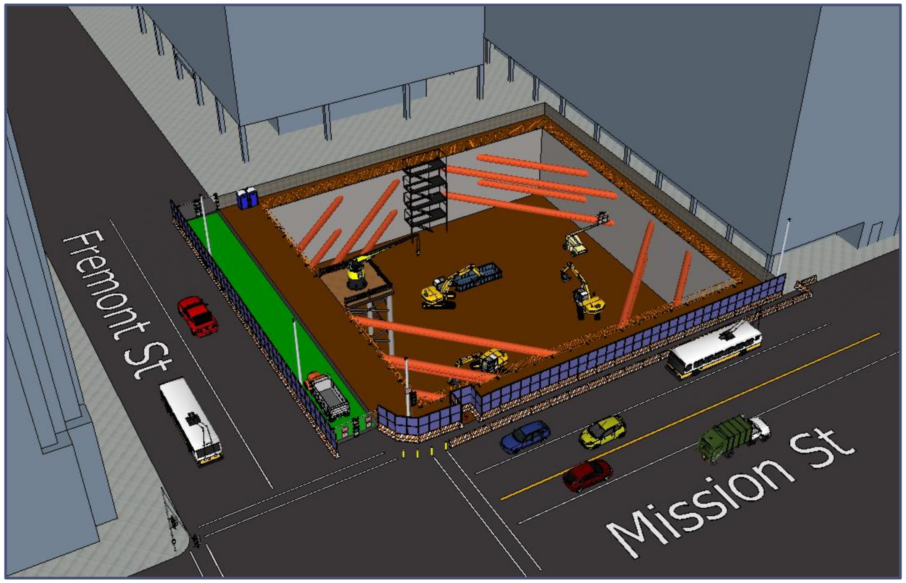

Figure H: Excavation Phase

Based off the Geotechnical Report, there are 20 steel pipe piles and roughly 700 timber piles located on the site. As excavation occurs, these piles will need to be cut off and removed. The removal of these piles will reduce the potential for seepage in the channels, ground surface settlement, and disturbance to the foundation during construction. Monitoring of the slurry wall will also be critical during this stage to ensure that there are no effects to the surrounding structures and utility lines. Surveying points will be used to monitor the movement of the shoring during excavation.

As excavation progresses, temporary internal braces will be installed to the slurry wall to reduce the movement of the shoring. Excavation should not proceed below any level of bracing until all bracing for that level has been installed. Once the mat foundation is installed and construction for the parking garage begins, each of the braces will be removed after the concrete for the parking garage has been cured.

SUPERSTRUCTURE

The structural steel system of 350 Mission will be compiled of W14 columns with beams ranging from W8 to W36. Our structural team members designed all of the columns to be W14s because they are more slender and uniform in size. These columns will contain heavier weights which will allow 350 Mission to have smaller columns with high strengths. Two inner columns were added to the proposed floor plan to reduce the beam depths to allow for greater ceiling heights. Since these structural members contain heavier weights, our innovative construction team members had to check the crane specifications to determine if the crane can support these members. The weight of the largest column was calculated to be 8.47 tons. According to the crane specifications, the maximum load that the crane can lift at a distance of 135 feet is 17.67 tons *(Refer to Appendix Page C-11 for column sizes and C-2 for crane calculations).*

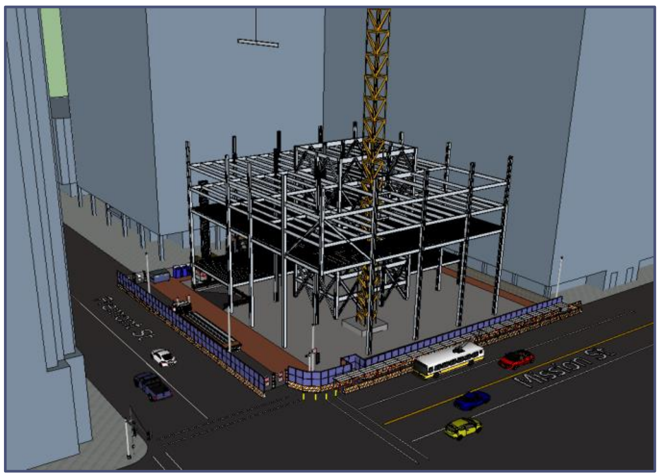

Figure I: Steel Erection Phase

Two story columns will be used to minimize lifts. This will cut down the number of lifts required for the columns in half and will reduce the schedule for steel erection. This was coordinated with our structural team members to determine which floors will be spliced. The columns will be spliced every two floors starting at the fifth floor. Ground level up to the fifth floor will be built up columns to support the load of the building.

The steel erection phase will take approximately 16 months. During this phase, the field office location will be moved to the parking garage. This will allow for easier communication amongst project managers, superintendents, and subcontractors. The tower crane will be brought to site and will be assembled. The base of the crane will be placed on top of the parking garage. Coordination with our structural team members will have to be conducted so the parking garage can support the added structural load.

A large task which needs to be addressed is the sequencing of the structural steel. Our innovative construction team members have determined to break the steel structure into eight different zones. This will allow for easier sequencing with the other trades. These zones can be seen in **Figure J**. The first zone consists of the lobby, restaurant, and equipment room. Zones two through seven consist of four office floors each with the last zone consisting of the 30th office floor, roof, and penthouse.

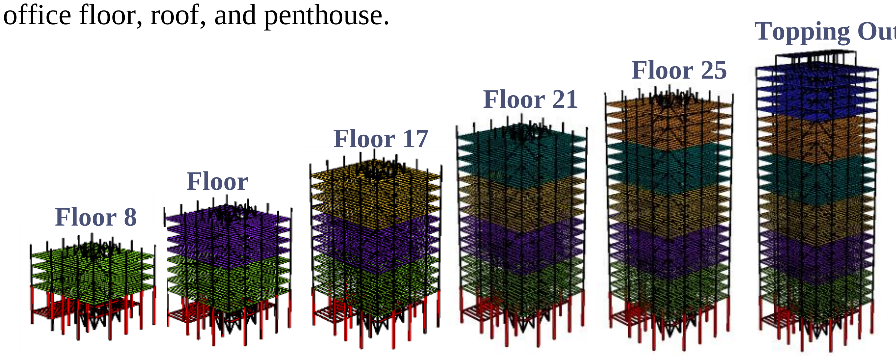

Figure J: Steel Sequencing Zones Breakdown

Since the Southern corner column does not extend to ground level, special sequencing was involved. When erecting the fifth and sixth floor, the beams will not be placed in the area as shown in the red in **Figure K**. Prior to installing the column for these levels, the cross bracing will need to be installed which can be seen in blue in **Figure L**. Once this cross bracing is installed, the fifth and sixth level beams and spliced column can be installed as shown in green in **Figure L**. This process will also be utilized up to floor eight. Our innovative construction team and structural team members believe the spliced column will not be able to be structural stable to account for the column above until the bracings are in place. *Refer to Drawing Page C-102 for steel sequencing plan.*

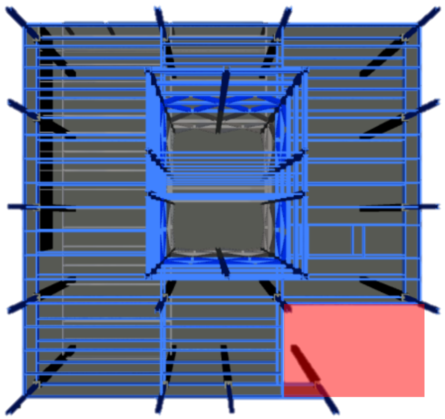

Figure K: Beam Layout

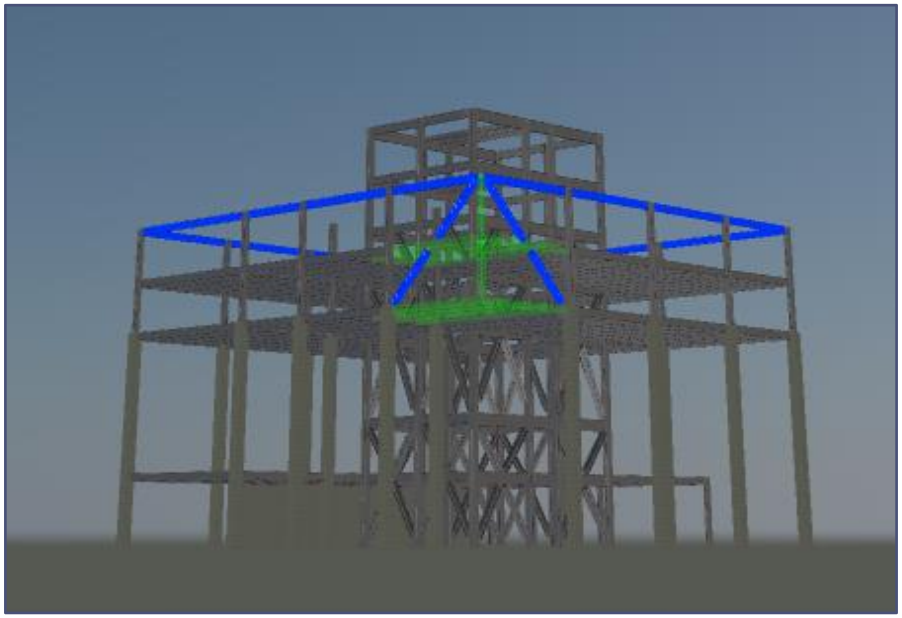

Figure L: Erect of Cross Bracing and Level 5 and 6 Fill In

ENCLOSURE

During the design process, our mechanical team members concluded that a double glass façade is most beneficial for reducing energy levels through natural ventilation. **Figure M** shows the double façade. The double façade will use a 30 inch air space to capture the air to create an artificial environment barrier around the building which will be heated up through solar radiation. This air will then be used to heat up the office spaces. This façade will be placed on the Southeast and Southwest sides. The Northeast and Northwest sides of the building will be a single glass façade. These sides will not contain a double façade because they are adjacent to neighboring buildings and do not receive sunlight.

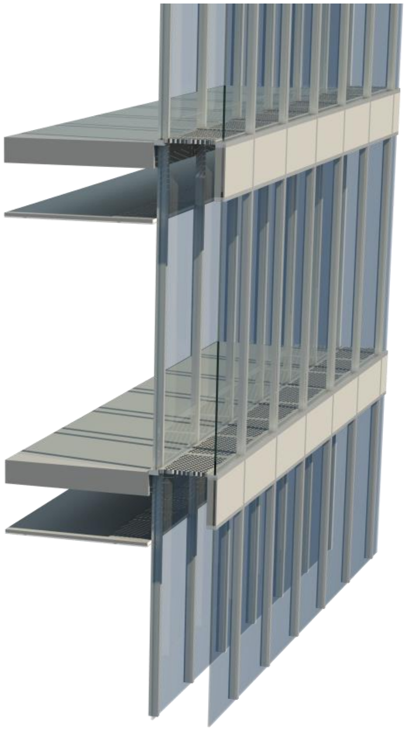

Figure M: Double Facade

Enclosure will begin six months after the steel erection begins. A monorail hoisting system will be used to raise and place the panels. This system will be run along the bottom flange of the supporting beams. Two monorail hoists will be used on this project. One hoist will be used to install the single glass façade panels on the Northeast and Northwest ends and the other one will be used to install the double glass façade on the Southeast and Southwest ends of the building. With the use of these hoists, the façade of 350 Mission will be able to be installed while the steel structure is being erected.

These hoists will be sequenced similar to the steel structure. The hoists will be moved every four floors moving horizontally and the flow of installation can be seen in **Figure N**. The panels will be installed in a vertical fashion and once that column is installed, the hoist will be moved horizontally to begin the next column. This will continue on until the entire façade for that section is installed. The façade will use the same sequencing zones as the structural steel. Once those floors are completed, the hoists will be moved up to the next section of floors and the same process will be completed. The tower crane will be used to install the last three floors.

Figure N: Flow of Installation of Facade

Waste Management Plan

To minimize waste on this project, our innovative construction team members have developed a construction waste management plan. This plan will ensure proper recycling of as much waste as possible. Source separation as well as commingling will be used on this project. Since site constraints do not allow for on-site separation of demolition debris, on-site commingling will be used. This will help lower the costs for demolition since recycling has lower fees than landfill fees. *To view the entire waste management plan, refer to Appendix Page C-6.*

Building Information Modeling:

During the initial design phase, each of the different team members held meetings to inform other team members about their potential systems. In these meetings, there were discussions about the overall systems and how it will impact the other team members. This allowed for each team member to be informed about how the system would affect them. This process helped educate all of our team members about the systems which were implemented into designing 350 Mission. When it came down to critical designs, all of our team member's had a good understanding of the systems and were able to discuss which system would work best with the overall design of the building.

Three Dimensional Coordination

During the preconstruction process of 350 Mission, multiple programs were used for coordination of the building's systems. Clash detection was used to model how the systems would be implanted into the building and prevent each of the systems from colliding with one another. Each of the different team members modeled their systems in Autodesk Revit and was imported into Autodesk Navisworks for clash detection.

Multiple clash detections analyses were performed. **Figure O** is an example of one of the clashes found in the Mechanical vs Structural Clash Report *(Refer to Appendix Page C-7 for a full report)*. One of the return

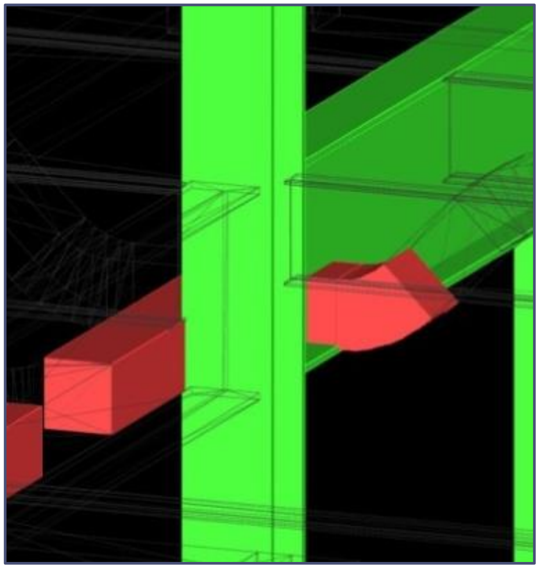

Figure O: Clash Detection Example

ducts clashed with one of the core beams. The purpose of this return is to circulate the air into the elevator lobby. Since this clash was detected early in the design process, an alternative route was established to run the return duct under the smaller beam size in the core. To obtain this solution and others similar to it, our team held coordination meetings were we analyzed all of the clash reports and would communicate on how to resolve the issues. The alterations were then made to the models and clash was conducted again to see if any other clashes arose. This process helped each of our team members have a better understanding of all the systems and where these systems were located in the building.

Another issue which was addressed in our team's coordination meetings was the coordination of the floor knock-out. Each floor of 350 Mission will contain a 10 ½ foot wide by 17 ½ foot long floor knock-out. The purpose of this knock-out is to allow future tenants to have the flexibility of placing a staircase in the office to allow for multiple office floors. For this knock-out to be made possible, coordination amongst all of our team members was conducted so no beams, ductwork, or wires would be located in this area. **Figure P** shows the results of how each of our team members coordinated together to avoid placing their systems in this area. Since there are no beams, ductwork, or wiring running through this knock-out, this allows for an area inside the building footprint to easily place the tower crane.

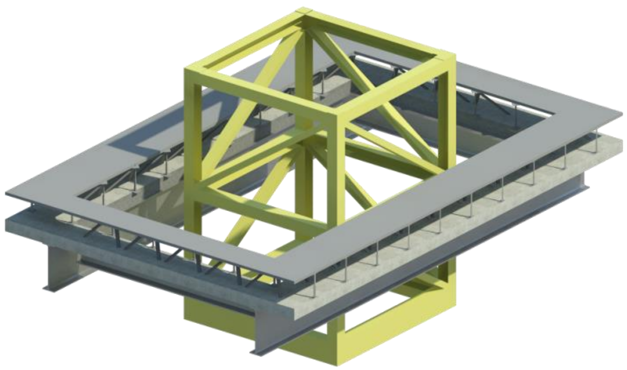

Figure P: Section of Knock-out with Tower

After coordination with our innovative construction team members, it was decided to move the knock-out from the Northwest end of the building to the Southeast end for the tower crane. This move allows for the tower crane to be swinging into the construction site instead of out over the public. A challenge which will need to be addressed is the removal of the tower crane from the knock-out. Extreme measures will need to be taken to ensure no damage will occur to the overall building. After removal of the tower crane, each of the floor knock-outs will have to be filled in.

Four Dimensional Modeling

A complete 4D model and a typical office floor model of 350 Mission was developed using Autodesk Navisworks. The complete 4D model's purpose is to create a visual aid which can be used to show construction during the different phases, construction sequencing, and to assist in site management. The typical office floor model was used for clash detection of all the building systems.

With the use of these models, contractors will have the ability to visually plan out where everything will be located on site prior to construction of the project. Contractors will be able to see where all of the trades will be located and coordinate accordingly.

Navisworks will be used as a tool to regulate site management by allowing the Design – Builder to keep track of all trades to see if they are on schedule. This tool will be able to show what trades will be on site during a specific time period and phase; allowing for proper precautions to be taken for site management. 4D modeling will be an asset to this project since 350 Mission is a small congested site and multiple activities will be occurring at once.

Prefabrication

To accelerate the schedule, our innovative construction team members will be using prefabricated assemblies. Using prefabrication has many benefits on this project. It will allow for safer working conditions, better quality of products, and faster construction.

With the use of 3D coordination and 4D modeling, prefabrication can be accomplished. The use of 3D coordination will allow for all the plumbing, electrical, and ductwork layouts to be determined and finalized before prefabrication begins. Knowing where all of these components are laid out will make it possible for prefabrication. Each trade can look at the 2D and 3D plans and will know where to lay their components out, which can later be tied into the main systems once installed.

The assembles will be constructed and stored in a warehouse due to site constraints. This warehouse will be located on one of the piers in the bay, as shown in **Figure Q**. This is beneficial to the project because each trade will be working in a controlled environment which will allow them to work safely and efficiently. Since these trades will be working inside, weather conditions will not be a factor. Prefabrication will help accelerate the schedule since multiple trades will be working simultaneously.

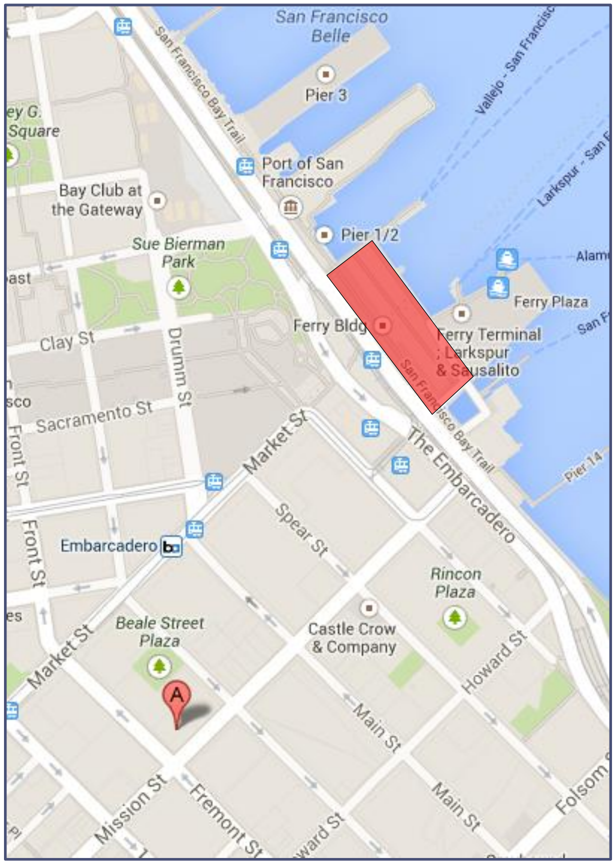

Figure Q: Warehouse location

Our innovative construction team members plan on prefabricating most of the building systems. Some of the systems which will be prefabricated are the ductwork, plumbing, and conduit. Some of the supply ductwork runs large distances. To cut down on installation on site, these larger runs will be prefabbed into smaller sections which will be brought to site and installed. Since the bathrooms and kitchenettes are located at the same location on each floor, the plumbing will be prefabbed into stacks.

Pod construction will be used for this project for the kitchenette and bathrooms located on the office floors. A Pod is a preassembled structure with piping, electrical, mechanical, and fixtures. An example of these Pods can be seen in **Figures R and S**. These Pods will be assembled fully off site and lifted into place once brought to site. Once these Pods are installed, all of the systems will be tied into the distribution system for the building. These Pods will accelerate the schedule by 1 month.

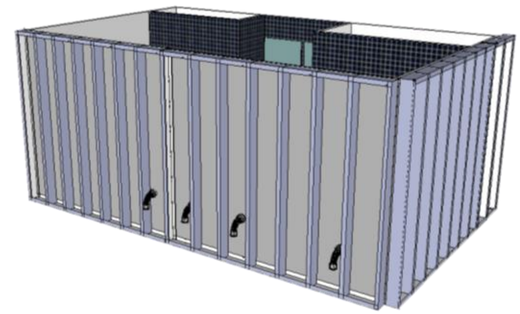

Figure R: Pod for Bathroom

Figure S: Pod for Kitchenette

Integration amongst our team's structural, mechanical, and electrical team members was coordinated for these Pods to be possible. The main mechanical system being implanted in this building is a raised access floor system with underfloor air distribution. This system will raise the floor to 14 inches above the slab. Our mechanical team members were concerned that the bracing for the raised access floor would not be able to support the extra load of the Pods. As a result of this issue, the Pod will contain a finished floor height of 14 inches and will contain its own bracing. Coordination was also conducted with our structural team members to accommodate for the additional load. As a result, our structural team members adjusted their loading factors for these areas for the structure to hold the load.

Prior to installing the Pods, the concrete slab must be poured and cured. Once the Pods are delivered to site, the crane will lift them up onto the floor. The monorail hoist system will be used to lift the Pods into place. The raised access floor system will be installed after these Pods are installed and the façade is placed. Tie ins for the Pods will occur once distribution systems are installed.

To accelerate the schedule for the enclosure, the double façade system will be prefabricated. This system will be prefabricated into 5 foot wide by 14 foot tall panels by 3 foot deep which will be brought to site. These panels will contain all connections, grates, and louvers. Once these panels arrive on site, they will be lifted by the monorail hoisting system as previously stated and installed. These panels will be welded to the supporting I beam and contain a kicker angled for torsional support which can be seen in **Figure T**.

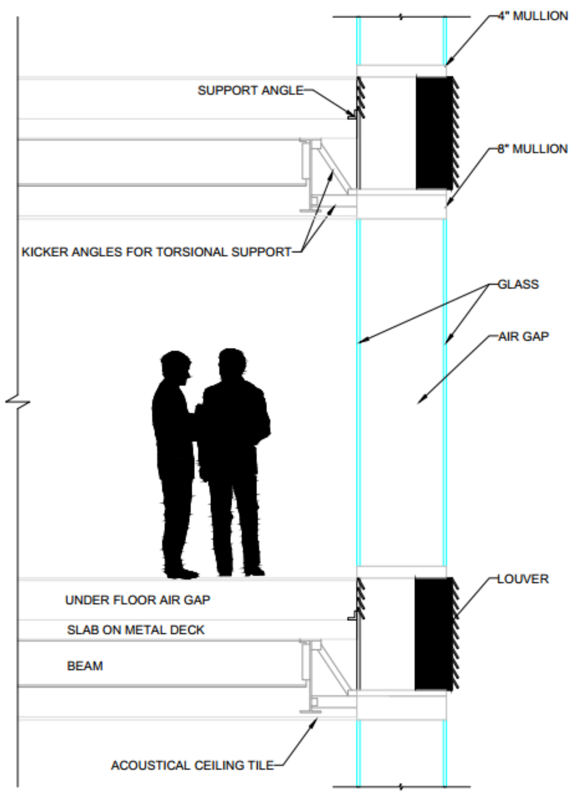

Figure T: Schematic Design of Double Facade

Construction Schedule:

Our innovative construction team members compiled a construction schedule for 350 Mission. The proposed schedule is a 29 month schedule beginning February 2014 and concluding July 2017 *(Refer to Appendix Page C-15 for the construction schedule)*. Our innovative construction team members generated this schedule by using RS Means 2014 to calculate the duration of tasks and estimated durations off of similar projects.

Our innovative construction team members optimized the schedule to minimize the overall cost of 350 Mission. The overlapping of sequencing and prefabrication of building systems were used to minimize the schedule. Without prefabrication or overlapping of activities, the proposed building schedule was a 46 month construction schedule. Through the approach our innovative construction team members took, our construction schedule was shorted to a 29 month schedule.

Once Notice to Proceed is obtained, Mobilization and Asbestos Removal will begin and last for approximately three months. Since it is not determined whether there is asbestos located in the existing building, this task can be time adjusted accordingly. The next few tasks leading up to steel erection will be precedent because they cannot overlap each other. These tasks will occur for approximately a year.

The steel erection will last for approximately 16 months. A large contributor to shortening the schedule is the sequencing of the steel structure erection, Pods, and the façade. Prior to the enclosure, all of the concrete slabs will be cured and the Pods will be placed. The enclosure for the lobby level will begin once the steel structure is erected up until the 14th floor. This process will continue up until the steel structure has topped out and the enclosure is completed. This will allow for the project to be enclosed sooner and provide a safer working environment for the trades on site.

Cost Estimate:

Our innovative construction team compiled a detailed and a general conditions estimate of 350 Mission. The estimated cost for 350 Mission is $148,095,270. A summary of the cost breakdown can be seen in **Figure S** and on *Appendix Page C-9*. This cost was generated from RS Means 2014 and manufacture websites. A 15% allowance was added to the total cost for commissioning. Commissioning will occur throughout the design and construction process and once the building is operational. The parking garage estimate was determined by performing a square foot estimate with an additional floor factor added.

The Sitework and Foundation price includes the cost of excavation, the dewatering system, the slurry wall, and the mat foundation with reinforcement. The Structure price includes the cost of the metal decking with concrete and reinforcement for the office floors, the steel columns and beams, the brace framing system, the built up columns located in the lobby, and fireproofing. The Services price includes the cost of the gas sprinkler system, rain water collection system, elevator and lifts, stair construction, and plumbing fixtures and fittings. The Mechanical price includes the cost of the cooling tower, air handling units, boilers, microturbines, chillers, the raised access floor system, and the ductwork. The Electrical price includes the cost of the switchgear, generator, transfer switch, transformers, panel boards, wiring, lighting fixtures, receptacles, and the photovoltaic panels. The Enclosure price includes the cost of the double façade and the roof.

The general conditions estimate for this project is estimated to be $10,500,566. A summary of this breakdown can be seen in **Figure T** and on *Appendix Page C-10.* This cost was generated from RS Means 2014. This estimate is broken down into staffing, temporary facilities, temporary utilities, bonds and insurance, permits, and contingences. The temporary facilities cost accounts for both stages of the field office being located off site in an adjacent building and in the underground parking garage.

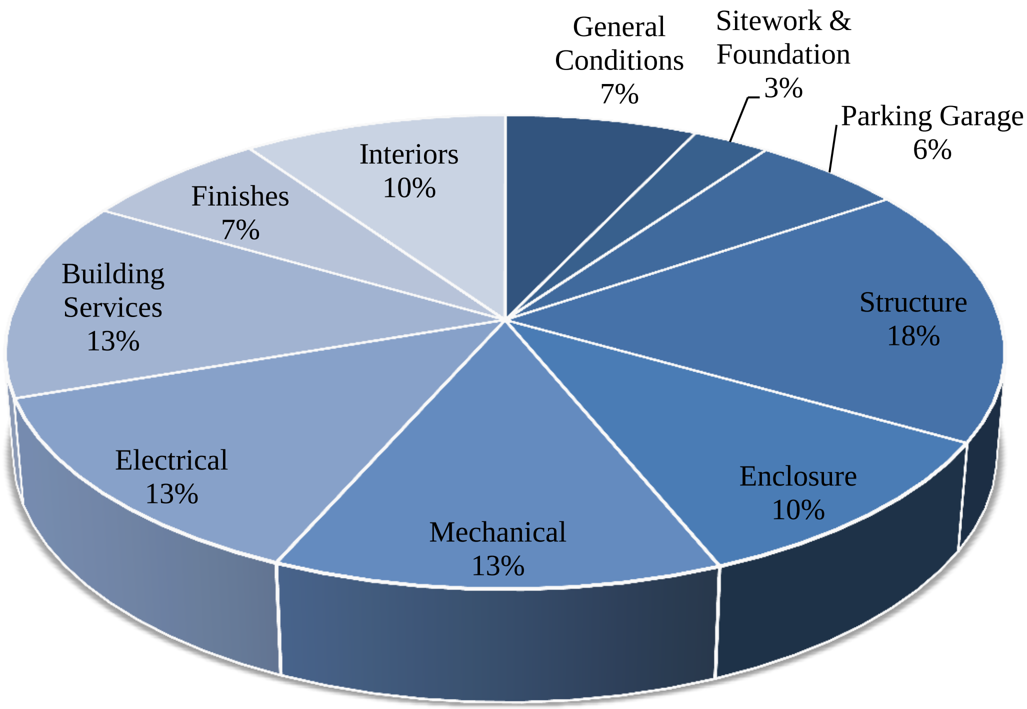

Figure S: Breakdown of Cost Estimate

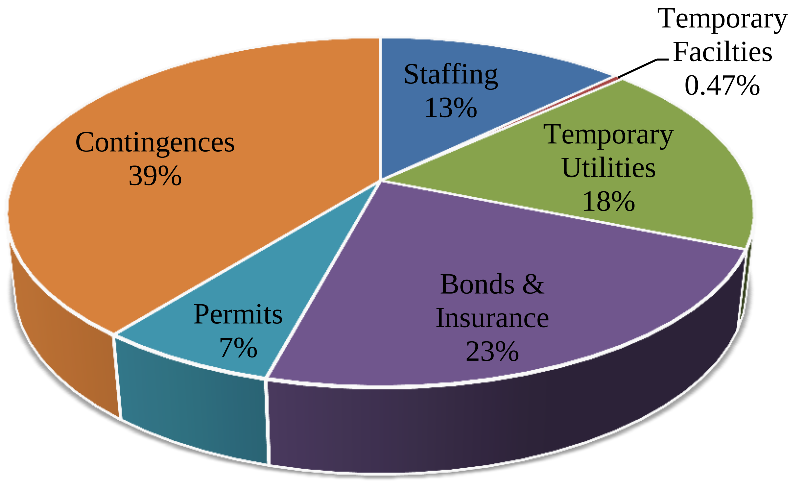

Figure T: Breakdown of General Conditions

LEED:

Our team's goal was to produce a high performance energy efficient building. LEED was not a required goal for this project but our team decided to analyze the building from a LEED perspective. After discussing with all of our team members and using LEED 2009 for New Construction and Major Renovations, our team believed that 89 LEED Points are achievable giving 350 Mission a LEED Platinum Certification. Through our innovative construction methods, our innovative construction team was able to achieve 41 LEED Points. Our innovative construction team members were able to achieve these points by the location of 350 Mission, the waste management plan being implanted, recycling and reusing of materials, and by having LEED accredited professionals on site. **Table 1** shows a breakdown of all the points achieved from our innovative construction team members and overall team. Refer to *Appendix Page C-8 for a full breakdown of all the LEED Points our team achieved.*

Figure U: LEED Platinum

Table 1: LEED Point Breakdown

	Innovative Construction		Overall	
Category	**Achieved**	**Possible**	**Achieved**	**Possible**
Sustainable Sites	19	24	21	26
Water Efficiency	2	4	8	10
Energy and Atmosphere	2	2	30	35
Materials and Resources	8	14	8	14
Indoor Environmental Quality	5	6	12	15
Innovation and Design Process	1	1	6	6
Regional Priority Credits	4	4	4	4
Total	**41**	**55**	**89**	**110**

Conclusion:

Through our innovative construction methods, structural considerations, and building system designs, our team believes we will enhance the quality, efficiency, and value of large building construction. The goal of our innovative construction team members is to construct a near net zero high-rise building that addresses safety, project delivery, project planning, budgeting, and scheduling through integration and communication with our mechanical, structural, and electrical team members.

Our innovative construction team members have achieved these goals by providing evacuation, waste management, and safety plans which will provide a safe working environment for the public and construction workers on site. Proposing a Design – Build delivery method allows for more collaboration amongst all trades on site and helps shorten the construction schedule. Providing construction concerns which will need to be addressed as well as 4 Dimensional models to assist site management and site control. Performing clash detection tests in the design phase to eliminate clashes in the field which can enable prefabrication of multiple systems and Pods. The ability to perform prefabrication allowed our innovative construction team members to help shorten the schedule to a 29 month schedule and will cost $ 148.1 million to build.

By working closely with our structural, mechanical, and electrical team members throughout this project, our innovative construction team members are confident we will provide a successful project delivery. Through collaboration, communication, and our team's design methods, 350 Mission will be able to provide a safe and sustainable lifestyle for their tenants and provide a new standard for near net zero high-rise building construction.