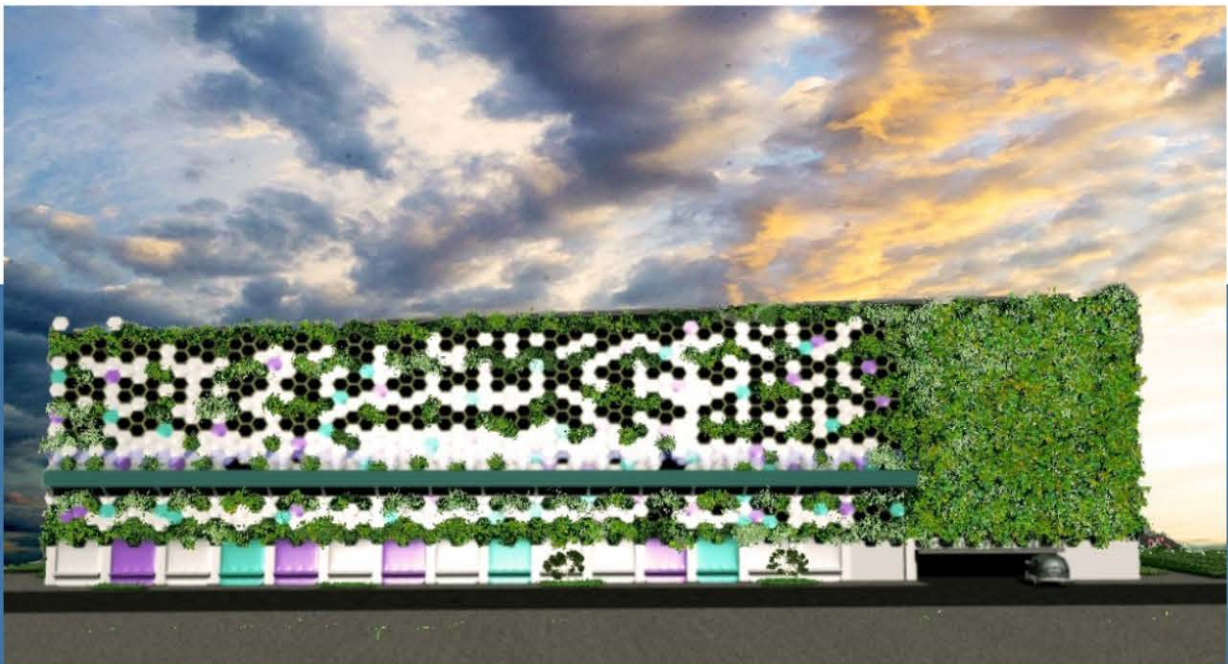


AN ALTERNATIVE ENVELOPE DESIGN FOR BOSTON CHILDREN'S HOSPITAL GARAGE



A Major Qualifying Project submitted to the Faculty of
WORCESTER POLYTECHNIC INSTITUTE
in partial fulfilment of the requirements for the
Degree of Bachelor of Science in Architectural Engineering

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ABSTRACT

To accommodate their growing needs, Boston Children's Hospital is expanding its campus in the Brookline Village. Their redevelopment plan includes demolishing of the existing garage, Two and Four Brookline Place buildings, and an addition to One Brookline Place. This Major Qualifying Project (MQP) focuses on an alternative design for the new garage that will serve these two facilities. The proposed design of the garage exterior aims to add aesthetic value to the Brookline Hospital Campus and create an identity, through featuring a green wall, cool lighting effects during the night and by looking more kid-friendly. As part of this MQP, I conducted structural analysis, developed architectural details, and visually presented the concept for the new garage envelope.

ACKNOWLEDGEMENTS

I am extremely grateful to have had the opportunity to pursue my interests, and would like to take this opportunity to thank all of those who have made this possible.

First and foremost, I would like to deeply thank my advisor, Professor Steven Van Dessel, for putting faith in me, affording me so many opportunities, and guiding my project. I have greatly benefited from his support, knowledge and advice. As I take my first steps in my career, I want to follow the successful path of my role model, Professor Van Dessel.

I want to extend a profound thank you to Professor Leonard Albano, for his continuing support, advice, and assistance with the calculations. I have sincerely enjoyed interacting with him and greatly appreciate his willingness to help me in so many different ways through my academic journey.

Lucilla Haskovec, Stantec project sponsor, thank you for providing documents and drawings to keep this project going.

EXECUTIVE SUMMARY

The new Boston Children’s Hospital (BCH) campus at Brookline Place (Boston) is redeveloping its site, aiming to accommodate the growing demand in pediatric care. Trying to expand their services outside of their main campus, their redevelopment plan includes the demolishing the buildings Two and Four Brookline Place, replacing a parking garage, and making an addition to One Brookline Place. A new seven-story parking garage that will be built to serve these two facilities will be able to accommodate 638 instead of 359 cars.

This MQP will introduce an alternative envelope design for the parking structure, focusing on the North elevation. The design is different from what the contracted architect has developed and was influenced by various elements that the architect provided, primarily focused on the use of aluminum material and hexagonal patterns. The parking structure design was not changed from what the engineers and architects designed, while the new details of the facade along with the connection details were redesigned. The wall sections and plan views provided by the architectural firm were modified to show the new concept. The new enclosure is intended to be more kid-friendly, to denote that the parking garage belongs to a children’s hospital. The proposed façade will be colorful, interesting, and interactive. LED light strips will be added to the window openings to enhance the structure’s aesthetics during the evening and night, by creating cool light effects.

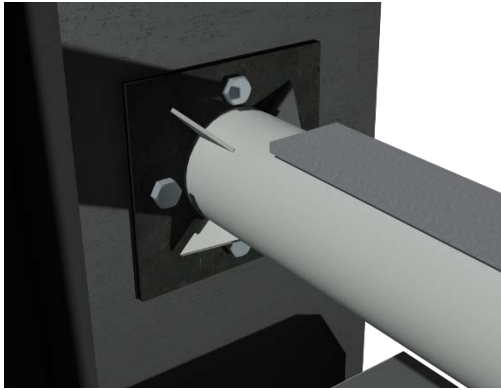


Façade Section Showing Pathway and Roof Structures

This new facade aims to connect better with the new landscaping that will be added after the renovation of the site thus providing the hospital with a new identity. The enclosure will be comprised of different aluminum hexagon boxes, a walkway on the third garage floor where people could walk around, and a glass roof to provide shade in the summer and protect the visitors from precipitation. There will be a spiral slide going from the third floor to the ground where children or visitors can slide down.

There will be three types of hexagons that will serve three different purposes. Some will serve as vases (planters) for green plants to grow, some will serve as window opening frames, and some will be covered in order to hide the concrete walls of the garage. These elements stand in the face of the

garage and will be connected together so they partially support each other's weight. The hexagons will be cross-braced in the back with four elements which will have a round tube in the middle that will serve as a connection with the garage's superstructure column through a steel plate that is bolted into the wall.



Pathway Joint Close-Up Showing the Wall Connection

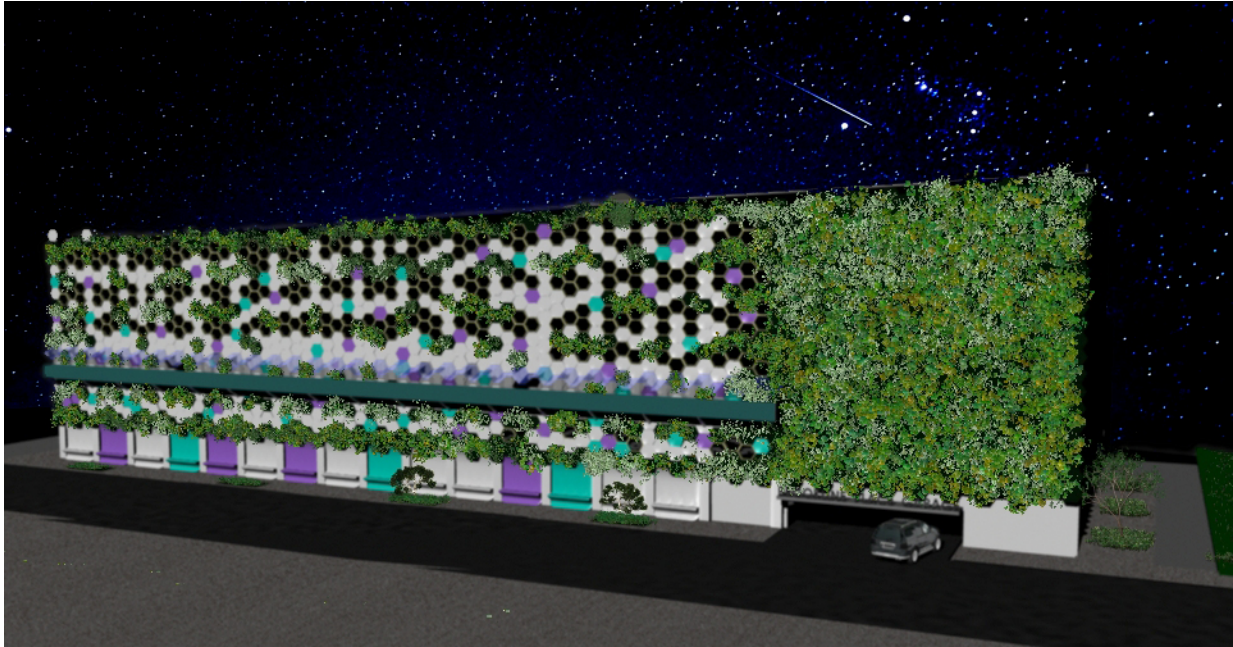
The walkway will be supported by two circular Hollow Structural Steel (HSS) members; one coming out straight, cutting through the center of the hexagon and the other one connected to an angle, cutting through the center of the hexagon below. These two members will be directly bolted to the columns in a 12 ft span, through a steel plate. The plate then will be embedded and bolted into the concrete with anchor T-bolts. Round hollow structural steel members were determined to be a better fit for building this structure. Not only will they be more aesthetic, but they will also reduce the

weight of the structure in comparison to other shapes, aiming to put as less weight on the foundation as possible. They will support two identical C channels, a steel grating, the railing, the hexagon weight, the occupancy live load and snow load.

A colored-glass canopy will be placed in the beginning of the fourth floor to protect the visitors from the weather conditions. The canopy will follow the shape of the hexagons and it will be slanted down, longer than the balcony, in a way that the snow or rain will slide outside of the pathway.

The International Building Code (IBC), American Institute of Steel Construction (AISC) and Americans with Disabilities Act Accessibility Guidelines (ADAAG) requirements, were taken into consideration when determining the dimensions of the elements for this project, to make the project is in compliance with these requirements. The calculation process consisted of determining different dead and live loads, sizing of the steel members for the pathway, roof and hexagons, comparing the deflections for these members to the maximum allowable deflections specified by AISC and making sure that the joints were stable.

Concrete garages, could be aesthetically very dull and ordinary structures. The implementation of this design will not only revitalize Brookline's Hospital campus aesthetically, but it will also create an identity to Boston Children's Hospital. The application of the greenery that will cover most of the North elevation will signify good health, bring acoustic isolation, potentially award some LEED points and most importantly, it will boost the workers and patients morale in a natural way if their windows have a garage view.



North Elevation Render showing Garage Entrance

TABLE OF CONTENTS

ABSTRACT	I
ACKNOWLEDGEMENTS.....	II
EXECUTIVE SUMMARY	III
LIST OF FIGURES	VII
1. INTRODUCTION	1
2. DESIGN STATEMENT	2
3. BACKGROUND	4
3.1 PROJECT OVERVIEW	4
3.2 ALTERNATIVE GARAGE ENVELOPE DESIGN	5
3.2.1 GARAGE ENCLOSURE ELEMENTS	5
4. METHODOLOGY.....	8
4.1 STRUCTURAL DESIGN.....	8
4.1.1 CODE REVIEW	8
4.1.2 LOADS AND FORCES.....	10
4.2 WALKWAY DESIGN	22
4.3 DRAWINGS AND RENDERINGS	36
5. RESULTS	37
6. ARCHITECTURAL DETAIL DEVELOPMENT.....	38
6. IMPLEMENTATION AND VISUALIZATION.....	53
7. APPENDIX.....	55
APPENDIX A- STEEL MEMBER PROPERTIES.....	55
Appendix B- ARCHITECT'S DRAWINGS.....	56
Appendix C- SKETCHES.....	60
Appendix D- LED STRIP CUTSHEET.....	61

LIST OF FIGURES

Figure 1 Brookline Village Hospital Campus	1
Figure 2 North wall section screen mounting detail.....	2
Figure 3 West Elevation of the Garage	3
Figure 4 North Elevation of the Garage	3
Figure 5 Rendered View of Brookline Site, provided by the Architect	4
Figure 6 Three types of hexagons. From Left to right: the vase hexagon, the hollow frames, the covered hexagons.	5
Figure 7 Box Hexagons, Back view showing the bracing and connection	6
Figure 8 Wall Section Showing the Roof and Pathway	7
Figure 9 Tributary Area Diagram	11
Figure 10 Hexagon Dimensions	11
Figure 11 Walkway Load Diagram	22
Figure 12 Loads acting on the Pathway	23
Figure 13 Grating Load Diagram	26
Figure 14 Railing Loads and Force Diagram.....	26
Figure 15 Railing Post Section.....	27
Figure 16 Square HSS Load and Bending Diagram.....	29
Figure 17 Bolt in Shear Diagram	30
Figure 18 Plate Dimensions	31
Figure 19 Floor-Floor Wall Section	39
Figure 20 Roof Section.....	40
Figure 21 Pathway Section	40
Figure 22 Detail A- Railing Detail Connection.....	41
Figure 23 Detail B- Pathway Detail Connection	41
Figure 24 Detail C- Railing Handle Detail	42
Figure 25 Detail D- Roof Detail Connection	42
Figure 26 Hexagon Connection.....	43
Figure 27 Detail E- Hexagon Detail Connection	44
Figure 28 Full Floor Plan- Showing the Pathway	45
Figure 29 Floor Pan Section Showing the Pathway	46
Figure 30 Detail F- Pathway Plan View	47
Figure 31 Glass Connection	48
Figure 32 Pathway-Hexagon Connection.....	48
Figure 33 Pathway Joint Connection	49

Figure 34 Rendered Wall Section49

Figure 35 Grate Connection Close up50

Figure 36 Roof-Hexagon Connection51

Figure 37 Roof- Hexagon Joint.....51

Figure 38 Roof-Column Joint Connection52

Figure 39 North Elevation53

Figure 40 Garage Perspective View54

Figure 41 Garage Entrance54

1. INTRODUCTION

Boston Children's Hospital (BCH) is expanding its campus in the Brookline Village, in order to accommodate the outgrowing need. The project consists of the construction of a new 180,000 square foot outpatient facility, an addition to an existing medical office building, and a replacement of the current parking garage. An alternative envelope design for the garage will be proposed in addition to what has already been developed by the architect firm Elkus Manfredi. Figure 1 below shows the Brookline hospital campus map and where each building is located.

Through this project Stantec is provided with:

- A new concept for the exterior of the garage,
- Structural design of the proposed garage exterior,
- Architectural Design Details of the garage enclosure, which encompass: drawings of wall sections, plan views, the North elevation, and
- Rendered views of the alternative design of the garage.

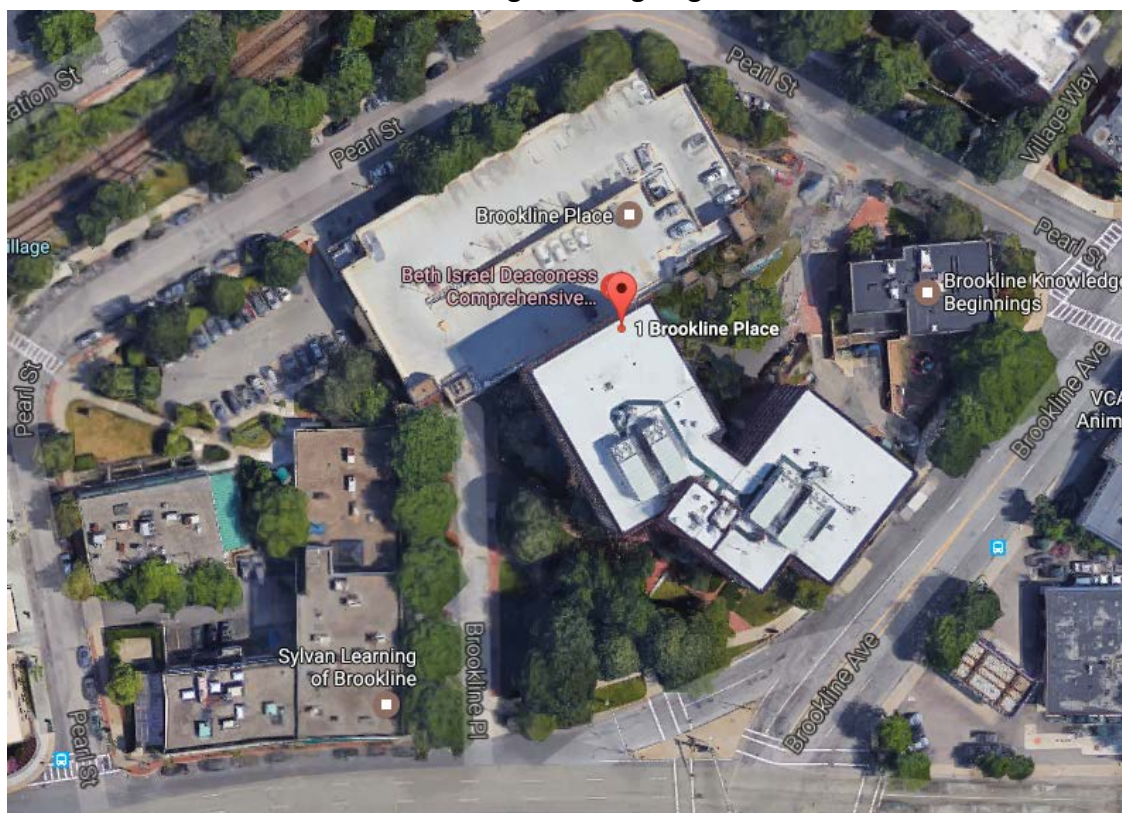


Figure 1 Brookline Village Hospital Campus

2. DESIGN STATEMENT

A new envelope design for the Boston Children's Hospital Garage, Brookline site is proposed along with the structural design, wall section drawings, plan view, North Elevation and renderings of the enclosure. This project mainly focuses on the North side of the building since the main entrance is located there.

The actual design proposed by the architect included a triple skin façade where part of the garage was covered in perforated aluminum panels and some other architectural decorative panels while combining them with masonry on the columns in the exterior.

For this project, the structural system of the garage was not changed. The wall section provided by Elkus Manfredi Architects was modified to show the connections of the hexagons and the exterior pathway along with the roof. North and West elevations along with their wall sections are shown in Figures 2-4 below.

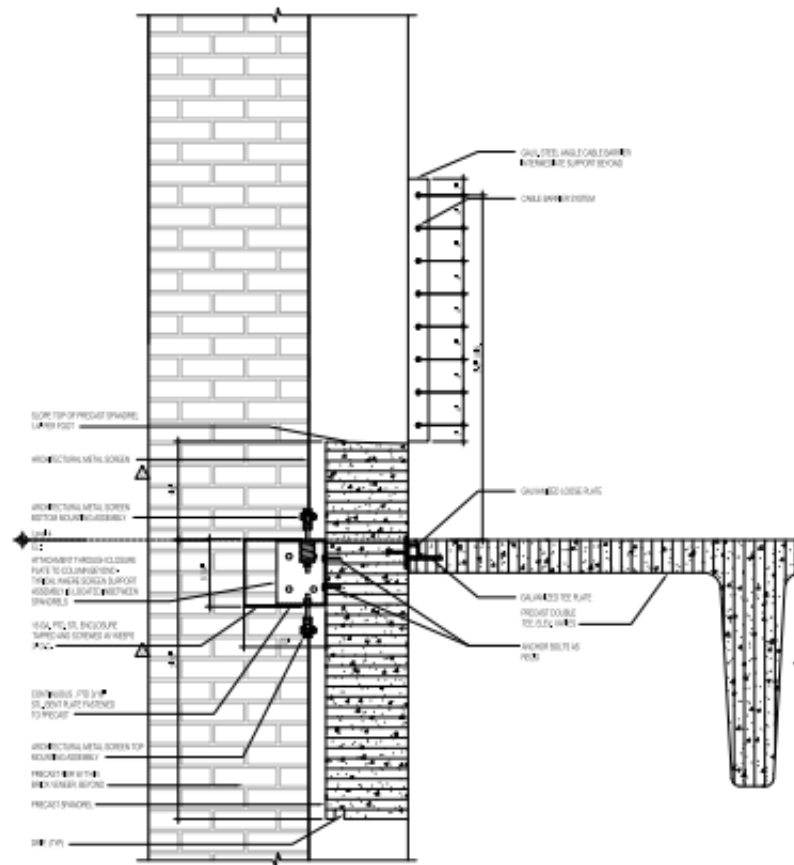


Figure 2 North wall section screen mounting detail

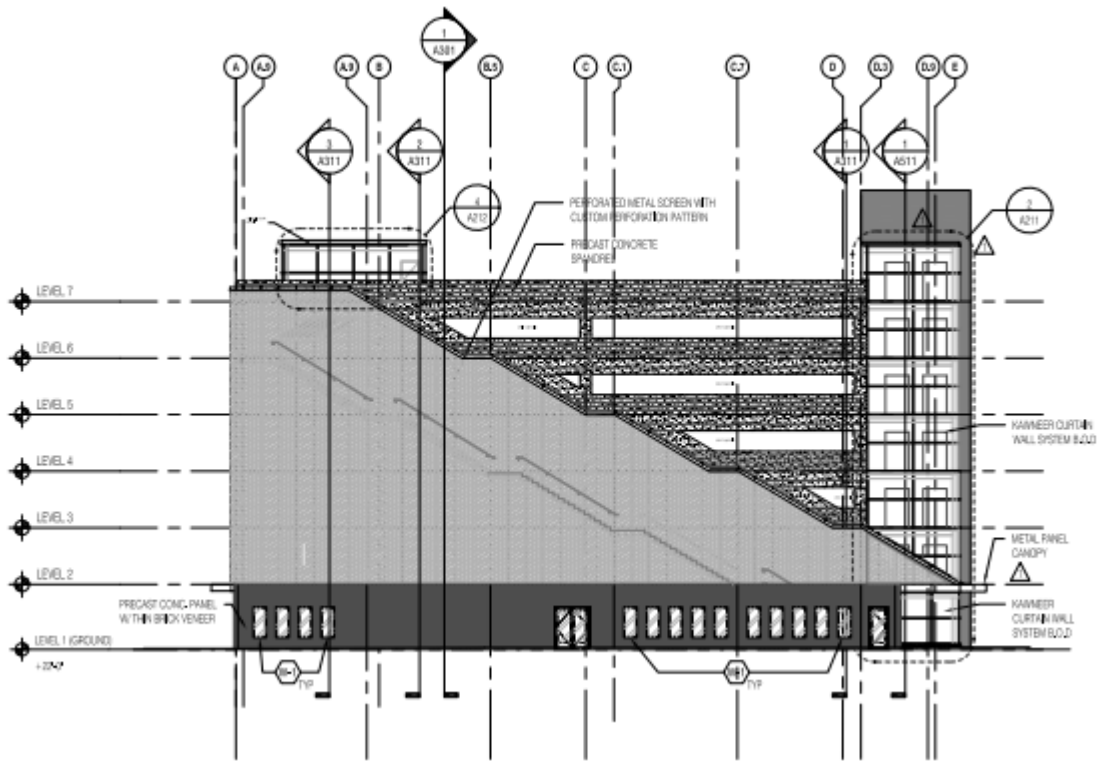


Figure 3 West Elevation of the Garage

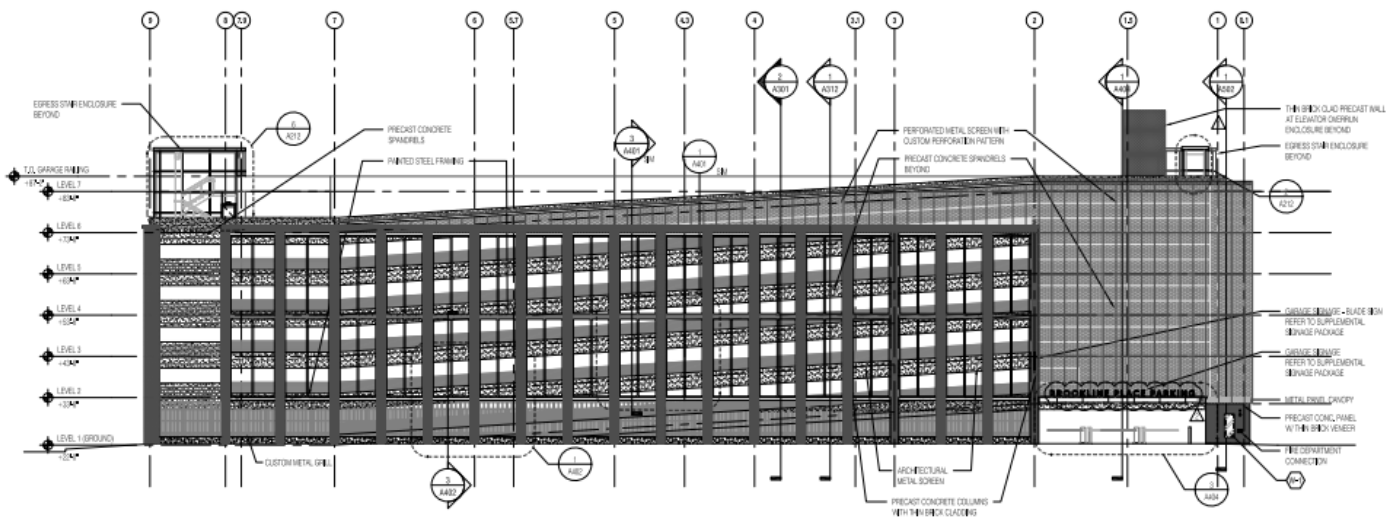


Figure 4 North Elevation of the Garage

3. BACKGROUND

3.1 PROJECT OVERVIEW

Boston Children’s Hospital (BCH) is a pediatric health care center that provides health care services to children, in various pediatric specialties, including but not limited to: Cancer, Cardiology, Gastroenterology, Neonatology, Nephrology, Neurology, Orthopedics, and Urology.

The new Boston Children’s Hospital campus at Brookline Place aims to accommodate a growing demand in complex pediatric care. The redevelopment of BCH in the Brookline site will enable BCH to expand their services outside of their main campus. Their redevelopment plan includes the demolishing of Two and Four Brookline Place buildings and an addition to One Brookline Place. Two Brookline Place, will be an eight-story mixed-use building with retail space on the ground floor and medical offices and ambulatory care in the upper floors. The addition to One Brookline Place, will be a six-story medical office use, and it will serve as a third wing (expansion) of the building, tied into the existing lobby on all floors.

The new garage that will be built to serve these two facilities, will be connected to One Brookline Place. The original 4-level steel and precast concrete garage which is now demolished had 359-parking spaces. The new seven-story structure will accommodate 638 cars and will be made out of precast concrete double-tee beams. The garage will be supported by pressure-injected pile foundation system. The exterior is wrapped in perforated aluminum panels

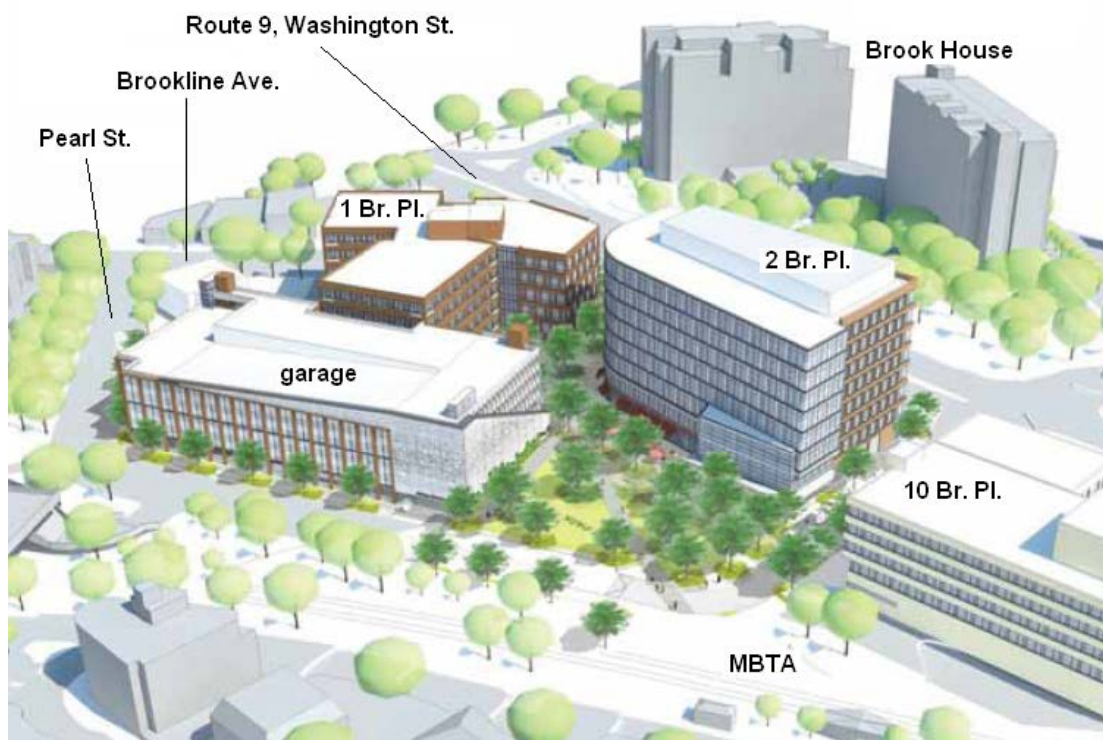


Figure 5 Rendered View of Brookline Site, provided by the Architect

combined with masonry, in order to make the garage more aesthetically pleasing for the staff and patients whose windows have a garage view.

3.2 ALTERNATIVE GARAGE ENVELOPE DESIGN

OBJECTIVE:

The proposed design of the garage exterior aims to add aesthetic value to the Brookline Hospital Campus and create an identity, through featuring a green wall, cool lighting effects during the night and looking more kid-friendly.

3.2.1 GARAGE ENCLOSURE ELEMENTS

The exterior of the façade will be comprised of three different type of hexagons, will have a walkway on the third floor where kids or patients could walk around and have fun. The walkway will be covered by a glass roof, to protect the visitors from getting wet in snow or rain. There will be a spiral slide going from the third floor to the ground floor where children or visitors can slide down.

The exterior will be composed out of three types of hexagonal aluminum “empty boxes”.

1. Vase hexagons, where the boxes will have a vase base and a net where plants could grow.
2. White hexagons, where the boxes will be white on the outside and will occupy the most surface of the exterior
3. Hollow hexagons, where the boxes will be just frames surrounded by stick-on LED color changing strips placed where most of the garage windows/openings will be located.

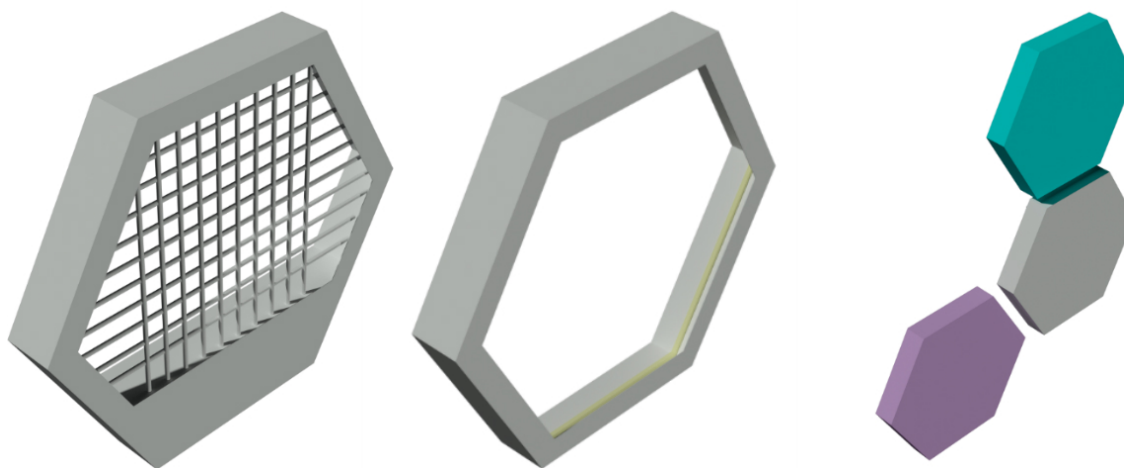


Figure 6 Three types of hexagons. From Left to right: the vase hexagon, the hollow frames, the covered hexagons

This design was influenced by various factors. The aluminum hexagonal shapes were based on the aluminum sheets with small hexagons cut out that the architect provided. The green wall was inspired by the controversy that the BCH main campus faced when the community didn't want to demolish the park. This green facade will connect better with the new landscaping that will be added and it will give the hospital a new identity.

The alternative design will be made from premanufactured aluminum boxes which will stand in the face of the garage. The hexagons will be connected together by a set of bolts vertically and on the sides and will partially support each other's weight. Each floor will have approximately three hexagons. These rows will be connected to the columns by a special connection as shown in Figure 7. The hexagons will be cross-braced in the back with four elements which will have a round tube in the middle that will serve as a connection with the column.

The walkway will be supported by two round tubular members; one coming out straight (horizontal), cutting through the center of the hexagon and the other one connected at an angle, cutting through the center of the hexagon below. These two members will be directly bolted to the columns in a 12 ft span, through a steel plate. The plate then will be bolted into the concrete using anchor T-bolts. Round hollow structural steel members were determined to be a better fit for building this structure. Not only will they be more aesthetically pleasing, but they will also reduce the weight of the structure in comparison to other shapes, aiming to impose as little additional weight on the foundation as possible. The walkway support structure described above will support two identical C channels which, in turn, will support a steel grating walkable surface railing. The grate will sit flush with the top of the two channels and will be supported by two other horizontal members from the bottom. The railing will be bolted directly to the side of one of the channels. This railing will be made from aluminum sheets with patterns cut out of it, to fit the façade theme.

A colored-glass canopy will be placed in the beginning of the fourth floor to protect the visitors from the weather conditions. The roof will follow the shape of the hexagons and it will



Figure 7 Box Hexagons, Back view showing the bracing and connection

be slanted down at a 15 degree angle, longer than the balcony, in a way that the snow or rain will slide outside of the pathway.



Figure 8 Wall Section Showing the Roof and Pathway

4. METHODOLOGY

This section discusses in detail how the components of the building enclosure and their connection and supporting elements. This includes a description of the calculation process and approaches and assumptions that were taken into consideration when determining the different loads, application of the Building Codes and requirements, determining the deflection of members and selecting appropriate size for the parts that will support the hexagons, walkway and roof. Steel Round Hollow Structural (HSS) Steel tubes will be used for the supporting members of the walkway, the roof and the hexagons. Steel C Channels will be used to support the grating with a span of 12 feet. ISC Manual was used to determine the appropriate member sizes to make this structural system work. By the calculations conducted, the appropriate size for the round HSS-s and C channel were determined. Grating and railing glass dimensions and weight was determined by looking at prefabricated options by different manufacturers.

The following elements were calculated and analyzed:

1. Pathway supporting members,
2. Channels supporting the grate,
3. Pathway's Grating supporting member,
4. Pathway's Railing Post,
5. Joint that connects the pathway members to the wall which includes:
 - a. Bolt diameter and strength
 - b. Plate dimensions and strength
 - c. Welding size
6. Roof supporting member

4.1 STRUCTURAL DESIGN

4.1.1 CODE REVIEW

The International Building Code (IBC), American Institute of Steel Construction (AISC) 14th Edition and Americans with Disabilities Act Accessibility Guidelines (ADAAG) requirements were extensively researched and consulted when designing the enclosure for this garage.

These include:

- IBC 2006 Chapter 4: Live Loads

TABLE 4-1 MINIMUM UNIFORMLY DISTRIBUTED LIVE LOADS, L_o , AND MINIMUM CONCENTRATED LIVE LOADS

Occupancy or Use	Uniform psf (kN/m ²)	Conc. lb (kN)
Apartments (see <i>Residential</i>)		
Access floor systems		
Office use	50 (2.4)	2,000 (8.9)
Computer use	100 (4.79)	2,000 (8.9)
Armories and drill rooms	150 (7.18)	
Assembly areas and theaters		
Fixed seats (fastened to floor)	60 (2.87)	
Lobbies	100 (4.79)	
Movable seats	100 (4.79)	
Platforms (assembly)	100 (4.79)	
Stage floors	150 (7.18)	
Balconies (exterior)	100 (4.79)	
On one- and two-family residences only, and not exceeding 100 ft ² (9.3 m ²)	60 (2.87)	

- IBC 2006 Guardrails

Height: Guards shall form a protective barrier not less than 42 inches (1067 mm) high, measured vertically above the leading edge of the tread, adjacent walking surface or adjacent seat board.

Structural Capacities: handrails, guardrails, and their supports must be designed for 50 lbs per linear foot, applied in any direction at the top of the top rail, and a concentrated load of 200 lbs applied in any direction at any location along the top of the top rail.

- ADAAG 4.13: Doors

Doorways shall have a minimum clear opening of 32 in (815 mm) with the door open 90 degrees, measured between the face of the door and the opposite stop.

- ADAAG 4.26: Handrails, Grab Bars, and Tub and Shower Seats.

The diameter or width of the gripping surfaces of a handrail or grab bar shall be 1-1/4 in to 1-1/2 in (32 mm to 38 mm), or the shape shall provide an equivalent gripping surface.

- AISC 14th Edition, Chapter L: Serviceability Requirements

Deflections under appropriate service load combinations, shall not impair the serviceability of the structure. $\Delta_{\max} \leq \Delta_o$

Δ_{\max} → elastic deflection computed under service loads

Δ_o → allowable deflection; depends on type of element supported by the

For beams, $\Delta_o = L/240$ or $L/360$ or maximum 1 inch down are common values.

4.1.2 LOADS AND FORCES

This section describes the method by which each load was calculated and the amount of forces that are imposed onto each structural member. The virtual work method was used to determine the force that was applied to each of the round members for the pathway by only applying a unit load where the main loads were located. It was also used to estimate the minimum area required for the bars to comply with the deflection limits specified by the AISC Standards.

The design occupancy live loads were obtained from the International Building Code (IBC) and snow values were taken from the Building Code of Massachusetts for Boston location. The dead loads were calculated by multiplying the weight per foot square with the appropriate tributary areas.

LIVE LOADS		DEAD LOADS	
Type	Value	Type	Value
Occupancy Load	100 psf	Avg. weight of hexagons/row	70.24 lbs
Snow Load	45 psf	Channel Weight	6.7 psf
Uniform Load on Railing	50 lbs	Aluminum Railing	436.32 lbs
Concentrated Load on Railing	200 lbs	Grating	4.9 psf
		Glass Roof	436.32 lbs

4.1.3 WEIGHT OF THE HEXAGONS AND OTHER LOADS

The three types of hexagons that will be used for this façade have different weights. The approximate weight of the hexagons was determined by taking the whole area and multiplying it by the thickness of the aluminum sheet and its density. An additional load was added to the hexagons that serve as vases, taking into account the weight of soil, plants and water collected from the rain, snow or watering process. The worst-case scenario was taken into consideration when determining the member size that would support the hexagon wall. The right side of the North elevation, above the garage's main entrance, which will serve as a green wall, will carry the most weight, therefore the calculations for the members were performed with the assumption that the three hexagons connected in series will be vases.

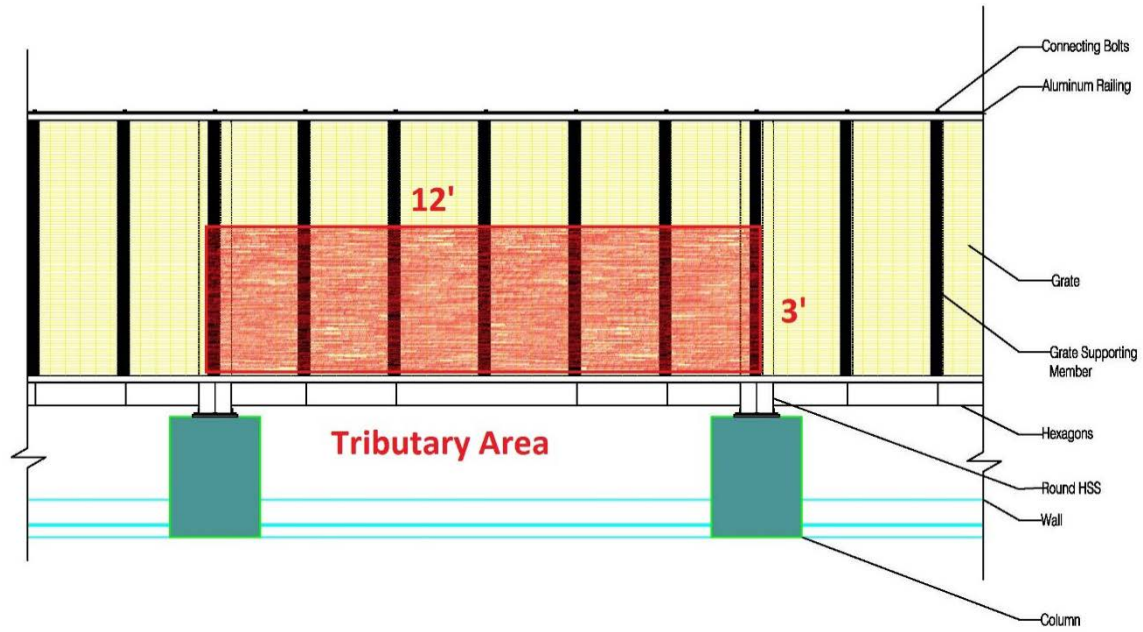
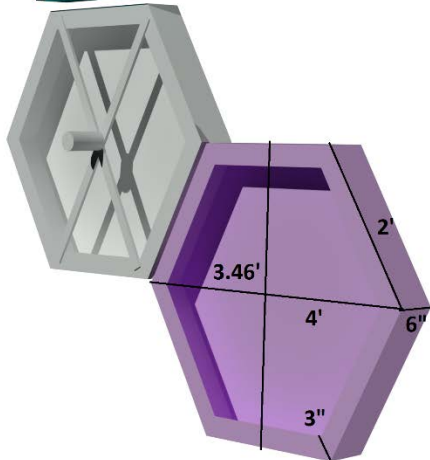


Figure 9 Tributary Area Diagram

Hexagon Dimensions:

Perimeter= 12'



Height: 3.46 ft

Diameter: 4 ft

Side: 2 ft

Area: 10.39 sq-ft

Perimeter: 12 ft

Depth: 6 in

Thickness: 0.063 in

Density of the material (**d**): 0.101 lbs/in³

Figure 10 Hexagon Dimensions

Calculating approximate weight per row:

1. Hollow Hexagon:

$$P * D * T * d = 12 \text{ ft} * 12 \frac{\text{in}}{\text{ft}} * 6 \text{ in} * 0.063 \text{ in} * 0.101 \frac{\text{lbs}}{\text{in}^3} = \mathbf{5.49 \text{ lbs}}$$

2. Covered Hexagon:

$$\begin{aligned} (A * T * d) + \text{Hollow Hexagon Weight} \\ = \left(10.39 \text{ ft}^2 * \frac{144 \text{ in}^2}{\text{ft}^2} * 0.063 \text{ in} * 0.101 \frac{\text{lbs}}{\text{in}^3} \right) + 5.49 \text{ lbs} = \mathbf{15 \text{ lbs}} \end{aligned}$$

3. Vase Hexagon:

$$\begin{aligned} \text{Hollow Hexagon Weight} + \text{Area of sides} + \text{Volume of Vase} * \text{Wet Soil Density} \\ = 5.49 \text{ lbs} + \left(2 * 4.325 \text{ ft}^2 * 0.063 \text{ in} * 0.101 \frac{\text{lbs}}{\text{in}^3} \right) + \left(0.97 \text{ cf} * 78 \frac{\text{lb}}{\text{cf}} \right) \\ = \mathbf{75.66 \text{ lbs}} \end{aligned}$$

There will be approximately three hexagons per row in a floor.

$$\frac{10 \text{ ft}}{3.46 \text{ ft}} = 2.89 \sim \mathbf{3 \text{ hexagons per row}}$$

The weight of the hexagons per row was considered as if all the hexagons would be vase hexagons; therefore:

$$3 * 75.66 \text{ lbs} = \mathbf{218.76 \text{ lbs}}$$

The average weight per floor was based on the assumption that there are three different types of hexagons in a row; therefore:

$$5.49 \text{ lbs} + 15 \text{ lbs} + 75.66 \text{ lbs} = \mathbf{96.175 \text{ lbs}}$$

4.2 WALKWAY DESIGN

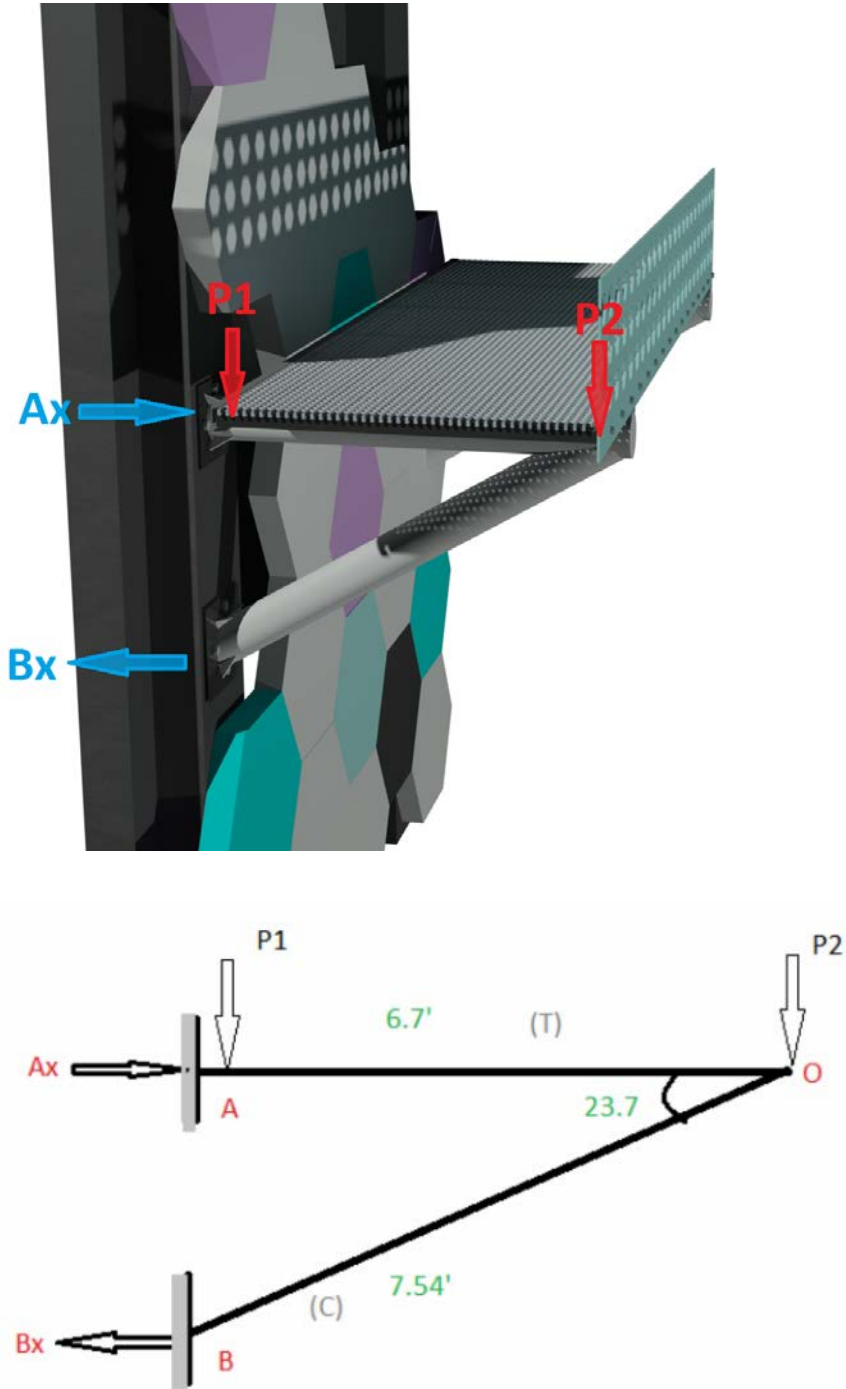


Figure 11 Walkway Load Diagram

Calculating Loads for the Pathway Supporting members:

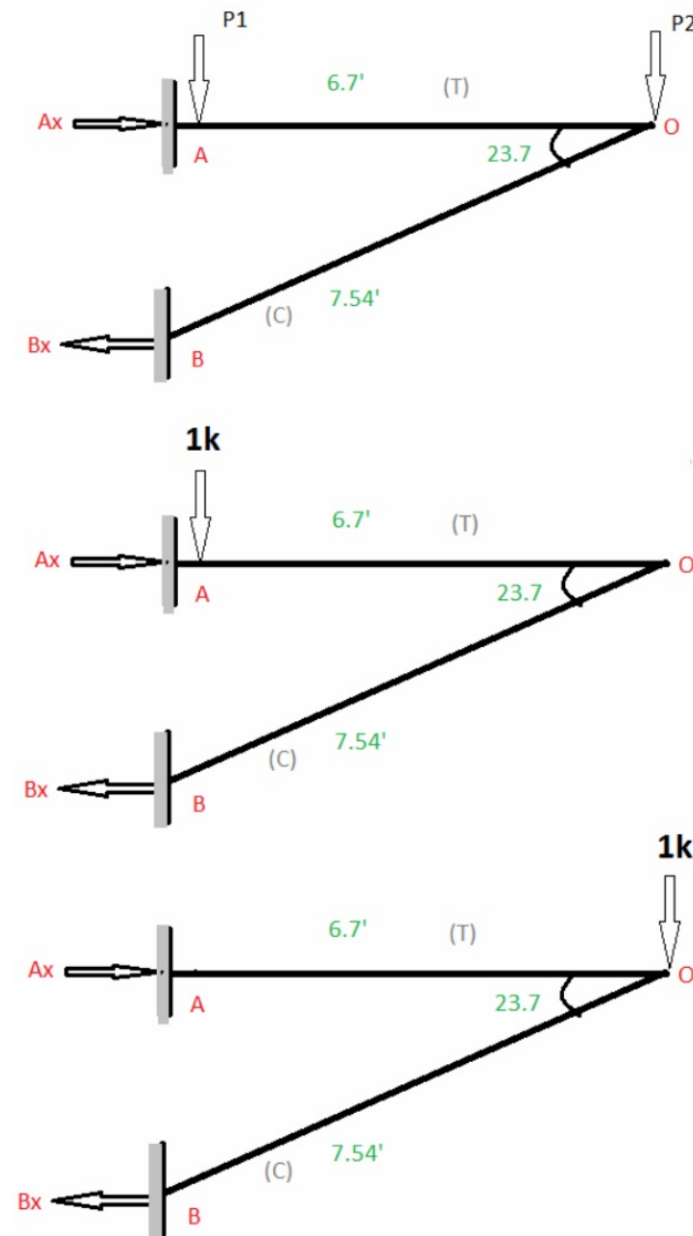


Figure 12 Loads acting on the Pathway

using Pythagoras theorem where the height is measured from the center of one hexagon to the quarter of the other. The calculations resulted in 7.54 ft for member OB which creates an angle of 23.7 degrees with member OA determined by using cosine formula $\cos(\theta) = \text{Opposite}/\text{Hypotenuse}$.

The loads for the pathway will be distributed in two main points as shown in Figure 12.

P1 represents the weight of the hexagons, the channel, part of the grating weight, part of the square HSS weight and part of the live occupancy load. P2 represents the weight of the channel, railing, part of the grating weight, part of the square HSS weight, part of the live occupancy load as well as the forces applied to the railing when pushing on it. The span was considered the length from column to column which is 12 feet because the walkway structural components will be connected in the columns. Since, ADAAG suggested that the length of the pathway should be no less than 5.5 ft: allowing for a wheel chair to operate and make a full rotation, this walkway was designed for 6 ft in order to allow for tolerances.

Taking into consideration that the depth of the hexagons is 6 inches and allowing 2-3 inches of tolerance from the wall for practical installation purposes, results in a length of the member OA of 6.7 ft. The length of member OB was determined

Each load that was given in pounds per square feet was multiplied by the tributary area as in:

$$\text{Grating load} = 4.9 \text{ psf}$$

$$\text{Load imposed by Grating} = 4.9 \text{ psf} * 36 \text{ sqft} = 176.4 \text{ lbs}$$

1. Walkway supporting members

The calculations were based on member OB since it is the most critical, carrying the most load in bending and compression. However, the size selected was double checked if it fit member OA as well.

$$Mu = \frac{PuL^2}{8} = \frac{15448.5 * (7.54 * 12)^2}{8000} = 15808 \text{ in} - \text{lbs}$$

$P_u \rightarrow$ point load acting on member OB.

$F_y = 42$ ksi for round HSS (AISC Manual, Table 4-5)

Plastic section modulus Z should be calculated in order to get an area estimate for this tube.

$$Z \geq \frac{Mu * 12}{0.9F_y} \geq 88.3 \text{ in}^3$$

AISC Manual, Table 1-13 lists a series of HSS shapes along with their properties from which help sort based on Z and Area values. After a series of trial and error checks it was determined that the best fit would be **HSS 8.625x0.625**. After that the values for W_u , Z and M_u were revised by updating them with the section properties.

$$P_{u_{revised}} = Pu + (1.2 * 52.45 * 12) = 16218.2 \text{ lbs}$$

$$Z_{revised} = 92.67 \text{ in}^3$$

$$M_{u_{revised}} = 291.93 \text{ in} - \text{lb}$$

$$\Delta_{max_{revised}} = \frac{PL^3}{3EI} = \frac{16218.2 * (7.54)^3}{384 * 29 * 10^6 * 119} = 0.672 \text{ in}$$

$$\Delta_{max} < 1 \text{ in maximum deflection}$$

Shear strength was calculated using the smallest $F_{critical}$

$$F_{cr} = 0.6 * 42 \text{ ksi} = 25.2 \text{ ksi}$$

$$V_n = F_{cr} * \frac{A_g}{2} = 25.2 * \frac{14.7}{2} = 185.2 \text{ kips}$$

$$\phi_v V_n = 0.9 * 185.2 = 166.7 \text{ kips} \rightarrow \text{Available shear strength}$$

$$\phi_v V_n > V_c = 1.2DL + 1.6LL = 16.2 \text{ kips}$$

$$\phi_t P_n = 62.7 \text{ ksi} \rightarrow \text{available yield strength for members in tension (AISC Manual, Table 5-6)}$$

$$\phi_t P_n > \phi_v V_n$$

$$\text{Calculated stress } \sigma = \frac{F}{A} = \frac{16821.2 \text{ lbs}}{14.6 \text{ in}^2} = 1103 \text{ psi} < F_y = 42 \text{ ksi.}$$

F → the force in the member

A → Area of the member

After all these checks were passed, **HSS 8.625x0.625** was decided to be used as the pathway support.

This section was used to check for member OA, to determine if it would be suitable to support its load. It was expected that it will be suitable and the calculation proved it right.

The stress calculated should be less than the yield strength F_y given in kips.

2. Channel Sizing:

This pathway will have two identical C channels, supporting the grating and its supporting members. The grate is A type of screen made from sets of parallel bars placed across each other in approximately the same plane, allowing water to flow to drainage, while covering the area for pedestrian. The channel that carries the most weight was considered when determine the right size so the system would work and also, it would not interfere with the design. The channel also will serve as an architectural element rather than only being a structural member. The aluminum railing, the grate and a square HSS tube will be connected through the C channel. The channel will not support any significant weight as the weight of the pathway will be transferred from the grating, to the supporting member beneath and then to the round HSS tube. However, a size had to be identified in order for the channel to be able to fit the grate, the member beneath and the connections for the railing. **C 5x 6.7** was identified as the best fit.

3. Pathway's Grating Supporting member

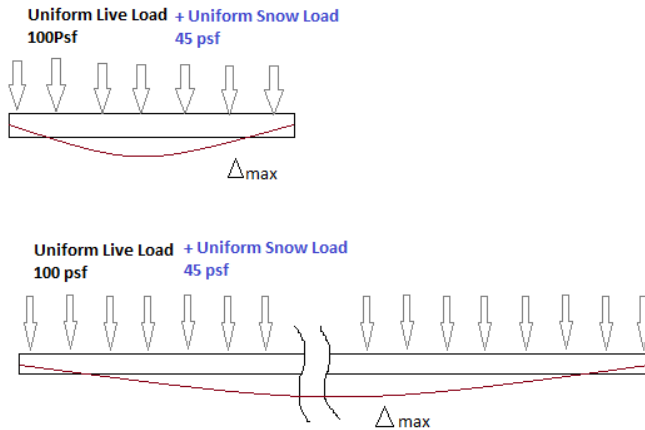


Figure 13 Grating Load Diagram

The grating's dimensions were obtained from the manufacturer's specification. Most manufacturers give the customers the ability to fully customize the dimensions of the grating to meet their projects' needs. This grating's dimensions are 6 ft Wide x 12 ft Long. There will be live load and snow load acting upon this grating. The grating will be open, allowing most of the snow accumulated to melt down, but for this calculation the worst case scenario was considered, assuming all the snow will be accumulated on top.

In order to reassure that the pathway is safe for everyone to walk on, the grating has been reinforced by adding square HSS members underneath it, every 2 feet. These members should be able to sustain the weight of the grate and the live loads for the tributary area that they support. The tributary area is:

$$2ft * 6ft \text{ length} = 12sq - ft$$

Factored Loads: 1.2 Dead Load+ 1.6 Live Load + 0.5 Snow Load

$$Wu = (1.2 * 4.9psf * 12sq - ft) + (1.6 * 100 psf * 12 sq - ft) + (1.4 * 45 psf * 12 sq - ft) = 2260.5 lbs = 2.26kips$$

4. Railing Post

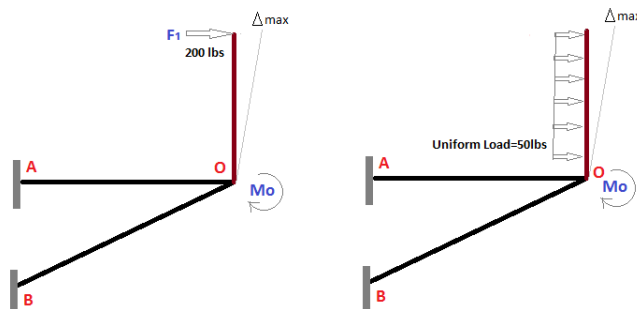


Figure 14 Railing Loads and Force Diagram

$h=2.5\text{ft} \rightarrow$ height of the post

$L=2\text{ in} \rightarrow$ the width of the post

The railing should be able to withstand 200 lbs concentrated force and 50 lbs uniform load applied in any direction. The biggest challenge with this system is that it has to resist the moment created at the bottom as it acts like a lever and affects the connection between decks' rim and joist. The greatest stresses are at the bottom. For this calculation the worst case scenario was considered where the forces are applied horizontally, at the top. The railing designed for this project is assumed to be made from 0.5 in thick perforated aluminum panels. These panels are bolted at the bottom at the channel where the grating sits. Since these sheets won't have any post supporting them from the back, the section highlighted in yellow in the picture below was considered as such.

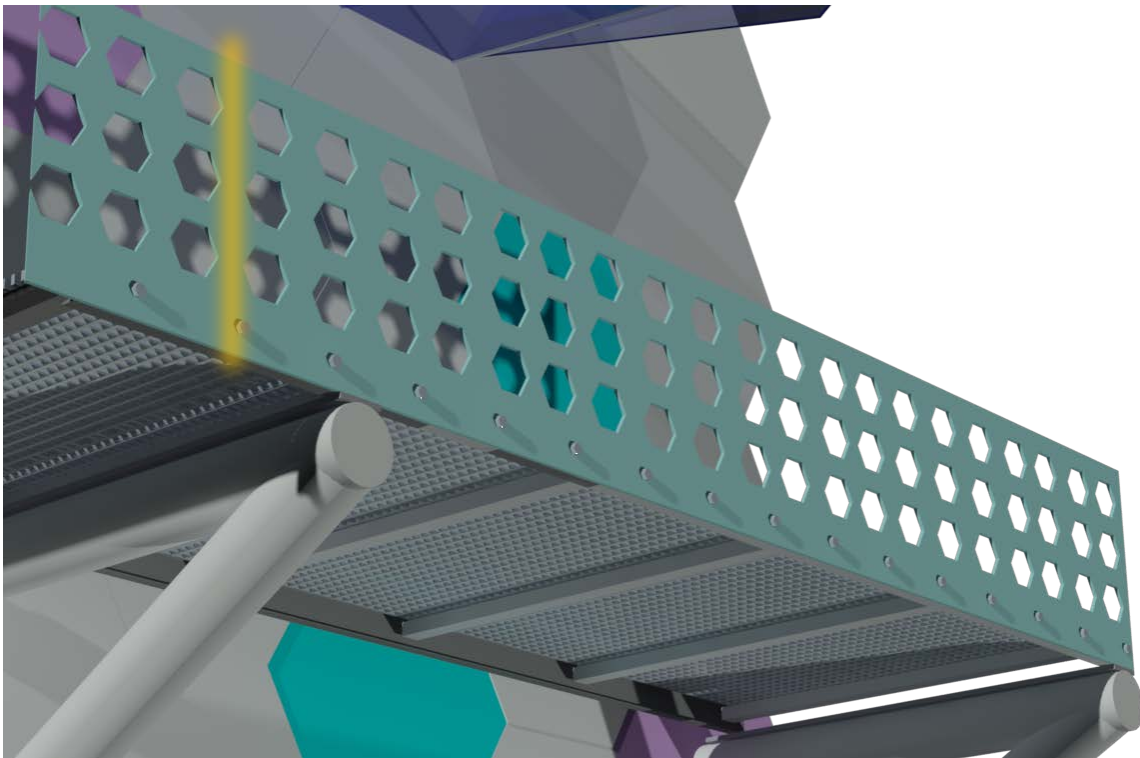


Figure 15 Railing Post Section

The applied moment M_o is equal to the resisting moment M_r which acts in the opposite direction. For the concentrated point force, the applied maximum moment is $M_o=F_1*d$ where d is the distance from the bottom of the post to where the force is applied.

$$M_o = 200\text{ lbs} * (2.5\text{ft} * 12\text{in}) = 5400\text{ in} - \text{lbs at the base.}$$

Under uniform load, the maximum moment M_u is:

$$M_u = \frac{Wl^2}{12} = 50 * 5^2 * \frac{12}{12} = 1250 \text{ in.} - \text{lbs}$$

The allowable stress of Aluminum should be greater than the bending stress of this post. For this design Tempered T-6 Aluminum was considered which has an ultimate tensile strength of 42 ksi and a yield strength of 35 ksi.

For the concentrated Load:

$$\text{Bending Stress} = \frac{M_o * c}{I}$$

c → the perpendicular distance from the Neutral Axis to the farthest point.

Since our post has a rectangular cross section, therefore the centroid of this post is located in the geometric center of the rectangle.

The moment of Inertia I for a rectangular section along y-axis is given by:

$$\frac{hb^3}{3} = \frac{\left[\left(2.5 \text{ ft} * 12 \frac{\text{in}}{\text{ft}} \right) * 2^3 \right]}{3} = 80 \text{ in}^3$$

$$\text{Bending Stress} = \frac{\left[5400 \text{ in} - \text{lb} * \left(\frac{2.5 \text{ ft} * 12 \frac{\text{in}}{\text{ft}}}{2} \right) \right]}{80 \text{ in}^3} = 1012.5 \text{ psi} = 1 \text{ ksi}$$

$< 42 \text{ ksi } \mathbf{O.K}$

For the uniform Load:

$$\text{Bending Stress} = \frac{1250 \text{ in} - \text{lb} * 15 \text{ in}}{80 \text{ in}^3} = 234.4 \text{ psi} = 0.2 \text{ ksi} < 42 \text{ ksi } \mathbf{O.K}$$

When the force is applied directly horizontally, the deflections on the post will be maximal. Since this railing was custom designed, it is necessary to check if the maximum calculated deflections will be less than the maximum allowable deflections specified by the code.

Maximal Allowable Deflections:

$\Delta_{max} = \frac{h}{24} + \frac{L}{96}$ (American Standards and Testing of Materials (ASTM) E 985, Standard Specification for Permanent Metal Railing Systems and Rails for Buildings)

$$\frac{h}{24} + \frac{L}{96} = 1.25in + 0.02 = 1.27$$

For Concentrated Load:

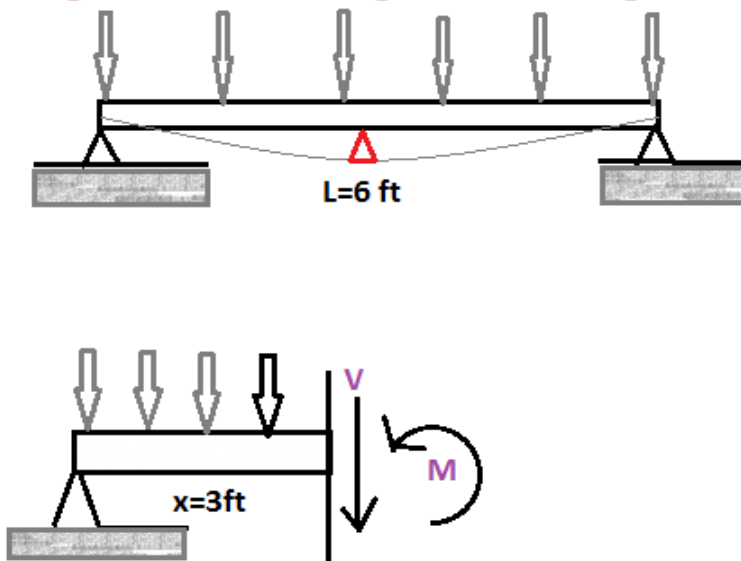
$$\Delta = \frac{F_1 h^3}{3EI} = 200 * 2.5 * \frac{12}{3 * 10,100ksi * 1.32} = 0.13 \text{ in horizontally} < 1.27 \text{ in OK}$$

For Uniform Load:

$$\frac{WL^4}{3EI} = \frac{[(50 * 12 * 2.5) * (2.5 * 12^4)]}{3 * 10,100 \text{ ksi} * 80in^3} = 0.2 \text{ in horizontally} < 1.27 \text{ in OK}$$

The values calculated for the deflections are less than the allowable deflections, therefore the post guard is safe to use.

Weight of the Grate+ Weight of Snow+ Weight of People



The square HSS tube selected for this structure will behave as a simply supported beam in tension because the deflection will occur at the middle of the beam downwards, since we have a uniformly distributed load along its span.

We use the allowable deflection value specified by AISC:

Figure 16 Square HSS Load and Bending Diagram

$$\Delta_{allowable} = \frac{L}{240} = \frac{6 \text{ ft} * 12 \frac{\text{in}}{\text{ft}}}{240} = 0.3 \text{ in vertically down.}$$

$$I_{required} = \frac{5WL^2}{384 * E * \Delta_{allowable}} \geq 7.58 \text{ in}^4 \text{ (AISC Manual, Table 3-23, Case 1)}$$

We use this fact to sort through the available square HSS shapes in the AISC Manual. After identifying a few that have moment of inertia above 7.58 in⁴, through a trial-and-error method the right HSS shape is selected. Table 1-12 of the Manual lists different sections and their properties. From the design of the pathway, a tube with a cross sectional height in the range of 3-

4.5 in would be a good fit. **HSS 4x4x1/4** is the smallest shape with moment of inertia greater than 7.58 in^4 therefore, calculations were performed to determine whether this member could sustain all the loads imposed on it without failing the deflection checks. From AISC Manual Table 2-4, the material properties for ASTM A500 Grade B state that this member has $F_y = 46 \text{ ksi}$ and $F_u = 58 \text{ ksi}$. Firstly, the factored load was revised to reflect the self-weight of the square HSS. I of HSS4x4x1/4 is 7.80 in^4 . From AISC Manual Table 3-13, the available flexural strength is $\phi_b M_n = 62 \text{ kips} > 3.35 \text{ kips}$ (revised factored load), therefore HSS 4x4x1/4 is safe to use.

5. Joint that connects the pathway members to the wall

The round HSS tube, will be connected to the wall through a steel plate. This tube will be welded into the plate and the plate will be bolted into the wall through some anchors. The welding size, the bolt diameter and the plate dimensions were calculated in order to make sure that this joint will be able to withstand the force applied to it. The joint connecting member OB was analyzed since the tube is connected to an angle and supports the most weight.

Bolts in Shear and Tension

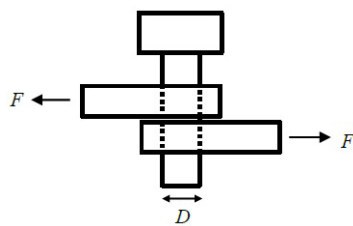


Figure 17 Bolt in Shear Diagram

Most bolts are subject to shear and tension. The bolted shear connections should be designed such that the factored design strength is greater or equal to the factored load. The bolt could fail in many ways, therefore it is necessary to consider the average shearing stress, the loads acting on an individual bolt, the dimensions and strength of the bolt and yield stress. The shear strength of one bolt is equal to the individual shear strength of a single bolt multiplying it by the total number of bolts in a connection. In this case, the bolt is exposed to both shear and tension, as the member that they support is connected to an angle. The forces acting on member OB have forces acting on it in both directions which makes the bolts and plate subject to combined bending and tension. For this calculation, it was assumed that the bolts have $3/4$ inches diameters and they are made out of A325 steel. The four bolts specified in this project should be able to withstand all the applied load.

Chapter J in the AISC Specification addresses bolted connections and specifies the minimum distances between the center of the bolts, the minimum and maximum edge distances, the design shear strength of bolts and bearing plate strength of connecting plates. Table 7-10 of the AISC gives the design shear of one bolt for different bolt types.

The typical bolt diameters for steel connections are ½ in, 5/8 in and ¾ in. This calculation will determine whether the selected diameter is suitable for the connection. From Table J3.2 in the AISC the nominal shear strength for one bolt of A32 steel is 54 ksi.

$$F_u = 65 \text{ ksi}$$

$$\text{Shear strength connection} = 0.75 * 54 * 4 = 165 \text{ kips}$$

Since the bolts are subject to bending and tension we should check that this connection is able to sustain failure in both planes. Equation J3-3a taken from AISC Manual should be satisfied:

$$F'_{nt} = 1.3 F_{nt} - \left(\frac{F_{nt}}{\Phi F_{nv}} \right) * f_{rv} \leq F_{nt}$$

F'_{nt} → nominal tensile stress modified to include the effects of shear and tension

$$F'_{nt} = 1.3 * 90 - \left(\frac{90}{0.75 * 54} \right) * 15.5 \text{ k} = 82.8 \text{ ksi} \leq 165 \text{ ksi}$$

Plate Strength and Dimensions

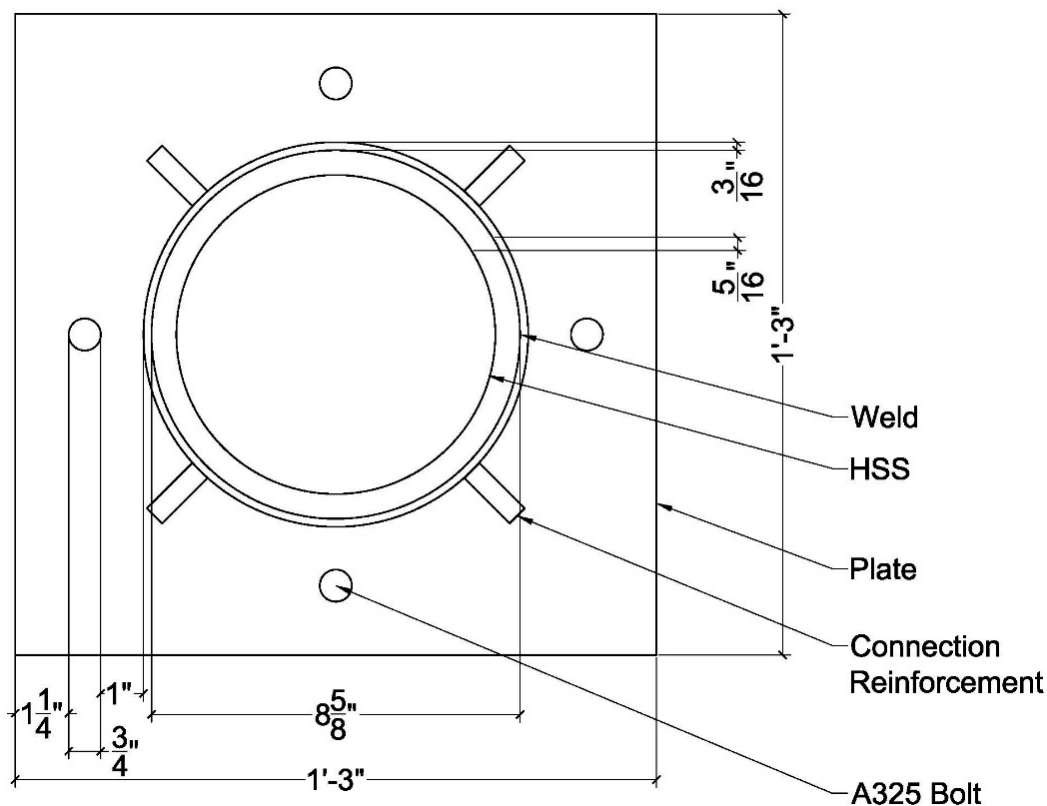


Figure 18 Plate Dimensions

It is assumed that the square steel plate will have a thickness of 5/8 inch. Through this calculation the dimensions and strength of the steel plate will be determined.

From J3.4, AISC Manual:

Minimum edge distance= 1in for rolled edges of plates

Plate Dimensions:

$$\begin{aligned}
 a &= 8.265 \text{ in (HSS size)} + 2 * \frac{3}{4} \text{ in (bolts)} + 2 * \frac{1}{16} \text{ in (tolerance)} + 2 * 1 \\
 &\quad - \frac{1}{2} \text{ in (edge distance)} + 2 \\
 &\quad * 1 \text{ in (distance from the bolt to the tube on each side)} \\
 &= 15.3 \text{ in} \rightarrow \text{design for } 15.5 \text{ in}
 \end{aligned}$$

$$A_g = 15.5 \text{ in} * 15.5 \text{ in} = 240.3 \text{ sq} - \text{in} = 1.7 \text{ sq} - \text{ft}$$

In order to prevent the deformation on the holes of the plate an upper limit is placed on the bearing load. The bearing strength for a single bolt is ΦR_n where $\Phi=0.75$ and $R_n = 1.2L_c * t * F_u$. L_c is the clear distance in the load direction from the edge of the hole to the edge of the next hole or material.

Design strength of individual bolt:

$$\Phi F_n A_b = 0.75 * 54 \text{ ksi} * 1.8 \text{ sq} - \text{in} = 72.9 \frac{\text{kips}}{\text{bolt}}$$

Shear Strength connection:

$$\frac{72.9 \text{kips}}{\text{bolt}} * 4 \text{ bolts} = 291.6 \text{ k}$$

Plate tension yield:

$$\Phi R_n = \Phi F_y * A_g = 0.75 * 240.3$$

Plate Bearing Capacity:

$$\Phi 2.4 * d_b t * F_u = 0.75 * 2.4 * \left(\frac{3}{4} \text{ in} * \frac{5}{8} \text{ in} \right) * 65 \text{ ksi} = 54.8 \frac{\text{k}}{\text{bolt}} \text{ or } 219.4 \text{ k}$$

The smallest of the bearing and tearing governs.

Since the plate itself is subject to combined shear and tension forces, it is necessary to check for prying action on the plate. Prying action is caused by the deformation of the connecting elements in bolted connections when tensile loads are applied. There will be some increased forces in some of the bolts above the forces caused by the direct tensile forces. The thickness of the plate should not be less than the minimum thickness specified by AISC.

$$t_{min} = \sqrt{4.44 T_u b' / p F_u}$$

T_u → the required strength of each bolt,

b' → the distance from the edge of HSS to the bolt,

p → the tributary length per pair of bolts and

F_u → the specified tensile strength of the bolts specified by AISC.

$$T_u = \frac{F_{OB}}{4 \text{ bolts}} = 15.44 \frac{\text{kips}}{4} \text{ bolts} = 3.86 \text{ kips}$$

$$t_{min} = \sqrt{\frac{4.44 * 3.86 \text{ ksi} * 1 \text{ in}}{1.5 \text{ in} * 58 \text{ ksi}}} = 0.34 \text{ in}$$

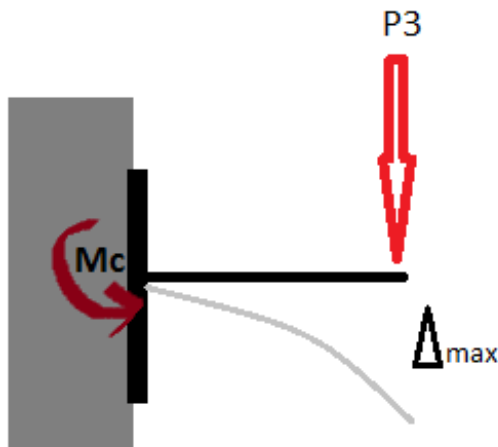
The minimum thickness calculated for the prying action is less than the chosen thickness for the plate, therefore, the plate makes a rigid connection.

Welding

Fillet welds are the most common in structures because a fillet weld can be loaded in any direction such as shear, compression or tension. These welds always fail in shear, through the throat of the weld. The welding sizes vary in 1/16 in increments. The thinner of the plate or the tube should be considered for the welding. Since the plate has a thickness of 0.6 in and the tube has a thickness of 0.625 in, the welding was designed for the thickness of the plate. The tube will be welded to the plate along its circumference.

From AISC Table J2.4 for minimum size of fillet welds, it is appropriate to use 3/16 in weld as a minimum.

4.4 ROOF DESIGN



The roof structure will have two types of connections. Some elements will be connected to the columns and some to the walls. The connection will go through the back of the hexagons since the roof will follow their shapes. The members connected directly to the wall will be longer than the ones connected to the columns but since the shorter ones are more critical, the calculations were conducted for the shorter members and then the same size was used for the longer pipes as well. The member sizes for the roof

were expected to have a smaller diameter since in comparison to the ones for the pathway, they will only support the weight of the roof and of the snow. One member will support two pieces of glass, therefore the tributary weight was calculated. P3 represents the load that goes on the roof member which includes the weight of the glass, the weight of the channel holding the glass sheets together and the snow load. The weight of the snow was taken from the Massachusetts building code for the Boston location. The volume of the glass sheets was measured from the AutoCAD drawing. A thickness of 3/8" was assumed for the glass of the canopy. And the density of 160 lb/cf was assumed when determining the weight of the glass since the density of common glass varies between 150-175 lbs/cf¹.

Since the load will be applied at the tip of the round HSS, the structure will behave as a cantilever beam and there will be some moment at the end of the beam. Due to the load applied directly horizontally at the beam, there will also be some deflection which should be within the range of deflection values specified by AISC.

$$\Delta_{allowable} = \frac{L}{240} = \frac{9 \text{ in}}{240} = 0.0375 \text{ in vertically down}$$

Using the method of virtual work applied to beams, an estimate of the moment of inertia for the member was determined. The virtual work method helps us evaluate the deflections when we have the moments due to virtual and real work, moment of inertia and young's modulus for the material. In this case, it was necessary to find the moment of inertia I, in order to find the right size of the member since we already calculated the maximum deflection using L/240. The

¹ "Densities Of Solids". Engineeringtoolbox.com. N.p., 2017. Web. 18 Apr. 2017.

maximum deflection will give the minimum moment of Inertia required for the pipe to sustain the load applied on it. The unit load of 1 was put at the tip and then the moment m was calculated as in:

$$m = 1k * 9 \text{ in} = 9 \text{ in.} - \text{kip}$$

Factored Load Design Equation

$$P3 = 1.2 DL + 0.5 Snow = (1.2 * 58.5) + (0.5 * 540) = 340.6 \text{ lbs} = 0.34 \text{ kips}$$

The moment due to load P3 was calculated:

$$Mc = P3 * 9 \text{ in} = 340.6 \text{ lbs} * 9 \text{ in} = 3065.2 \text{ in} - \text{lb.}$$

$$\Delta_{\max} = \int_0^L \frac{mM}{EI} dx = \int_0^9 \frac{9 * 3065.2}{29 * 10^6 * I} dx \rightarrow I = 1 \text{ in}^4$$

For selecting this member's size first I sorted through the moment of Inertia values from Table 1-13 and identified some members with moment of inertia greater than 1 in^4 .

The moment Mc , due to real work is given by:

$$Mc = \frac{P3L^2}{8} = \frac{340.6 \text{ lbs} * 9^2}{8000} = 3.44 \text{ in} - \text{lbs}$$

$F_y = 42 \text{ ksi}$ (Table 4-5 AISC Manual)

Z value was determined by:

$$Z \geq \frac{Mc * 12}{0.9F_y} \geq 1.09 \text{ in}^3$$

After a series of trial and error checks it was determined that the best fit would be **HSS 2.5x 0.25**. The values for P3, Z, Mc and maximum deflection were revised by updating them with the section properties.

$$P3_{\text{revised}} = P3 + (1.2 * 9 * 0.25) = 342.2 \text{ lbs}$$

$$Z_{\text{revised}} = 1.96 \text{ in}^3$$

$$Mc_{\text{revised}} = 6.16 \text{ in} - \text{lbs}$$

$$\Delta_{\max \text{ revised}} = \frac{P3L^3}{3EI} = 0.02 \text{ in} \leq \frac{L}{240}$$

Shear strength was calculated using the smallest F_{critical}

$$F_{cr} = 0.6 * 42 \text{ ksi} = 25.2 \text{ ksi}$$

$$V_n = F_{cr} * \frac{A_g}{2} = 25.2 * \frac{1.66}{2} = 20.9 \text{ kips}$$

$$\phi_v V_n = 0.9 * 20.9 = 18.8 \text{ kips} \rightarrow \text{Available shear strength}$$

$$\phi_v V_n > V_c = 1.2DL + 1.6LL = 0.342 \text{ kips}$$

$\phi_t P_n = 62.7 \text{ ksi} \rightarrow$ available yield strength for members in tension (AISC Manual, Table 5-6)

$$\phi_t P_n > \phi_v V_n$$

After all these checks were passed, **HSS 2.5x0.25** was decided to be used as the roof support.

The calculated stress should be less than yield strength F_y given in kips and is given by:

$$\text{Calculated stress } \sigma = \frac{F}{A} = \frac{339.5 \text{ lbs}}{1.66 \text{ in}^2} = 206.1 \text{ psi} < F_y = 42 \text{ ksi.}$$

$F \rightarrow$ the force in the member

$A \rightarrow$ Area of the member

4.3 DRAWINGS AND RENDERINGS

Section drawings of the wall, plan views, elevations and architectural details will be drawn using AutoCAD. Renderings of the new concept will be created using MAYA and presented on the report as .jpeg files.

AutoCAD is a computer-aided design and drafting software, part of Autodesk package.

Maya is a 3D computer graphics software part of the Autodesk package, used for modelling, rendering and animations.

5. RESULTS

This section concludes the results that were obtained from all the calculations conducted.

Walkway Elements Calculation Conclusion:

The calculations for the pathway concluded that member OB is the most critical member of the supporting structure as it will carry the majority of the load.

- Area of the round members should be around, but no less than 11.72 sq-in
- Member OA is in tension and carries 1.94 kips due to unit load applied at point P2, 0.13 kips due to unit load applied at point P1 and 11.8 kips due to real work.
- Member OB is in Compression and carries 2.18 kips due to unit load applied at point P2, 0.146 kips due to unit load applied at point P1 and 12.4 kips due to real work.

MEMBER SIZES

- Pathway Supporting member
 - HSS 8.625x0.625
- Channel
 - C 5x6.7
- Grate Supporting member
 - HSS 4x4x1/4

Connecting Joint

4 bolts $\frac{3}{4}$ in diameter

$\frac{3}{16}$ in welding

15x15x $\frac{5}{8}$ in steel plate

Roof Elements Calculation Conclusion:

- Load P3 applied to the tip of the beam is 339.5 lbs.
- Moment Mc due to P3 is 3059.2 in-lb and moment mc due to unit load is 9 in-lb
- Roof Supporting Member
 - HSS 2.5x0.25

6. ARCHITECTURAL DETAIL DEVELOPMENT

This section presents graphically the details of different elements that connect the façade to the columns. All the drawings are developed using AutoCAD drafting and modeling.

List of Drawings:

- Wall section showing the detail connections for the pathway and roof members
- Wall section showing the detail connections for the hexagons
- Floor plan showing the pathway
- Floor plan showing the roof
- Rendered pathway elements
- Rendered roof elements

The wall section below shows the third floor of the garage where the roof and pathway are located. This image shows all the connections that go to the columns. Floor to floor height is ten feet.

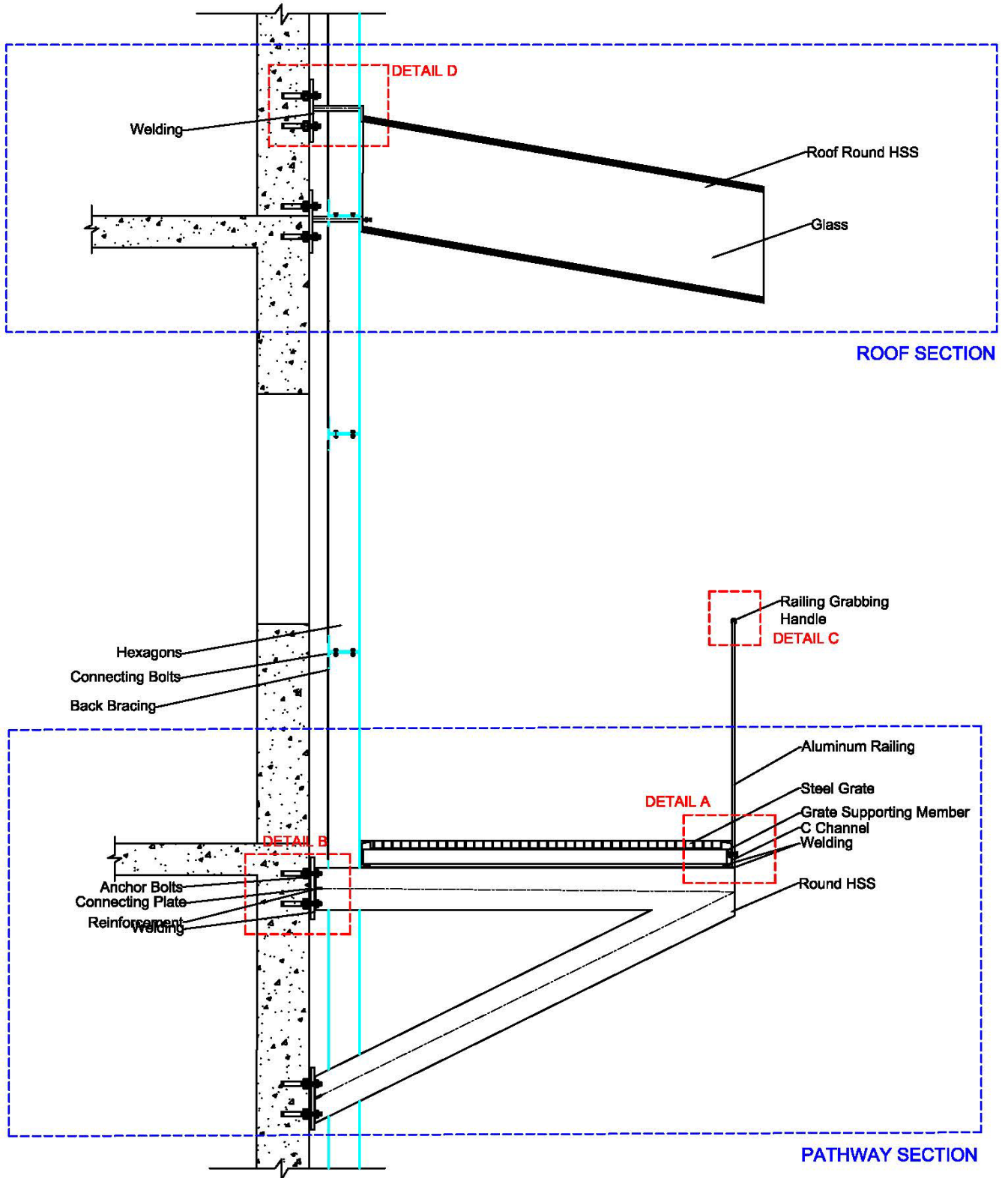


Figure 19 Floor-Floor Wall Section

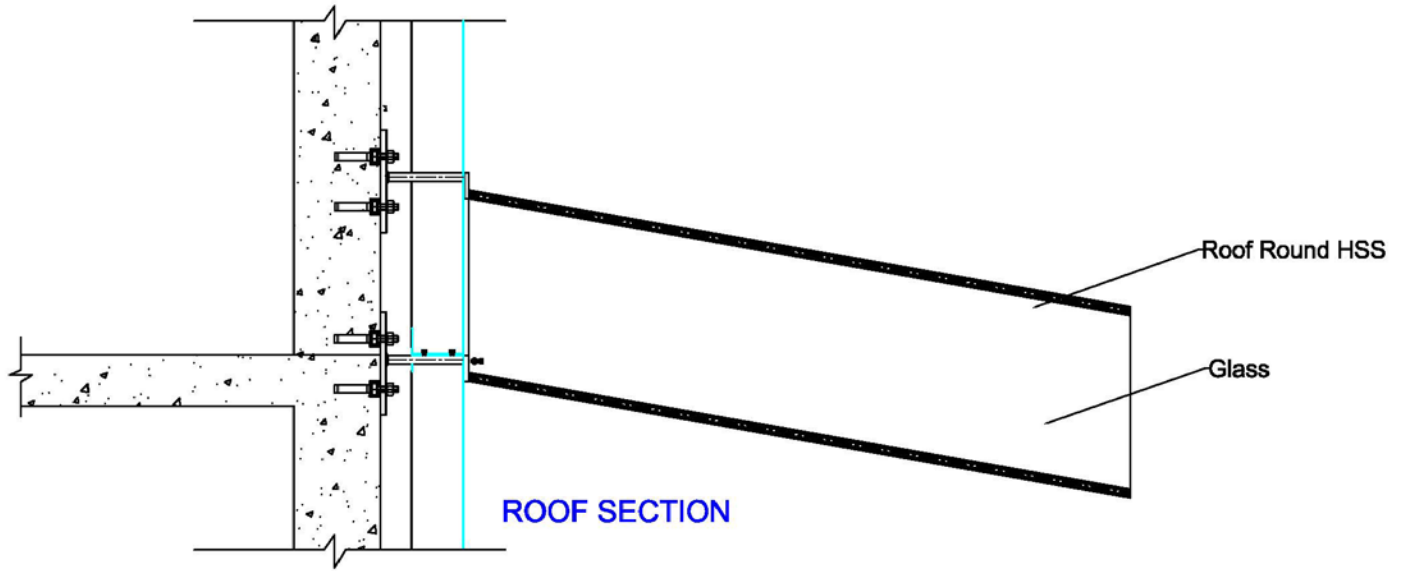


Figure 20 Roof Section

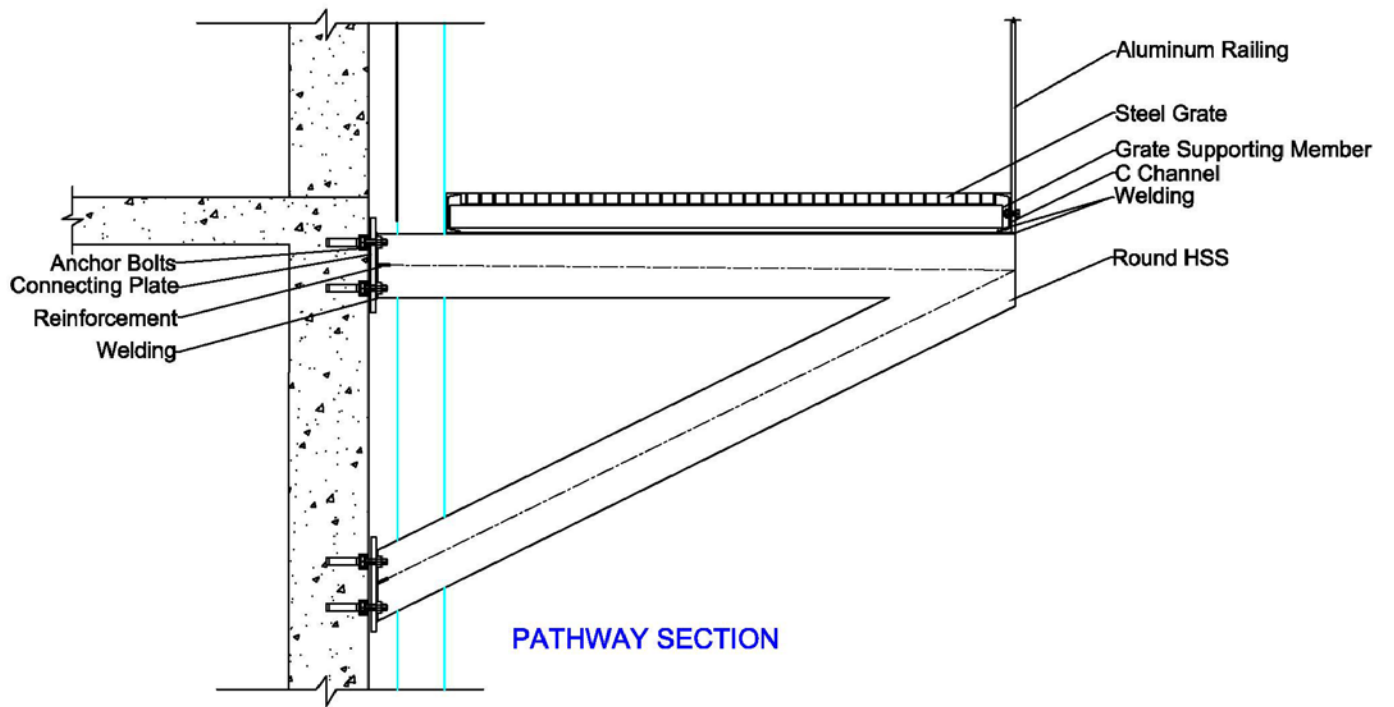


Figure 21 Pathway Section

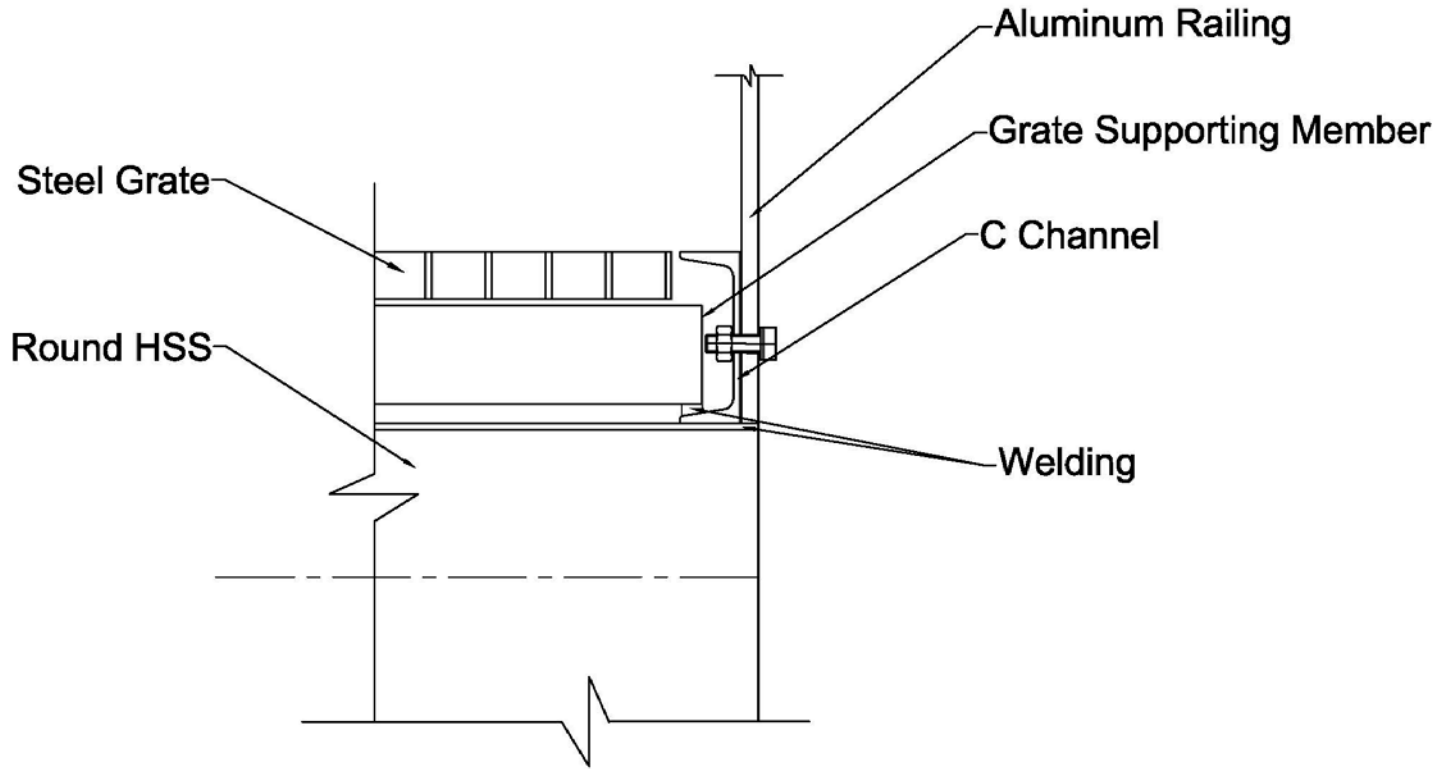


Figure 22 Detail A- Railing Detail Connection

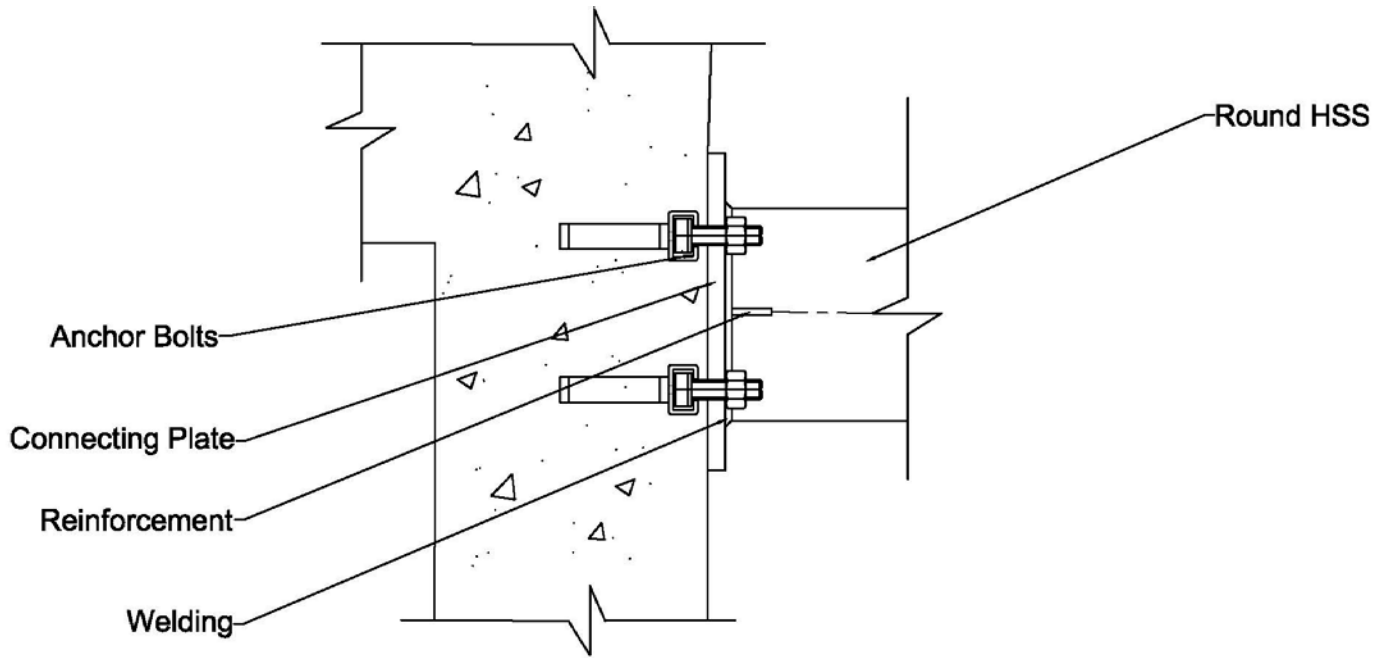


Figure 23 Detail B- Pathway Detail Connection

DETAIL B

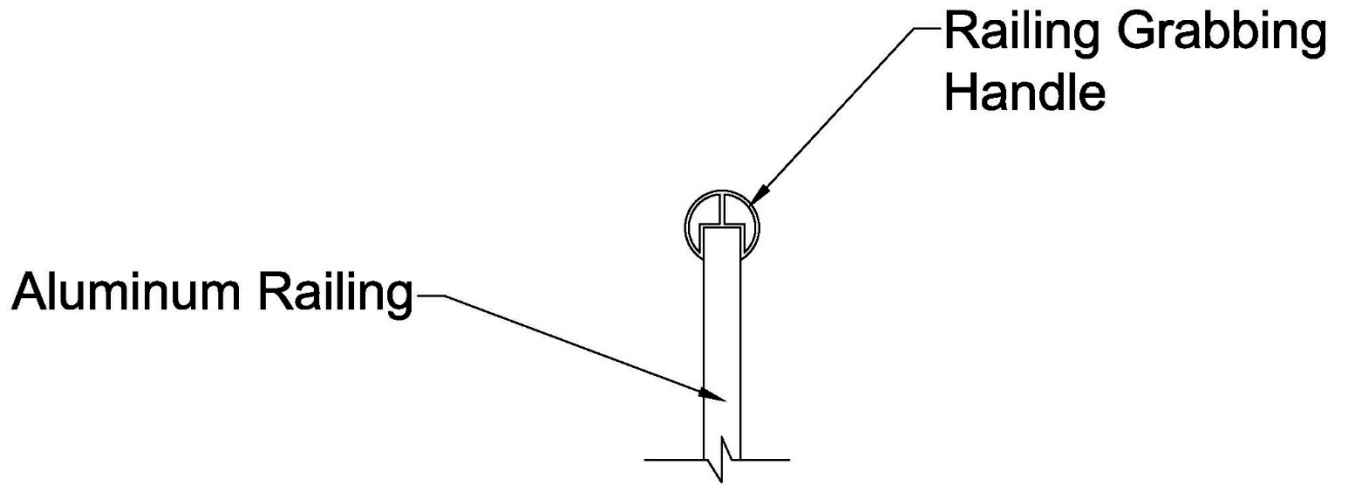
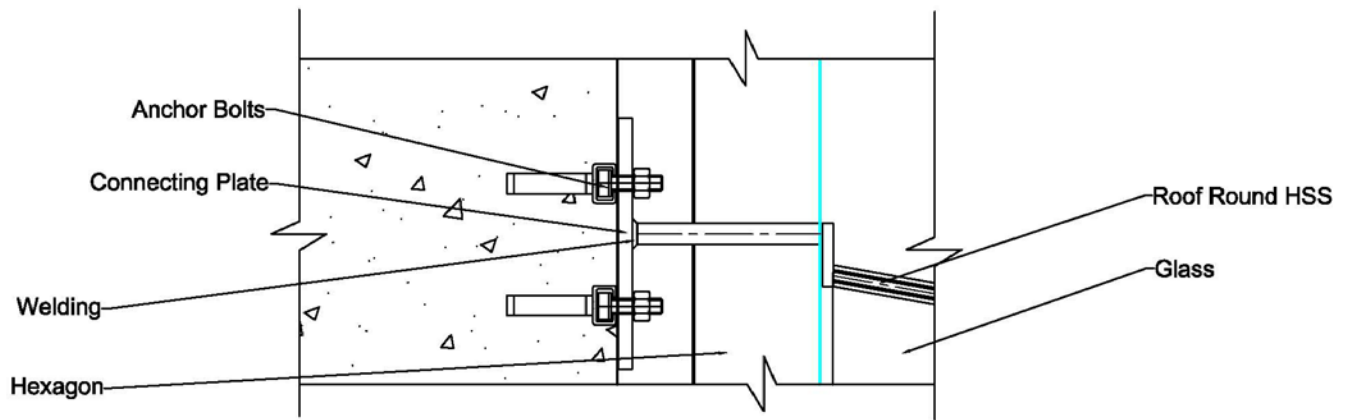


Figure 24 Detail C- Railing Handle Detail

Figure 25 Detail D- Roof Detail Connection



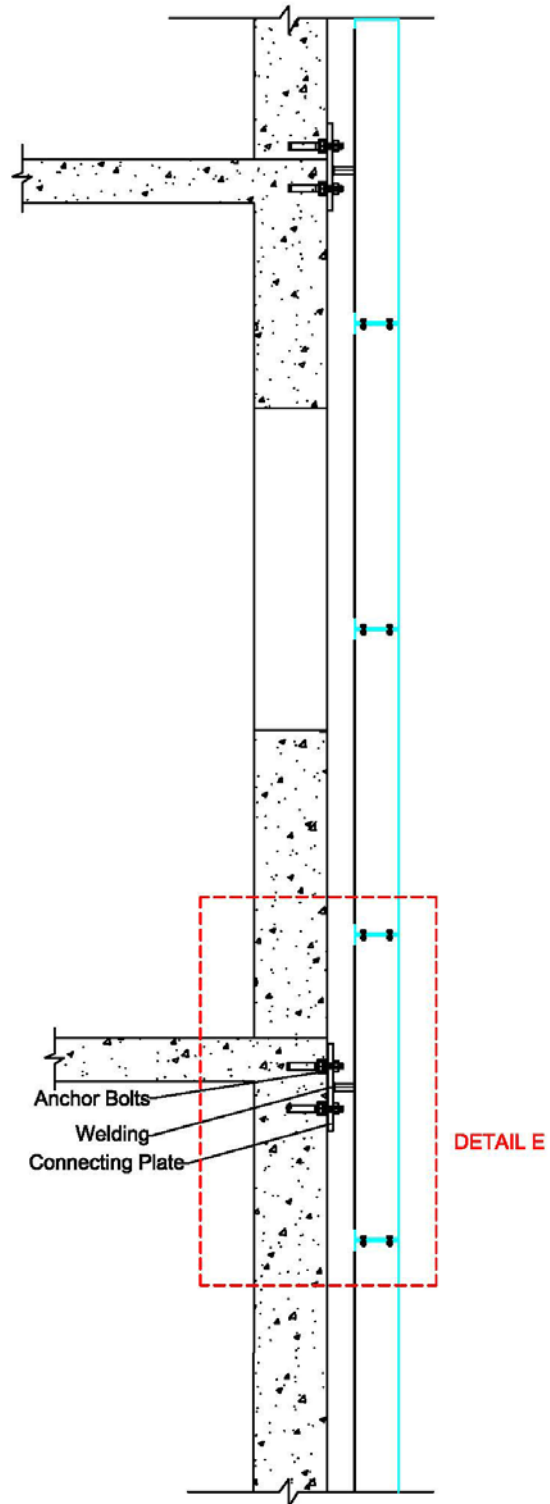


Figure 26 Hexagon Connection

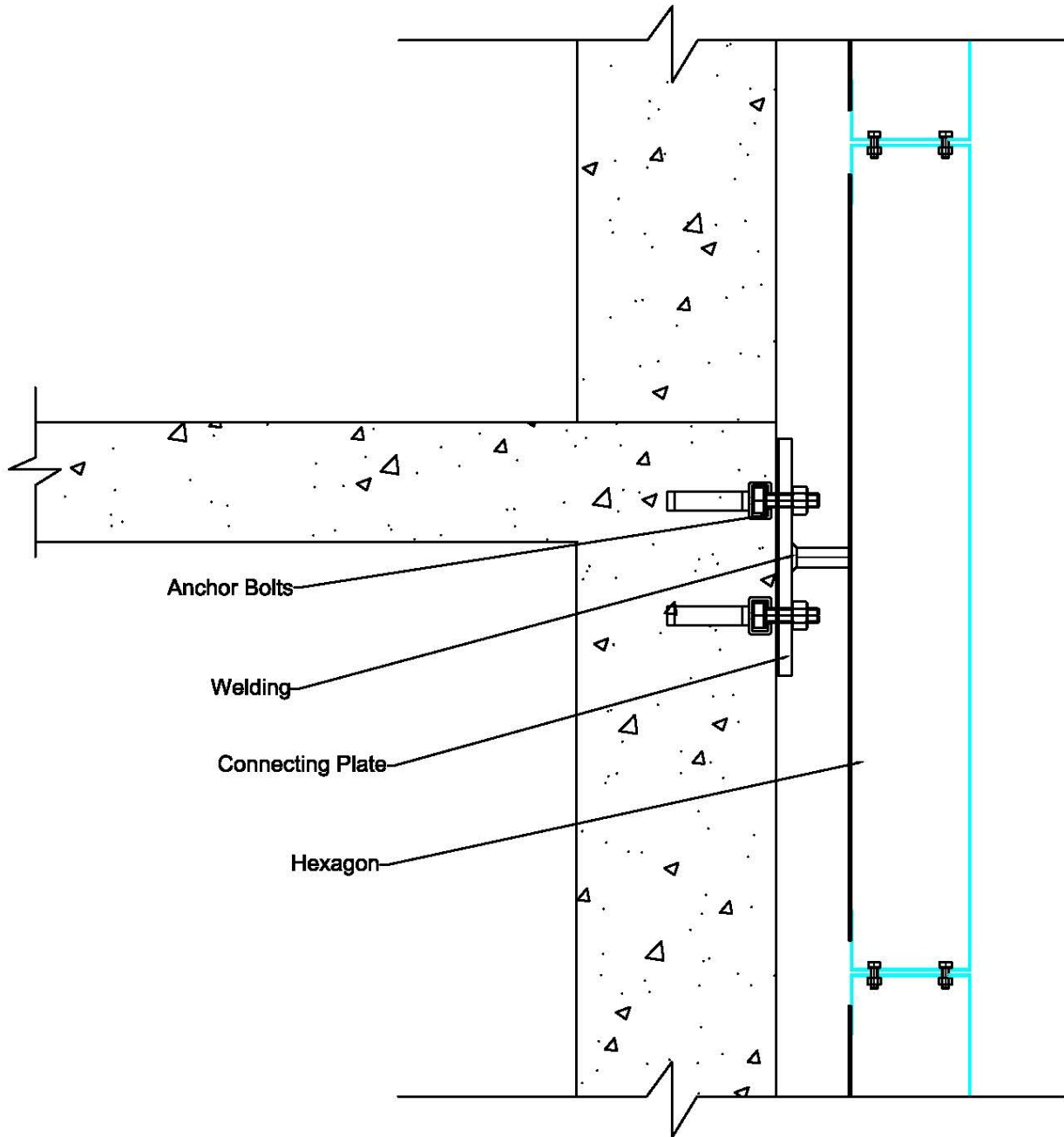


Figure 27 Detail E- Hexagon Detail Connection

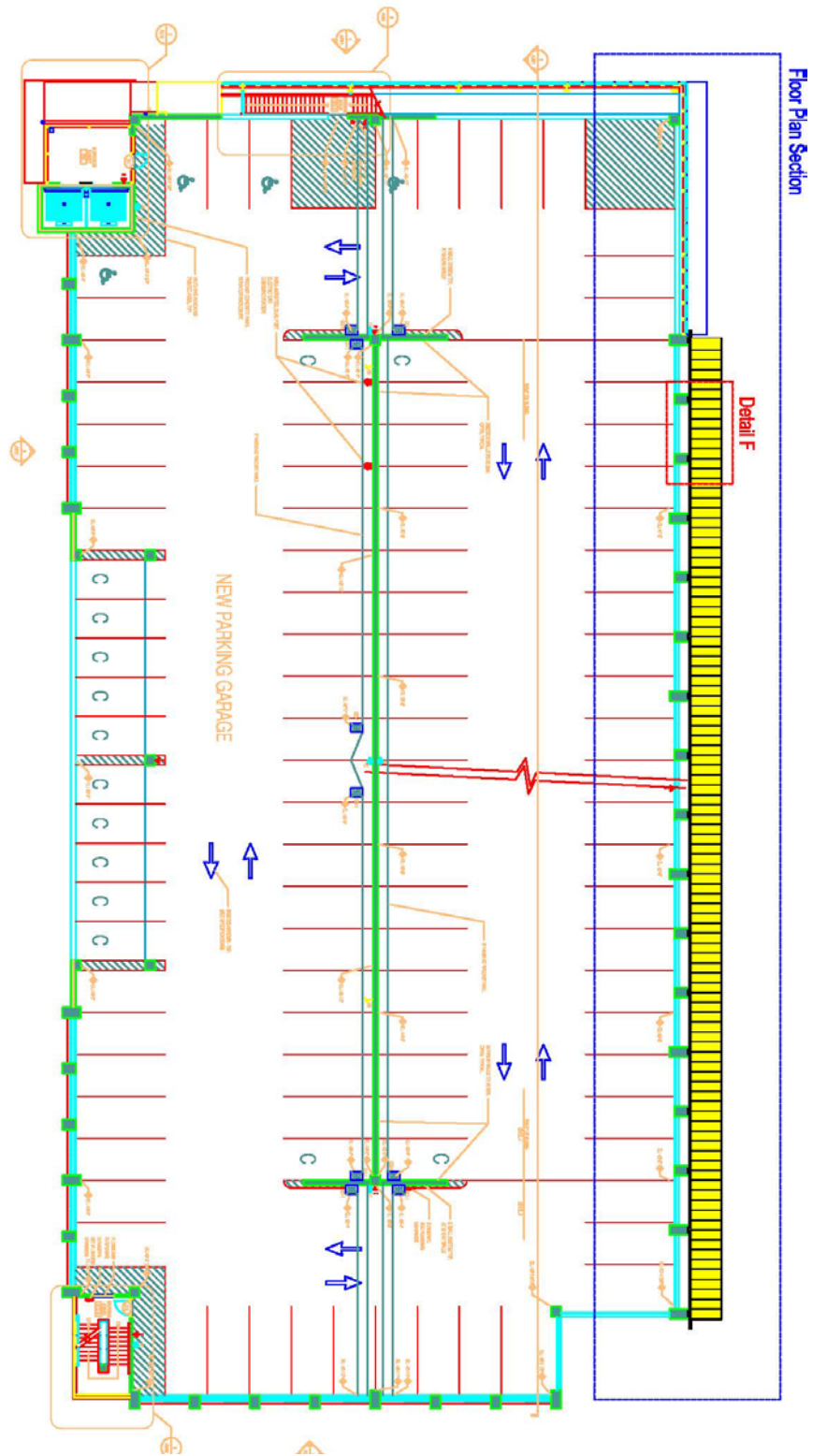
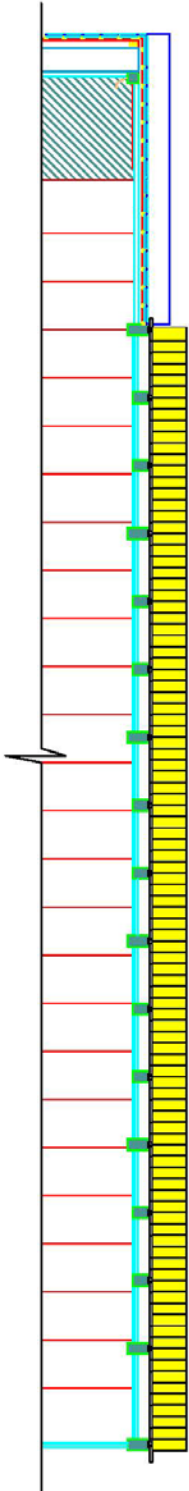


Figure 28 Full Floor Plan- Showing the Pathway

Figure 29 Floor Pan Section Showing the Pathway



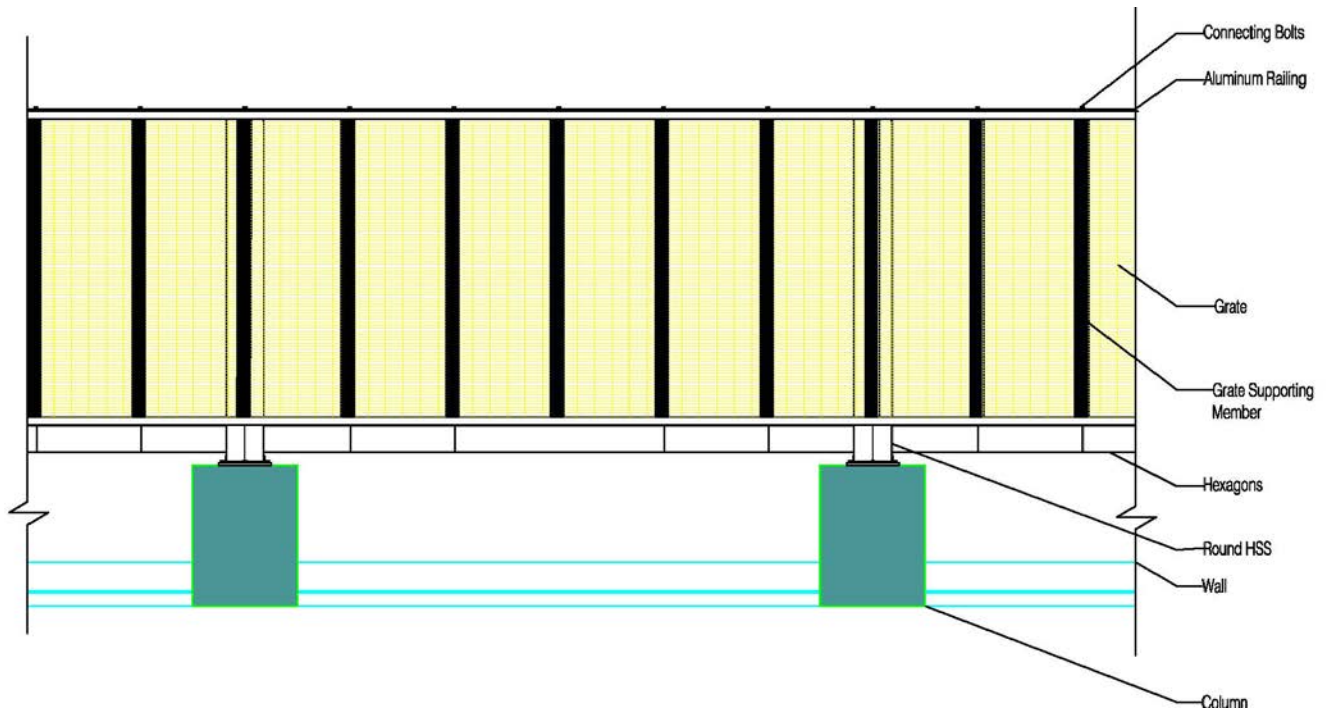


Figure 30 Detail F- Pathway Plan View

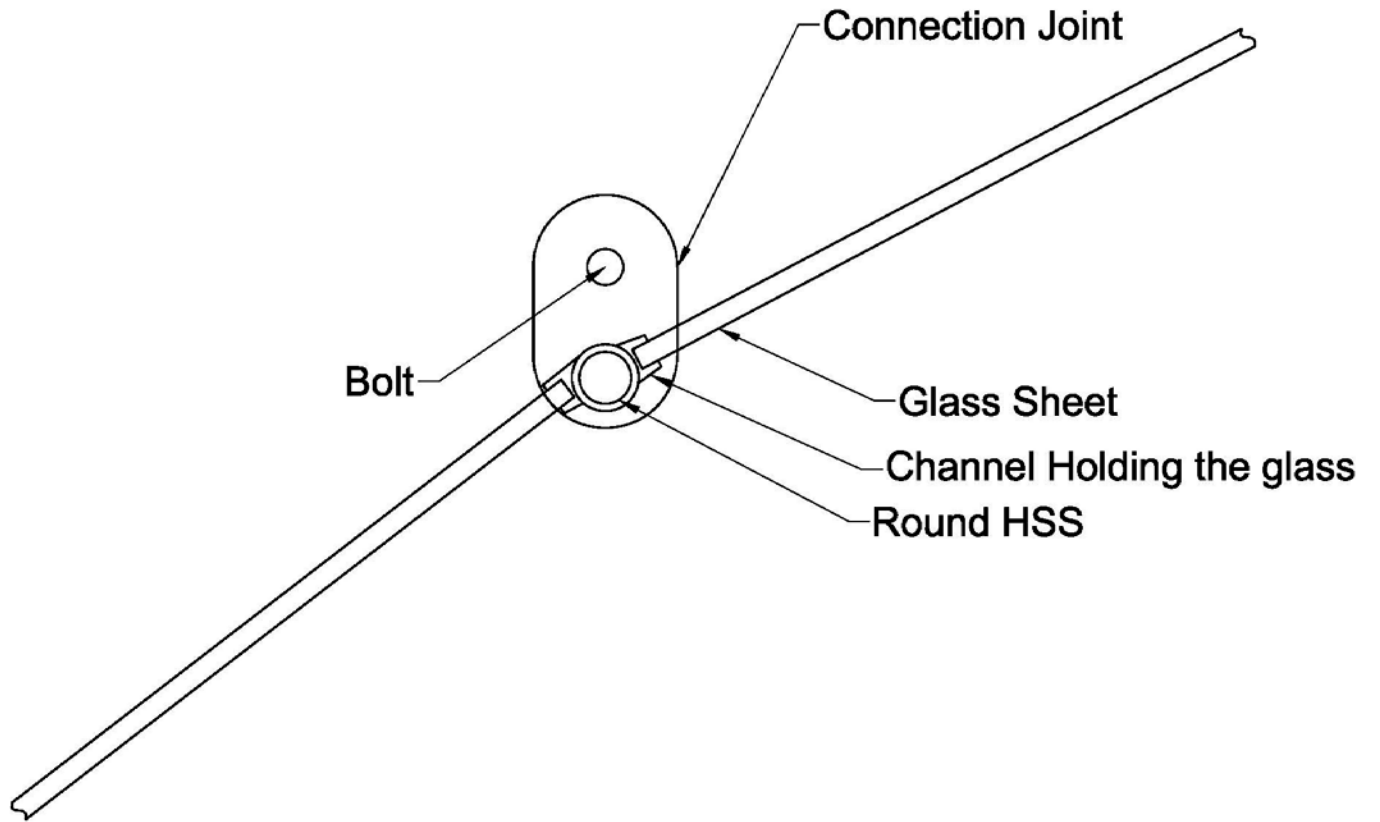


Figure 31 Glass Connection

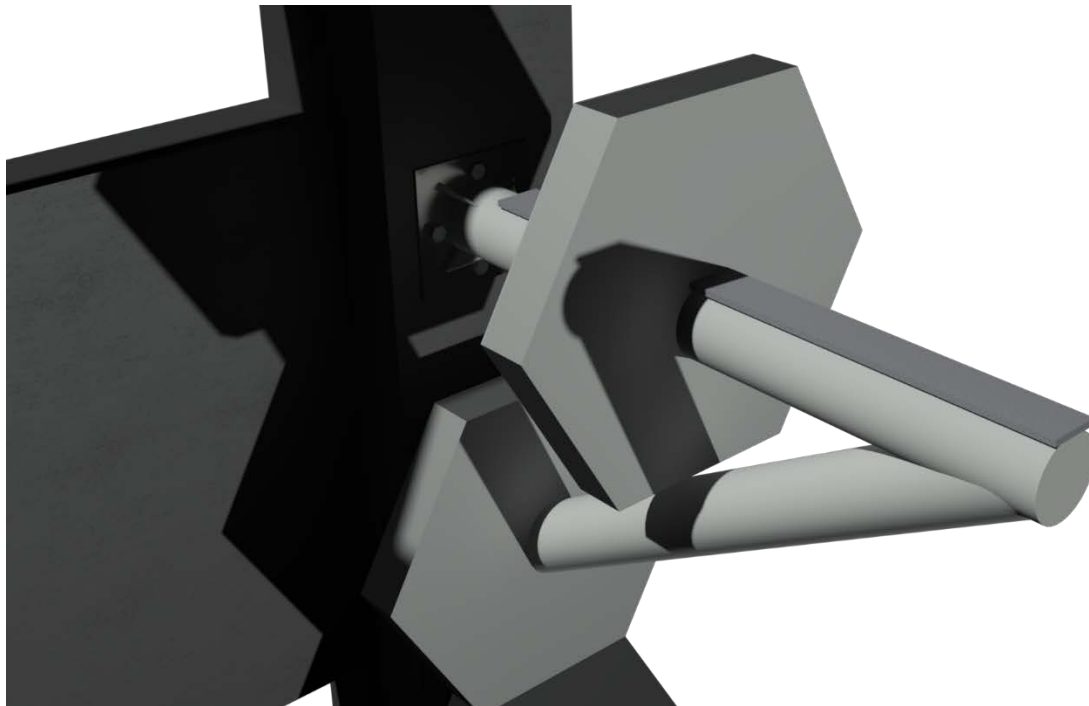


Figure 32 Pathway-Hexagon Connection

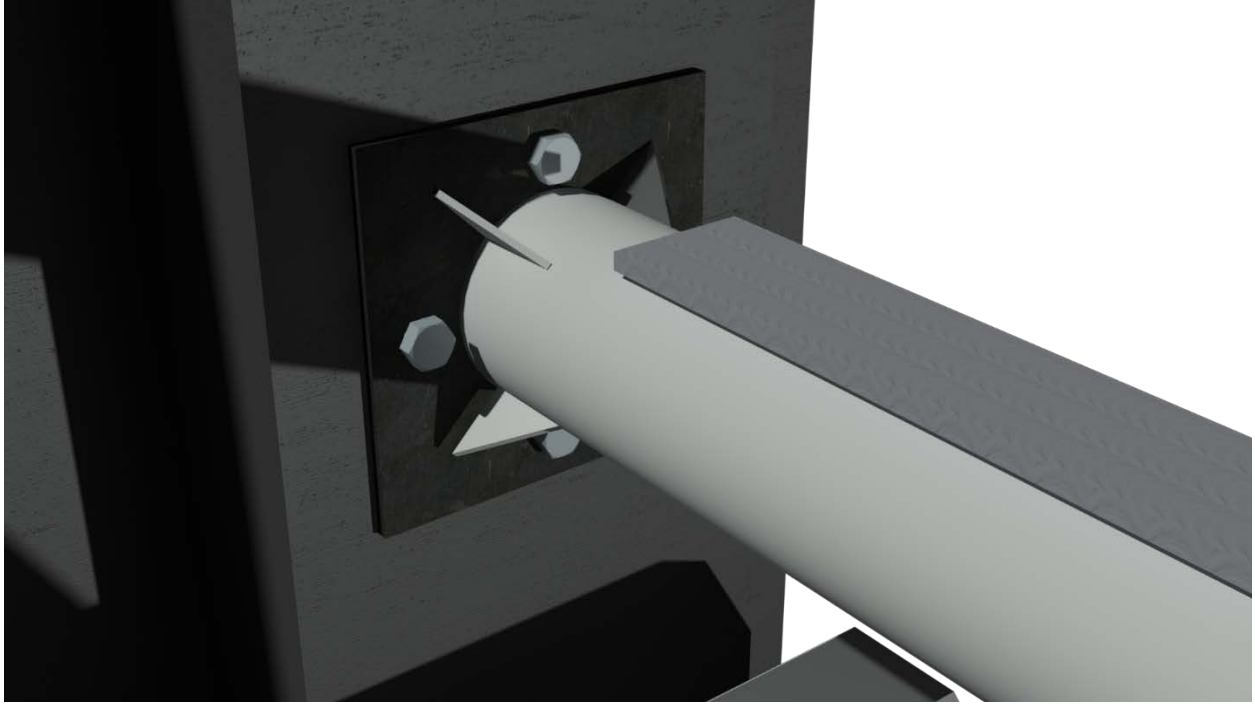


Figure 33 Pathway Joint Connection

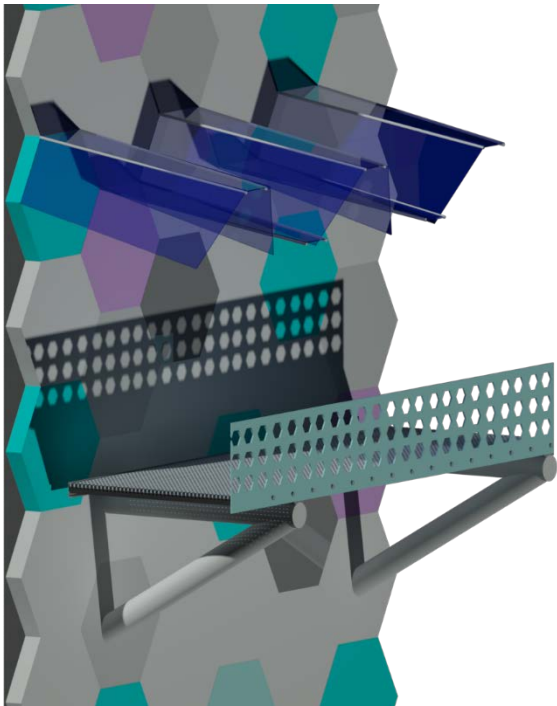


Figure 34 Rendered Wall Section



Figure 35 Grate Connection Close up

Roof Member Connections

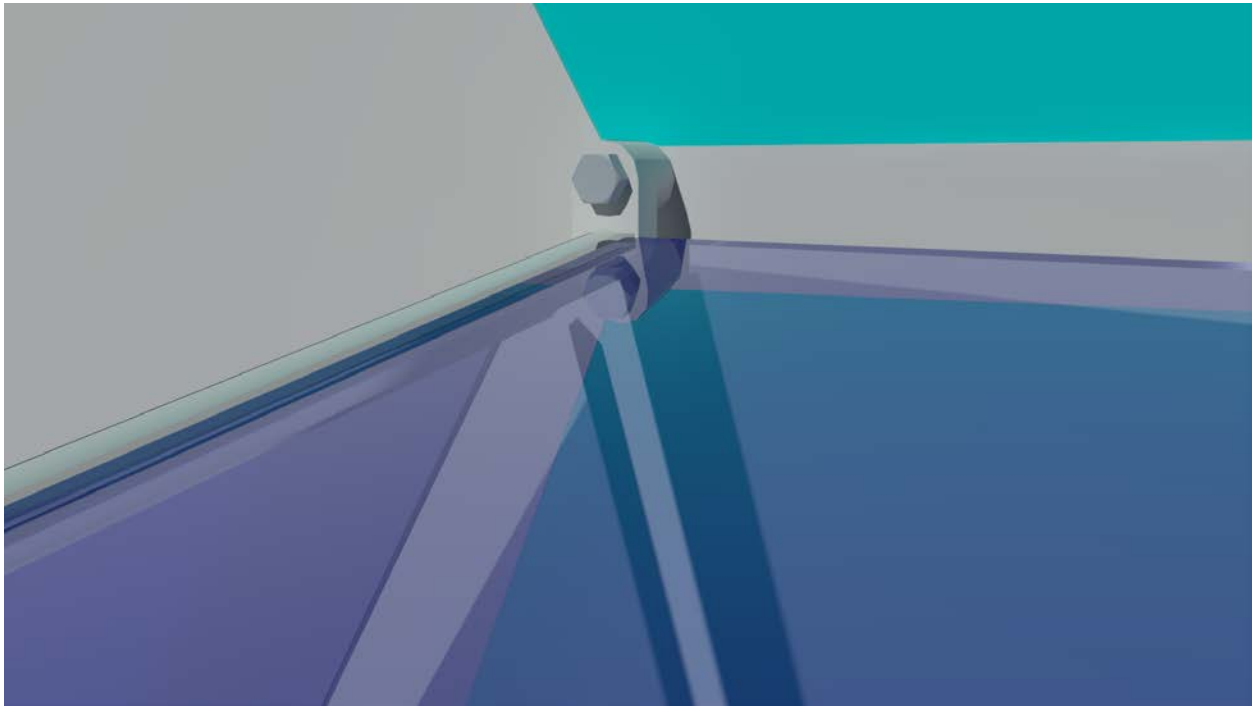


Figure 36 Roof-Hexagon Connection

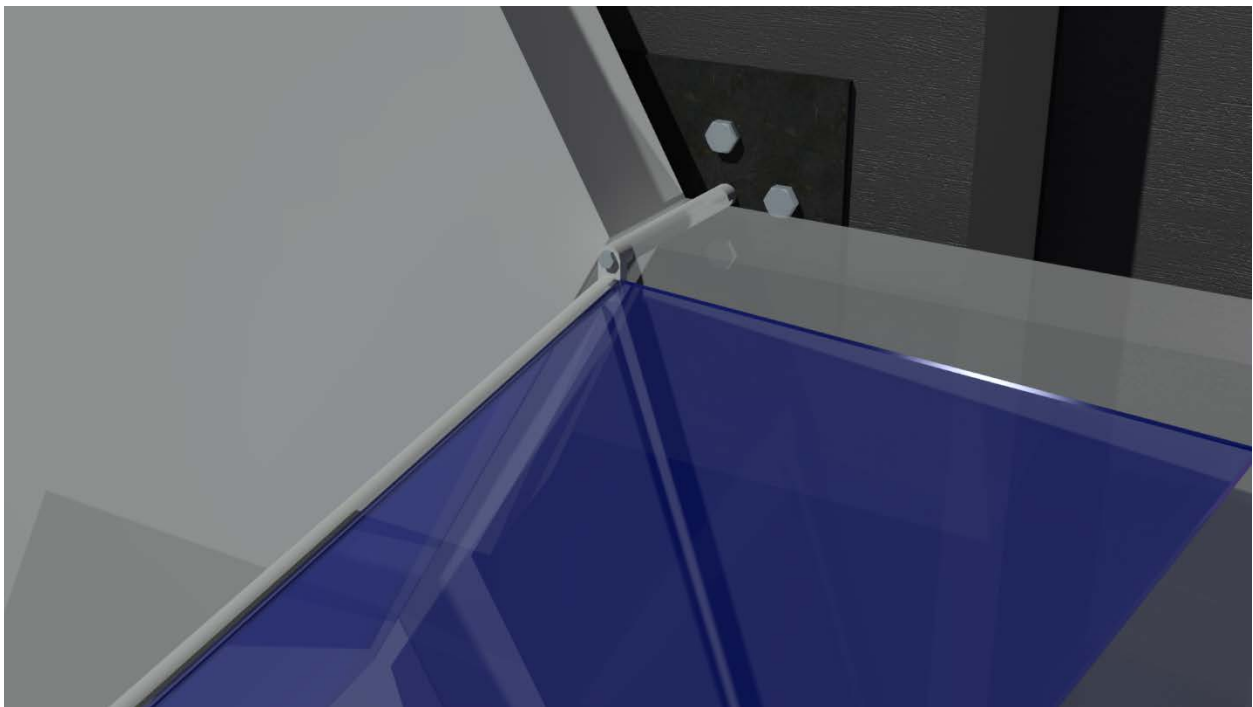


Figure 37 Roof- Hexagon Joint

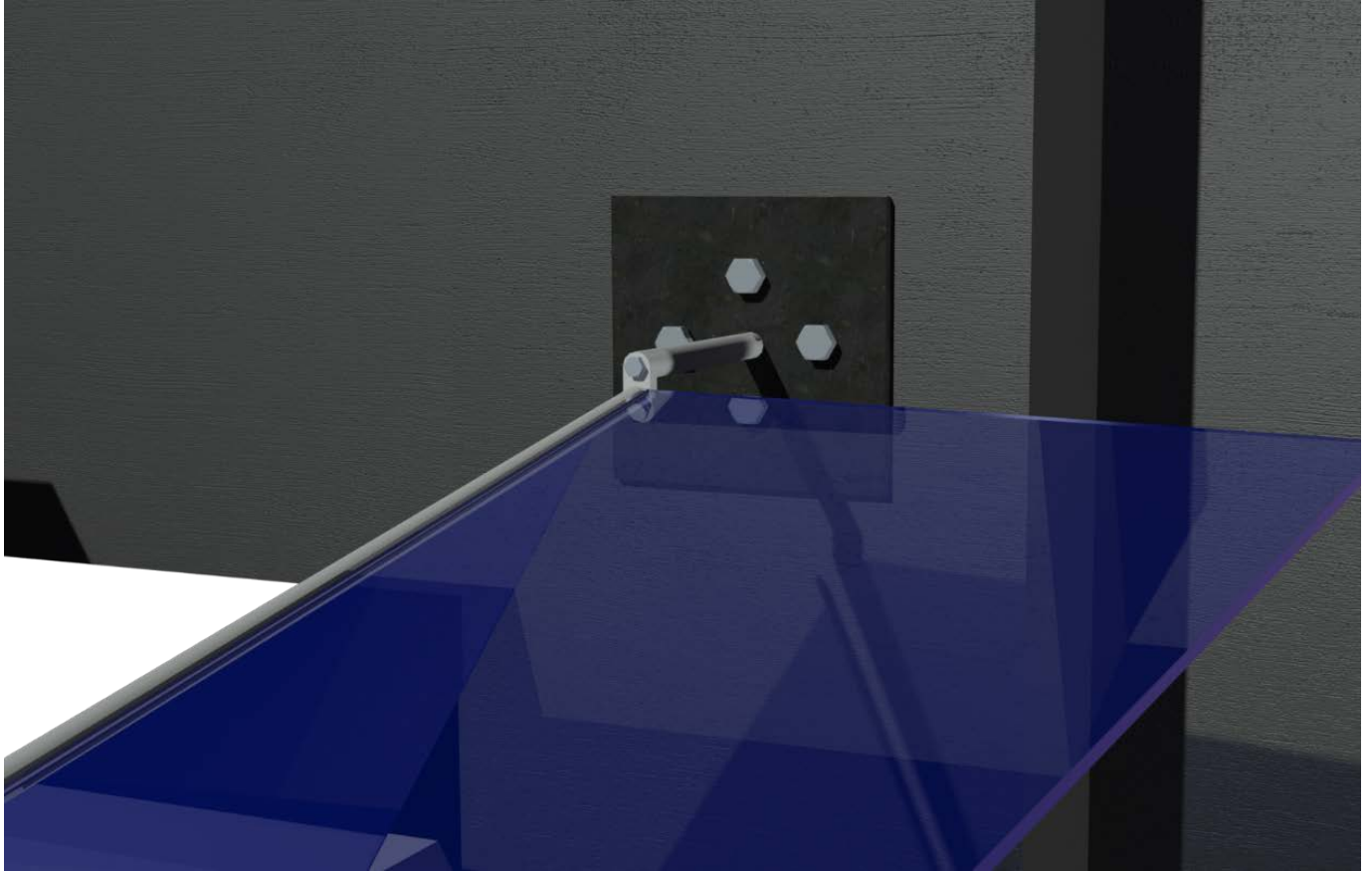


Figure 38 Roof-Column Joint Connection

6. IMPLEMENTATION AND VISUALIZATION

Concrete garages, could be aesthetically very dull and boring especially when the employees have to stare at them from the windows of their offices for at least eight hours a day. The implementation of this façade will not only bring aesthetical benefits to the site of Brookline hospital campus but it will also create an identity to Boston Children’s Hospital. None of the hospitals or other buildings at least in Boston area have a combination of aluminum and greenery. The green wall that will cover part of the North elevation will signify good health by improving the air quality around the site, bring acoustic isolation and potentially award the building some LEED points. It will also boost the workers and people living in the apartments nearby moods in a natural way if their windows face the garage. The new enclosure will be more kids friendly as it will be colorful, interesting and interactive. The LED light strips that will be added to the window opening of the garage will give this structure a cool touch that will grab attentions to everyone passing by during the evening and night. The patients, staff and visitors will be able to walk around this balcony and could get down throw a spiral slide which will serve as a mini-playground for both adults and children.

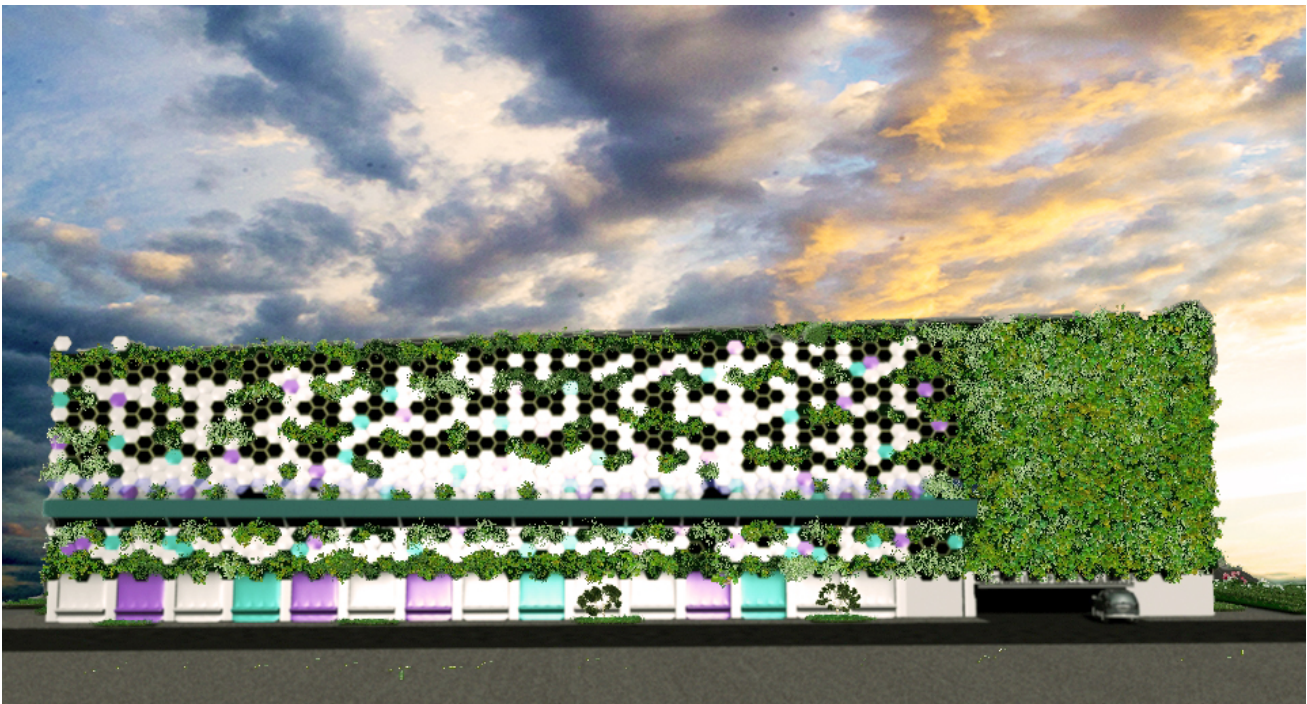


Figure 39 North Elevation

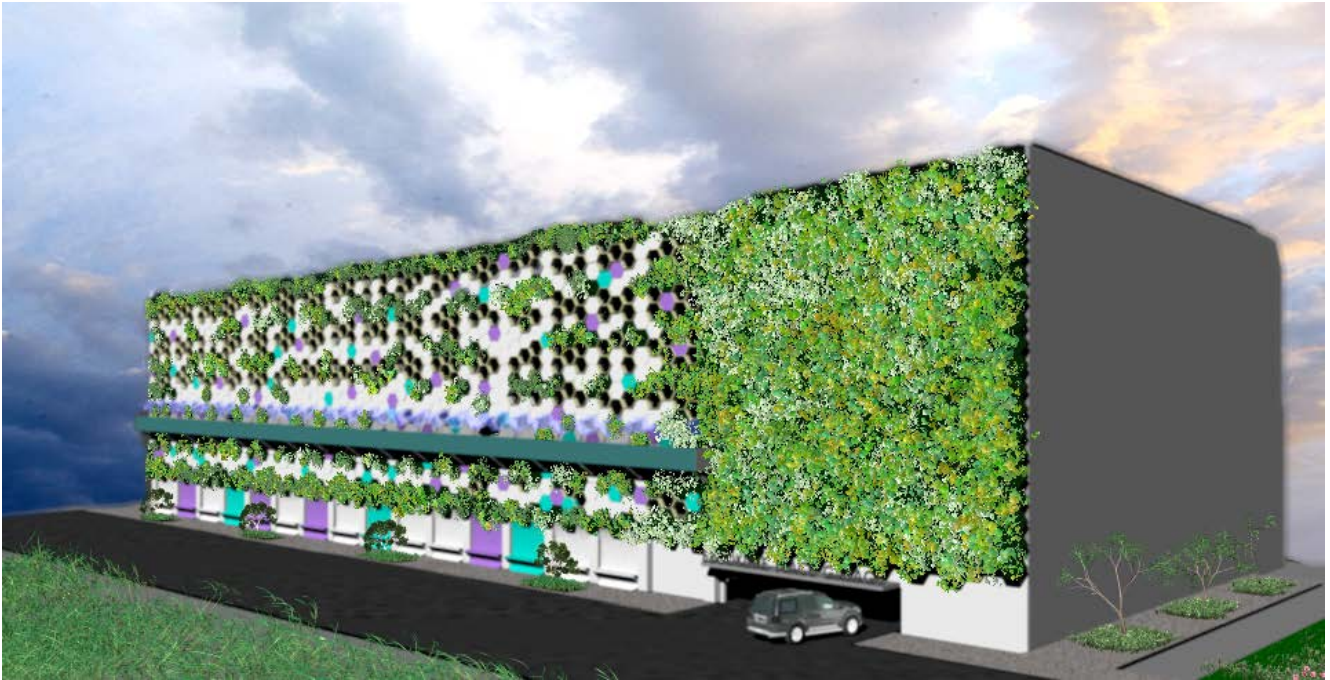


Figure 40 Garage Perspective View



Figure 41 Garage Entrance

7. APPENDIX

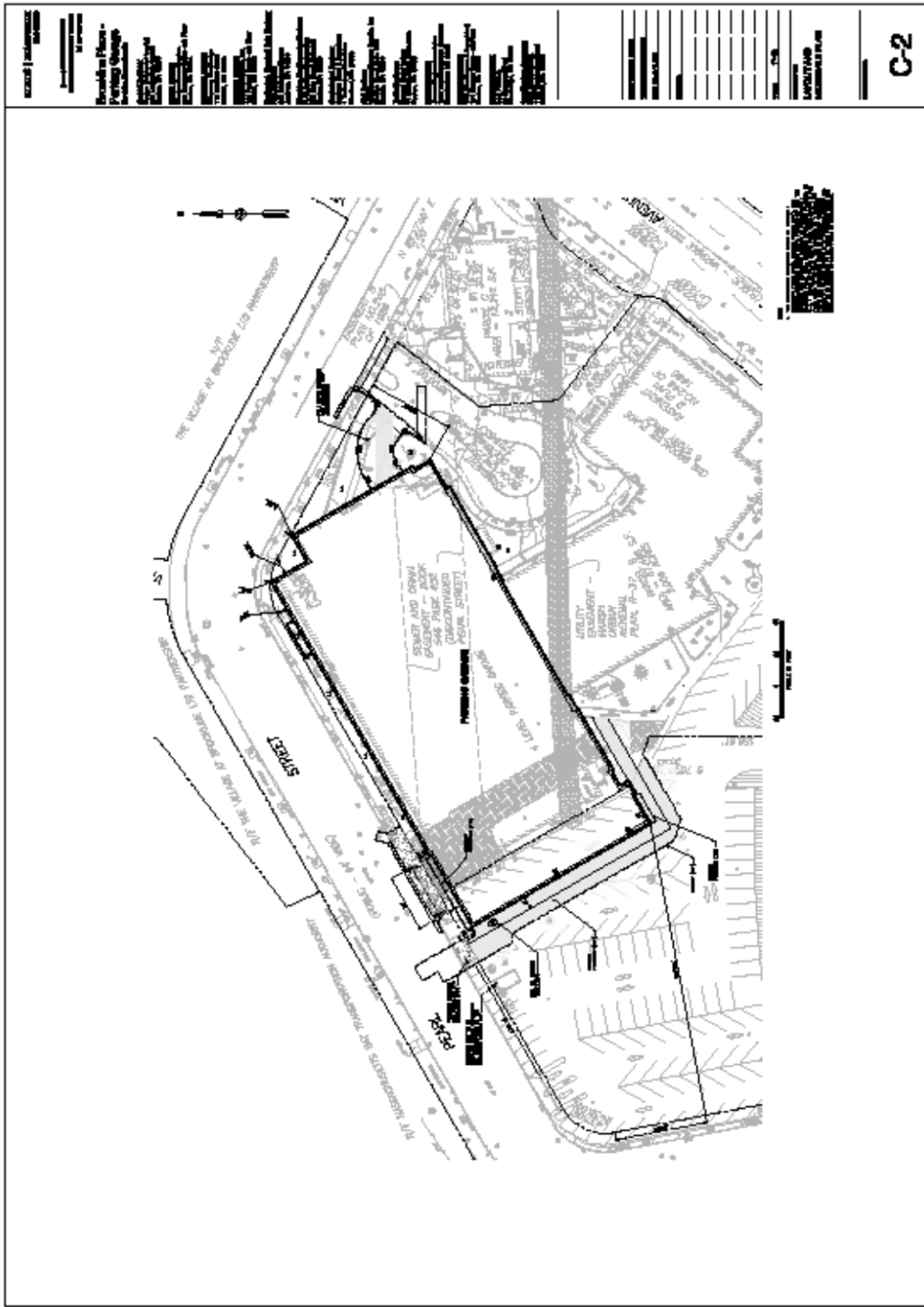
APPENDIX A- STEEL MEMBER PROPERTIES

Shape	Wall Thickness t (in)	Area A(in ²)	D/t	Nominal Weight (lb/ft)	Moment of Inertia I (in ⁴)	Section Modulus S (in ³)	Plastic Modulus Z (in ³)
HSS 8.625x 0.625	0.581	14.7	14.8	53.45	119	27.7	37.7
HSS 2.50x 0.250	0.233	1.66	10.7	6.01	1.08	0.862	1.20
HSS 4x4x1/4	0.233	3.37	14.2	12.21	7.80	3.90	4.69

Shape	Area A (in ²)	Depth D (in)	Web Thickness t _w (in)	Flange width t _f (in)	Axis X-X			
					I (in ⁴)	S (in ³)	r (in)	Z (in ³)
C 5x6.7	1.97	5.00	0.190	1.75	7.48	2.99	1.95	3.55

APPENDIX B- ARCHITECT'S DRAWINGS

Garage Layout Plan



The image displays four architectural section drawings of a parking garage, arranged in a 2x2 grid. Each drawing is accompanied by a numbered callout (1, 2, 3, or 4) and a small floor plan diagram. The drawings show the internal structure, including columns, beams, and parking levels. The title block on the right contains the following information:

BLAU | ZAPFENIX
Architectural
Pflanzstr. 10
40225 Düsseldorf
Tel: +49 (0) 211 3400-100
Fax: +49 (0) 211 3400-101
www.blau-zapfenix.de

Project Name -
Parking Garage
Project Location
Pflanzstr. 10
40225 Düsseldorf

Client
[Redacted]

Architect
Blau | Zapfenix
Pflanzstr. 10
40225 Düsseldorf
Tel: +49 (0) 211 3400-100
Fax: +49 (0) 211 3400-101
www.blau-zapfenix.de

Scale
1:500

SECTION PLACE
[Redacted]

A201

The image displays three vertical architectural section drawings of a building facade, labeled 'Q' at the top and '0' at the bottom. Each drawing shows a different elevation of the building, with various structural elements, windows, and interior spaces visible. The drawings are detailed, showing floor slabs, walls, and structural supports. A human figure is included in the middle drawing to provide a sense of scale. To the right of the drawings is a title block containing project information, a list of materials and finishes, and a table of specifications. The drawing number 'A311' is prominently displayed at the bottom right of the title block.

SECTION | MATERIALS
201201

BRONKHORST PLACE -
Parking Garage
Section 03/2012

PROJECT NO. 12-001
DATE: 03/2012
DRAWN BY: [Name]
CHECKED BY: [Name]
SCALE: 1/8" = 1'-0"

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03.96 - CONCRETE
03.97 - CONCRETE
03.98 - CONCRETE
03.99 - CONCRETE
04.00 - CONCRETE

A311

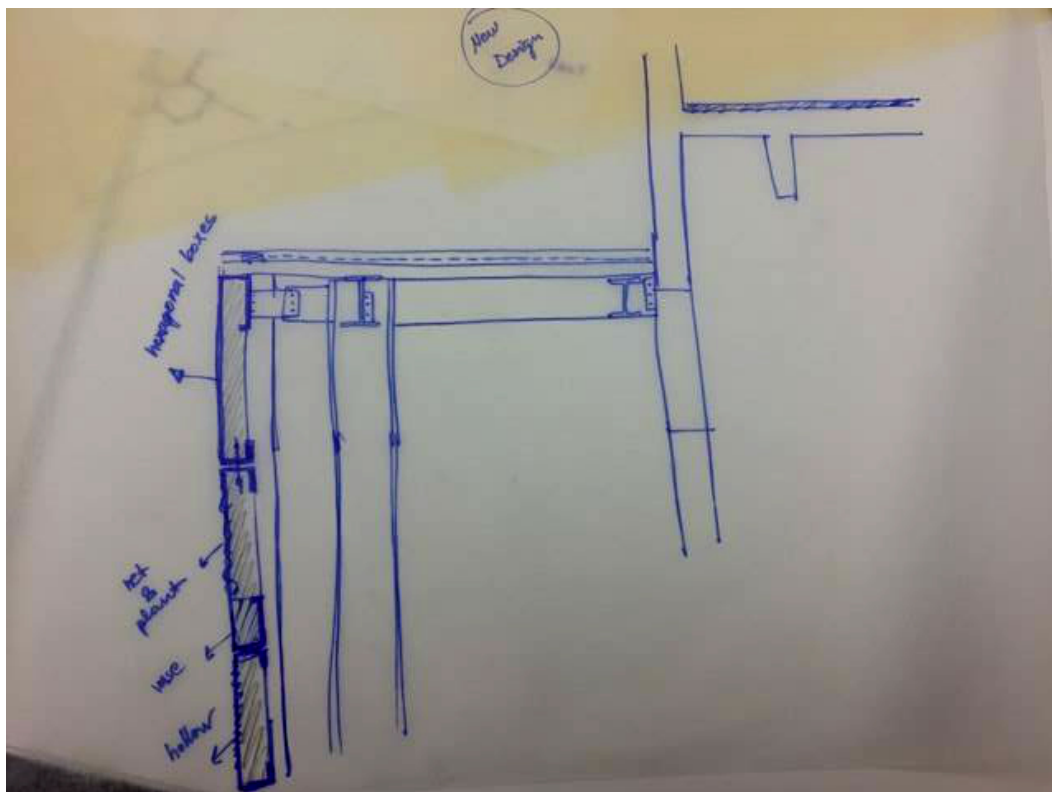
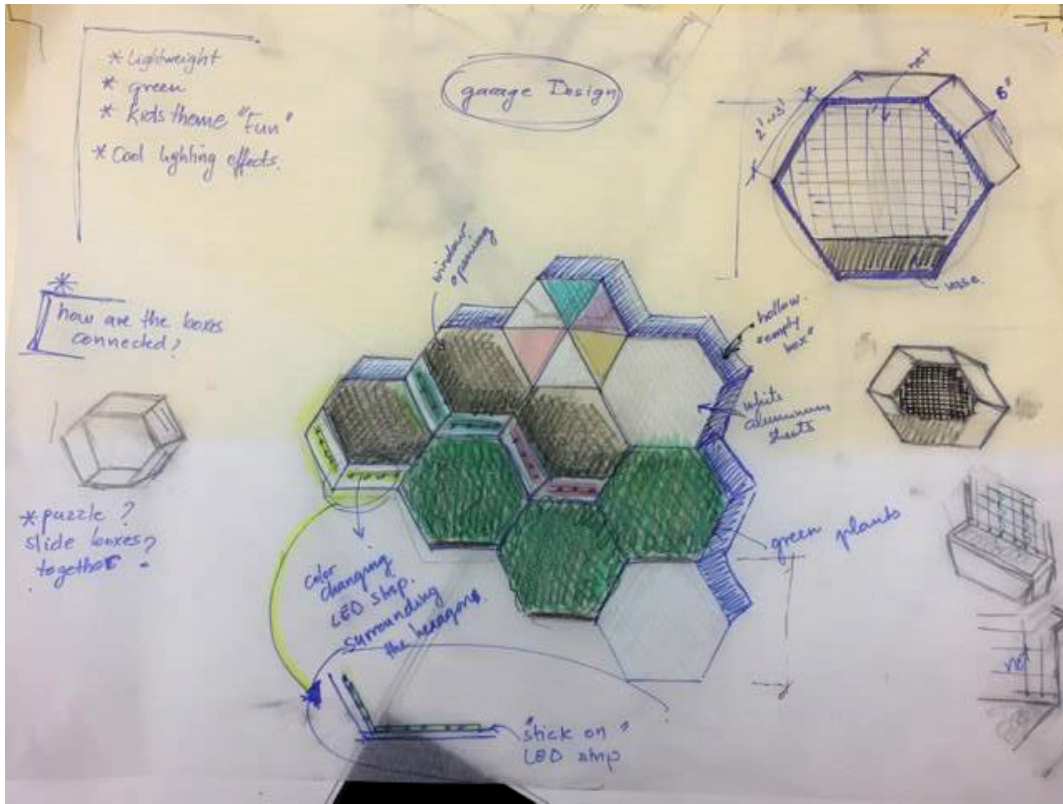
SECTION | MATERIALS
 Actual dimensions
 Architectural scale
 1/4" = 1'-0"

Brooding Place - Feeding Garage
 WALL: EXTERIOR
 WALL: INTERIOR
 WALL: ROOF
 FLOOR: EXTERIOR
 FLOOR: INTERIOR
 ROOF: EXTERIOR
 ROOF: INTERIOR
 TRUSS: EXTERIOR
 TRUSS: INTERIOR
 CEILING: EXTERIOR
 CEILING: INTERIOR
 WALL: ROOF
 FLOOR: EXTERIOR
 FLOOR: INTERIOR
 ROOF: EXTERIOR
 ROOF: INTERIOR
 TRUSS: EXTERIOR
 TRUSS: INTERIOR
 CEILING: EXTERIOR
 CEILING: INTERIOR

SECTION 1
 SECTION 2
 SECTION 3
 SECTION 4

A312

APPENDIX C- SKETCHES



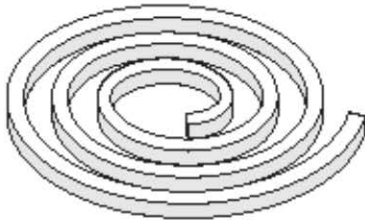
APPENDIX D- LED STRIP CUTSHEET

Acclaim Flex Tube SE RGB

Flex Tube SE RGB is a side emitting, outdoor rated, color changing LED tube. It is available with tri-color RGB LEDs, which cover nearly every possible color combination required. It features an IP68 rating, cut points every 3.28", and a minimum bend radius of 12". Sold in spools of 23' (7m), it is impact, UV, and saltwater resistant.

Flex Tube SE RGB™

ACCLAIM
LIGHTING



Client:

Project:



Type:

Order Code:

Quantity:

Flex Tube SE RGB is a side emitting, outdoor rated, flexible color changing LED tube. It is available with tri-color RGB LEDs, which cover nearly every possible color combination required. It features an IP68 rating, cut points every 3.28', and a minimum bend radius of 12". Sold in spools of 23' (7m), it is impact, UV, and saltwater resistant.

Specifications

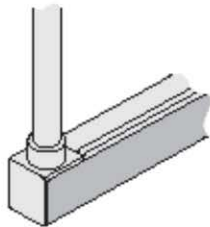
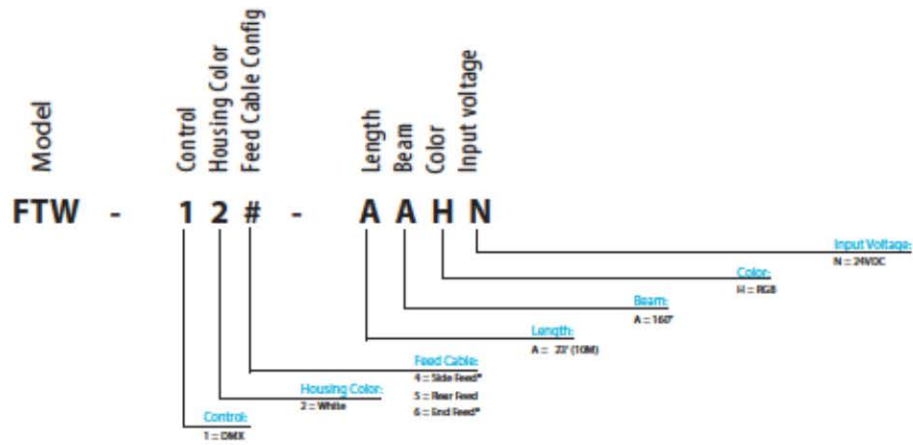
Color	RGB
Spool Length + Cut Points	23' (7m), Cut points every 3.28' (83.3mm)
Beam Angle	160°
Max Fixture Runs	23' (7m) - 1 spool maximum
Photometrics	Photometric testing in progress
Dimming Protocol	via DMX-512, 3 channels per spool / section
Mounting	via Self lock mounting channel
Power Consumption	76W @ 23' (1 Spool), minimum 3.3W per foot
Operating Voltage	24VDC
Lumen Maintenance	L70 @ 50,000 Hours (25° C)
Housing & Finish	White UV stabilized, flexible PVC jacket with silicone top
Installation Temperature	32°F to 113°F (-0°C to 45°C)
Operating Temperature	-40°F to 131°F (-40°C to 55°C)
IP / IK Rating	IP68 - Wet Location / Submersible, IK 08 - Up 5 Joule Impact Energy Protection
Fixture Connectors	10' (3m) Attached injection molded feed cable - rear, side or end feed options (see page 2)
Warranty	3 Years standard, 5 Years optional (additional charge)
Weight	8 lbs (3.62 kg)
Dimensions	W 0.63" x H 0.63" x L 32' (16mm x 16mm x 10m)
Certifications	 

Flex Tube SE RGB™

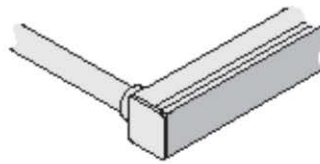


Order Codes

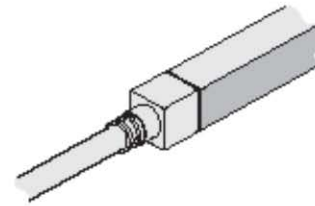
*Indicates Special Order



FTW-124-AAHN, Side Feed



FTW-125-AAHN, Rear Feed



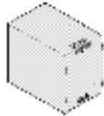
FTW-126-AAHN, End Feed

Flex Tube SE RGB™

ACCLAIM LIGHTING

Related Components

Power Supplies (Use with AL Dimmer 1 Pro)

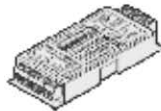


APS-240-24
Two Spools Maximum
240W, 24VDC, Dry location, DIN Rail Mount
115-230VAC (47-63Hz) Input



APS-480-24
4 Spools Maximum
480W, 24VDC, Dry location, DIN Rail Mount
115-230VAC (47-63Hz) Input

DMX Drivers



DPW-311-JBAT
AL Dimmer 3 Pro, 1 Spool Max.
Three channel DMX driver
Use in conjunction with APS Series



ALD-400-24
AL Driver 400 24V, 3 spools max
400W 24V power supply + DMX,
0-10V (source) & DALI driver
6 output ports, 100-277VAC input



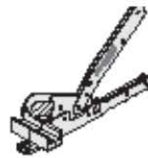
ALD-800-24
AL Driver 800 24V, 8 spools max
800W 24V power supply + DMX,
0-10V (source) & DALI driver
10 output ports, 100-277VAC input

Accessories

*Please note that there are no feed cables for this product. Cut sections cannot be re-used.



FTSEEC
Flex Tube SE end cap



FTTK2
Flex Tube Install Kit
Includes cutter and insert assists

Self Lock Mounting Channels



FTSEL1M
Flex Tube SE self lock mounting channel
3.28' (1m)



FTSEL5CM
Flex Tube SE self lock mounting channel
2' (5cm)