Civicus Engineering

Structural Division

Pedestrian Bridge for Cal Poly Pomona Design Report

Project No. 120817

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Prepared For:
Cal Poly Pomona
Professor Giuseppe Lomiento

CE 421-01

December 8, 2017

Progress Letter

Subject: Preliminary Design Report December 8, 2017

Dear Professor Lomiento,

Civicus Engineering has been contracted by Cal Poly Pomona on October 11, 2017. We have completed preliminary analysis of the site and design of the bridge. We have made corrections and have added CAD drawings to supplement the design.

This report consists of a design brief of the client, project information, site analysis, preliminary design of the bridge, and materials, and drawings for the bridge. We hope you find this report satisfactory.

We at Civicus Engineering appreciate the opportunity in providing our services for this project. It was a pleasure working with you. If you have any questions about the report or would like to request any services in the future, please feel free to contact us.

Sincerely,
Civicus Engineering
https://civicusengineering.github.io/

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Table of Contents

List of Figures

List of Figures

1.0 Design Brief

Client Overview
Client: California State Polytechnic University, Pomona (CPP)
- A public University that was established in 1938
- As of 2015, the university has over 23,000 students
- Learn by doing philosophy incorporated in educational system
- Pride in having a diverse metropolitan area while retaining its vegetative/natural landscape.

Client Representative: Dr. Giuseppe Lomiento

Problem
An excess of pedestrian traffic to and from the CPP Library to Bronco Student Center (BSC).

Cal Poly Pomona students have complained about the excessive pedestrian congestion out of the library main library entrance. Cal Poly Pomona has suggested a bridge as a solution.

Constraints

1. Use a design that is least disruptive to the environment in order to preserve the existing vegetation and landscape.
2. Retain the open space as much as possible at the project site.

Although constraints were presented, if the bridge design requires environmental disruption, minimal disruption is requested.

Needs
1. Bridge connecting 2nd Floor of BSC to 2nd Floor of CPP Library.
2. Bridge will provide the fastest route.

Risks
1. Open space/viewing obstruction at site.
2. Environmental Disruption – trees may be cut down.

Benefits
1. Another option for ingress/egress.
2. Faster travel.
3. Alleviate traffic congestion.

2.0 Introduction

2.1 Project Overview

Cal State Polytechnic University, Pomona (CPP) has received numerous complaints regarding pedestrian traffic congestion at the main Cal Poly Pomona Library entrance. Civicus Engineering and Cal Poly Pomona are working closely to formulate a suitable solution for this problem. CPP has requested for a new bridge to be built between the Bronco Student Center (BSC) and the library to ease overcrowding. A primary solution and an alternative solution have been formulated to satisfy project requirements. Representing the client is Professor Lomiento, who will be overseeing the design throughout the duration of the project.

2.2 Project Location

The project site is located on campus of Cal Poly Pomona of Pomona, California at Lat: 34.056857° Long: -117.821083°.

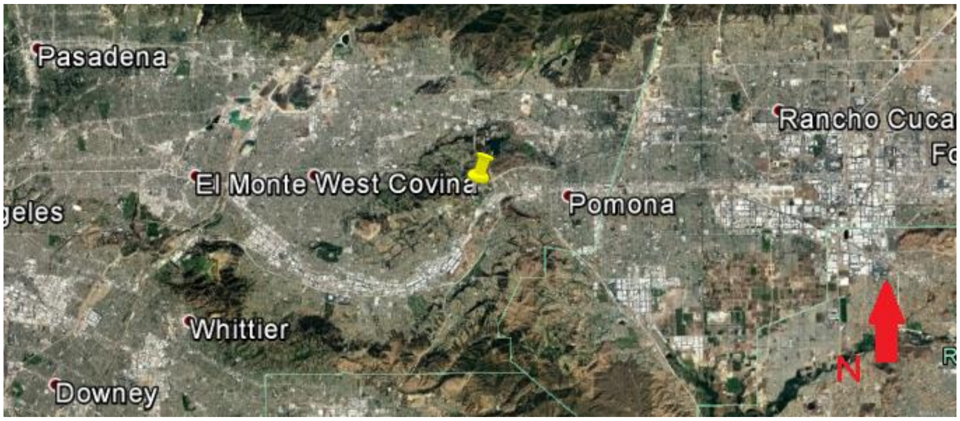


Figure 2-1. Project Site Location Overview.

Figure 2-2. Project Site Location plan view.

2.3 Project Purpose

The purpose of this project is to design a pedestrian bridge that connects the 2nd floor of the BSC with the 2nd floor of the Library.

The primary objective is to implement a modern, innovative, and functional design the that preserves the natural landscape with minimal disruption.

2.4 Project Scope

This report contains the design and analysis of the pedestrian bridge. Currently completed contracted work includes preliminary design and site analysis. Upon client approval of the preliminary design report, the analysis of the bridge and CAD sketches will be included.

3.0 Site Background

3.1 Existing Conditions

<u>3.1.1 Project Site</u>

The project site is located on 3801 W Temple Ave, Pomona, CA 91768. The proposed project site is a developed area. The site is enveloped by buildings with natural foliage.

In the northern section of the site there is a Starbucks and adjacent to that on the North-East Portion is the Main library entrance. There are also some utilities located in Western portion of the project area.

Figure 3-1. Current Conditions of the Site. *Taken from CPP 360 Panorama.*

3.1.2 Cal Poly Pomona Library

The client has requested to have the bridge connect on the 2nd floor of the library. Below are the current conditions of proposed location of the bridge entrance at the library. Red rectangle indicates location of bridge entrance and exit.

Figure 3-2. CPP Library Second Floor Map.

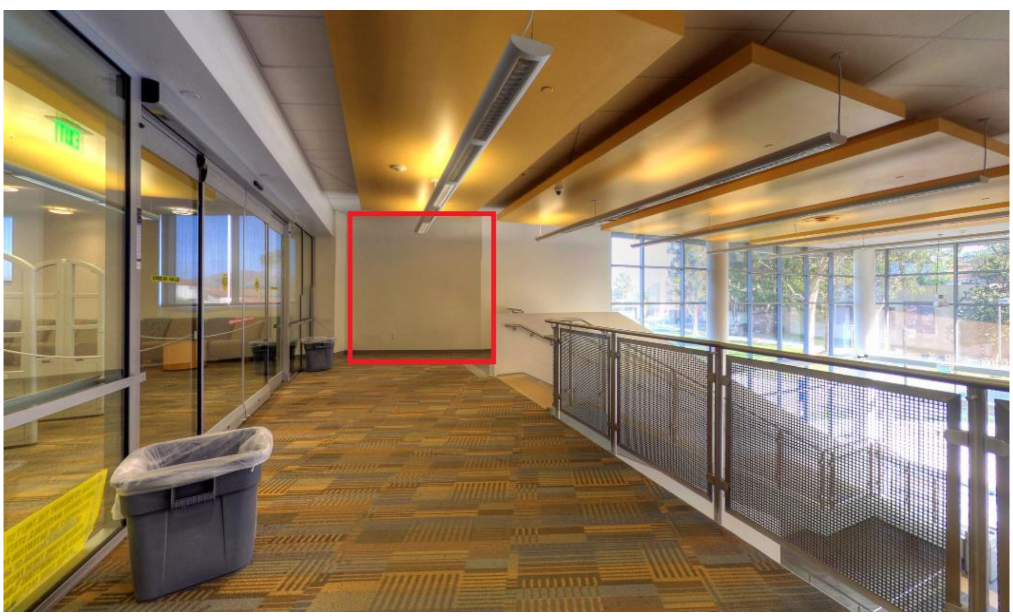


Figure 3-3. Proposed Location of Bridge Entrance.

3.1.3 Bronco Student Center

The client has requested to have the bridge connect on the 2nd floor of the BSC. Below are the current conditions of proposed location of the bridge entrance at the BSC. Red rectangle indicates location of bridge entrance and exit.

For this entrance, there are two choices. The first choice, 1, the ASI Marketing Room 2002 can be minimized to make room for a bigger hallway for the bridge entrance/exit. Or, the room can be moved to the empty meeting room at 2.

***Client approval is needed for this portion of the design.**

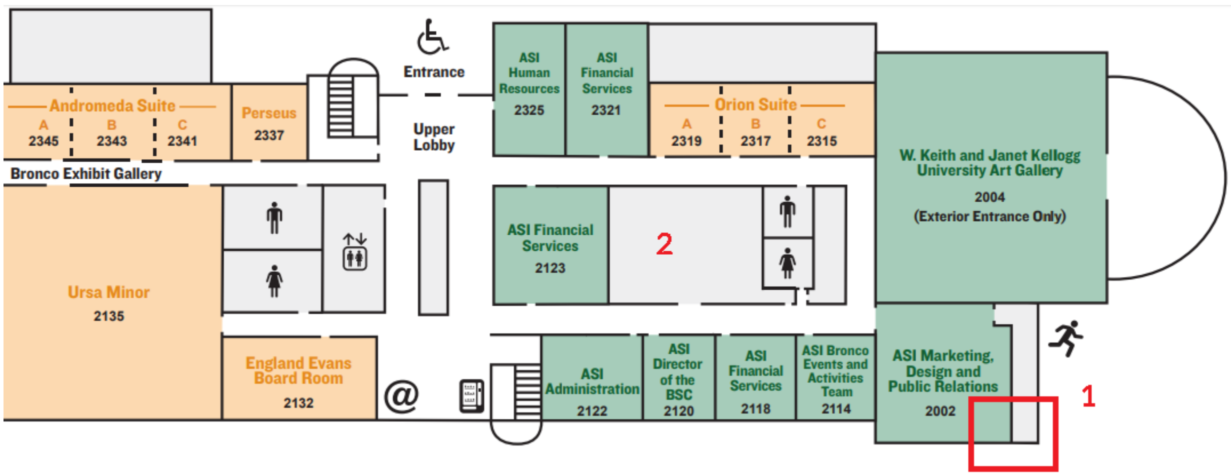


Figure 3-4. Partial Floor Map of BSC.

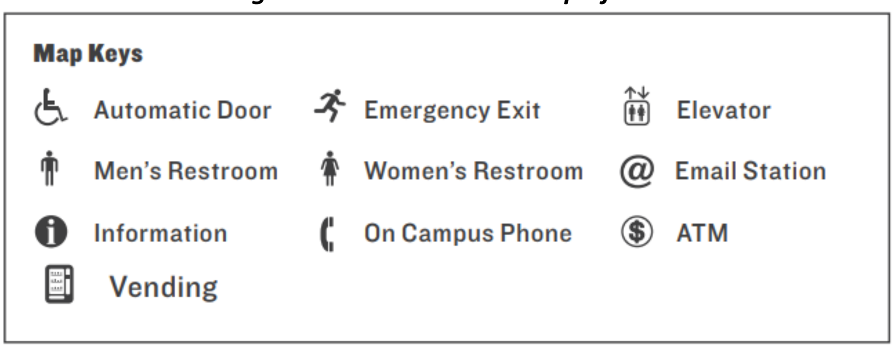


Figure 3-5. BSC Map Key.

3.2 Land Use

The area is used for recreational and special events. There are often booths/tents that are set up in the area. These events cause an influx of people to gather in the area. With such events, people may gather on the bridge to gain a better view. This must be considered for bridge design.

4.0 Preliminary Bridge Designs

4.1 Design A

Design A has been created based off the client parameters outlined in the design brief and in earlier sections. Cast in place reinforced concrete will be utilized for the bridge.

4.1.1 Columns

There will be seven columns that will hold the bridge. The columns were specifically placed to best mitigate the need for trees to be cut down (Fig 4-1). There are trees near columns A-F. Trees near columns B and E may need to be cut down. However, there are two trees near columns C and D which may or may not need to be cut. The placement of C and D may allow the bridge to circumvent the trees. Column F was originally placed near the library but there is a sewer pipe where the utility mark is located. Thus, column F will need to be placed a bit further than originally intended, which will increase the length and cost of the bridge.

Columns will be circular with a diameter approximately 2ft.

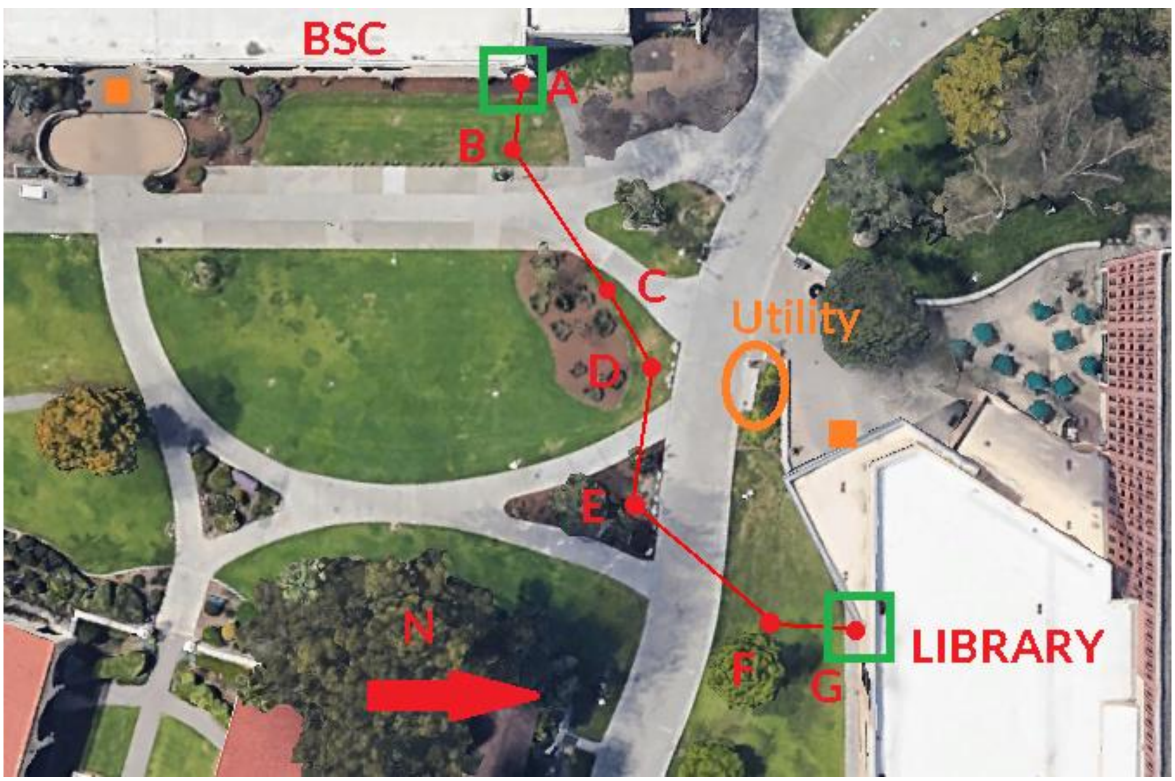


Figure 4-1. Bridge Design and Layout for Design A.

4.1.2 Deck

The width of the bridge shall be 10 ft. The bridge must be wide enough to allow inflow and outflow of people between the two structures.

The length of the bridge will approximately be 275 ft.

4.1.3 Clearance

The bridge shall have a minimum vertical distance of 14 ft. According to Google Earth, the elevation of the BSC entrance is 722 ft above sea level (ASL). The elevation for the library entrance is 730 ft ASL. The 2nd floor elevation of the library is about 745 ft ASL, providing a 15ft difference between the floors. The elevation of the roads beneath the bridge are between 725-727 ft. Ideally, the endpoints of the bridge should be at elevation 745 ft. At columns A and E, the bridge should have a slope inclination, allowing span A-E to be higher than elevation 745 ft. This should give more vertical clearance for vehicles passing under the bridge such as fire trucks, ambulance, garbage trucks, etc.

4.2 Design B

Design B exhibits three sets of columns. This implements larger spans between columns that will allow open space for vehicular activity and limit the obstruction of the view. Additionally, it is a span that is slightly angled in order for the trees to remain in their existing locations. Perhaps slight trimming of the tree branches will be required.

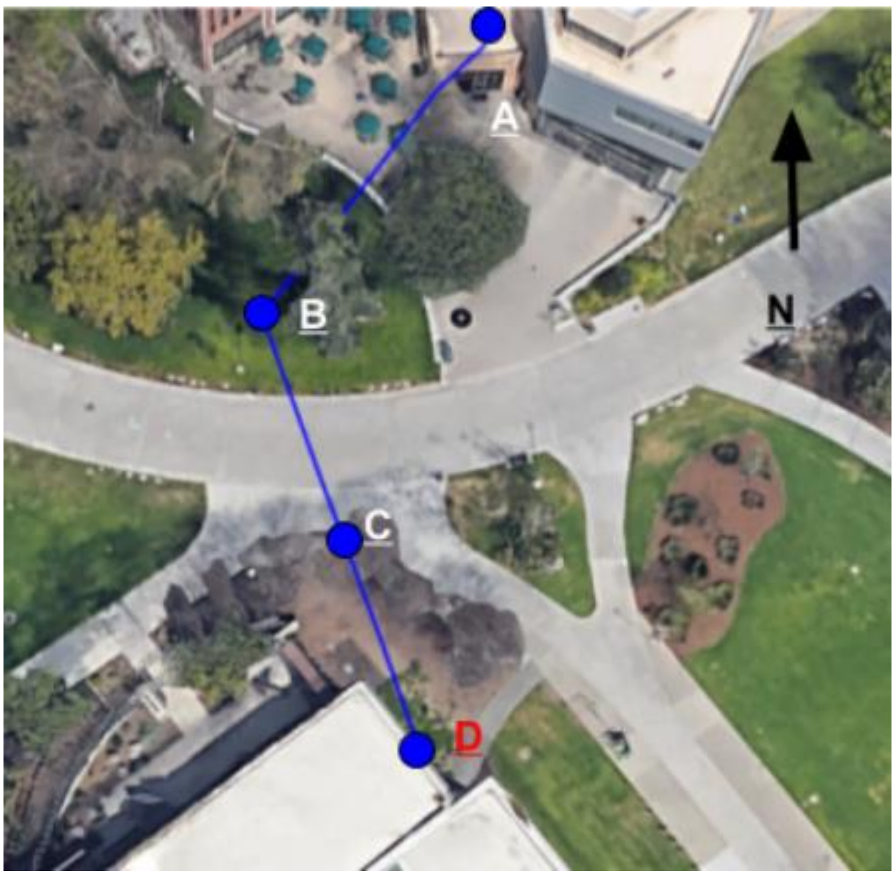


Figure 4-2. Bridge Design and Layout for Design B.

Part of the ASI Marketing Room 2002 will be annexed and used as a hallway to meet with the existing corridor located on the second floor of the Bronco Student Center.

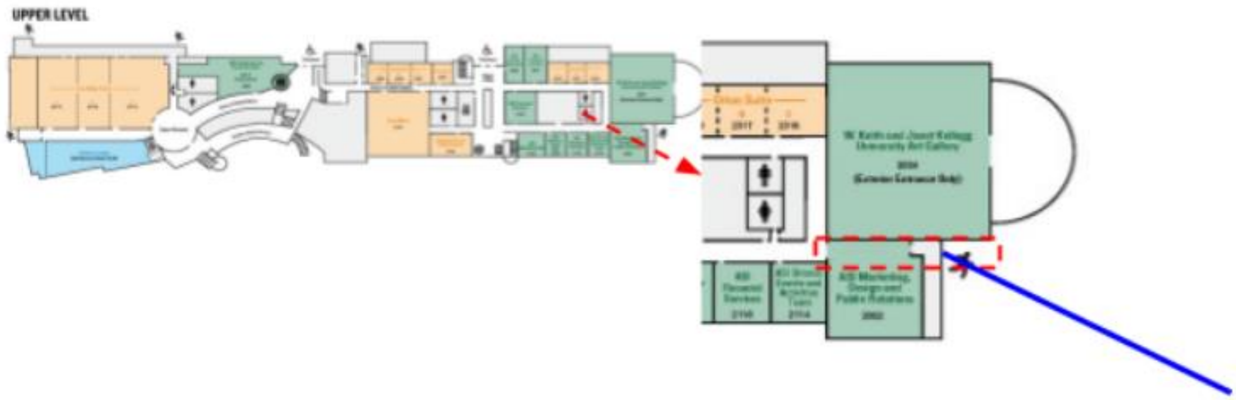


Figure 4-3. Bronco Student Center Layout for Design B.

<u>4.2.1 Columns</u>

Locations A through C shown in Figure 4-2 indicate where sets of circular columns will be located. The column diameters will be 2 feet. Therefore, there will be 4 columns in total. This is due to the fact that the approximate distance between columns A-B and B-C will be 100 feet.

<u>4.2.2 Deck</u>

The width of the bridge will be 11 ft with a deck length of 270 ft.

<u>4.2.3 Clearance</u>

The bridge shall have a minimum vertical distance of 14ft. According to Google Earth, the elevation of the BSC entrance is 722 ft above sea level (ASL). The elevation for the library entrance is 730 ft ASL. The 2nd floor elevation of the library is about 745 ft ASL, providing a 15ft difference between the floors. The elevation of the roads beneath the bridge are between 725-727 ft. Ideally, the endpoints of the bridge should be at elevation 745 ft to maintain the vertical clearance. At columns A and C, the bridge should have a slope inclination, allowing span A-E to be higher than elevation 745 ft. This should give more vertical clearance for vehicles passing under the bridge.

4.3 Preferred Solution

Based on the preliminary site assessments and client needs, <u>Design A</u> is the optimal option for the pedestrian bridge. This conclusion is due to the design's efficient use of the land and decreased span lengths. Additionally, having spans that are in closer proximity to one another will allow individual column loads to be lessened. Having a decreased load to support will enable the bridge deck to be slimmer.

5.0 Primary Design A

5.1 Deck

The deck will be 10 ft in width with a slab thickness of 4 inches (one way slab). The length of the bridge is approximately 275 ft. The bridge is comprised of six 2 – end continuous spans. Table 1 outlines the span lengths of the bridge.

Table 5-1. Bridge Span Lengths.

Span	Length (ft)
AB	30
BC	60
CD	35
DE	50
EF	70
FG	30

5.2 Beam Cap

A beam cap will be placed on top of the column to support the deck. The beam cap will be 2 ft in height, 3 ft in width, and 11 ft in length. There will be lateral supports at the ends of the beam cap (see drawing in Appendix A – sheet 7 of 8).

5.3 Columns

The lowest surface elevation of the bridge is 727 ft ASL. The highest surface elevation of the bridge is 730 ft ASL. Since the bridge will start at 745 ft ASL, the bridge provides a minimum vertical clearance of 15 ft and the maximum vertical clearance of 18 ft. At any point below the bridge, the minimum vertical clearance requirement is satisfied.

Because of this, 727 ft will be designated as the grade level. Columns will be 18 ft. (see drawing in Appendix A – sheet 8 of 8).

5.4 Load Path

Loads are applied to the slab as area loads, which transfers them to the beams as line loads. Beams transfer loads to the cap beams as point loads. Cap beams transfer loads to the columns, which finally transfer them to the footings.

5.5 Finishing

5.5.1 Parapet

There will be metal fencing used as a parapet. It will be 42 inches in height.

5.5.2 Flooring

For the deck, the material will be treated douglas fir.

5.5.3 Material Properties

The bridge will be cast in place. Since the bridge is comprised of concrete and steel, the materials are as follows:
Concrete: Normal Weight, f'_c = 4000 psi
Steel: Gr 60 Steel, f_y = 60,000 psi

6.0 Superimposed Loads

Table 6-1. ASCE 7-10 Loads.

Load Case	Uniform psf	**Description**
		Dead Loads
Floor Decking	40 psf	Superimposed Dead Load existing after concrete deck hardening. -Fiber Span pedestrian bridge deck accounts for 4-10 psf -other materials used in deck will account for remainder NOTE: “Balconies and decks: 1.5 times the live load for the occupancy served. Not required to exceed 100 psf (4.79 kN/m2)”
Guardrail	50 psf	“GUARDRAIL SYSTEM: A system of components, including anchorages and attachments to the structural system, near open sides of an elevated surface for the purpose of minimizing the possibility of a fall from the elevated surface by people, equipment, or material.” (ASCE 7-10 4.5.1 p.14)
Parapet	50 psf	Superimposed Dead Load existing after concrete deck hardening.
		Live Loads
Pedestrians	100 psf	Students Crossing Bridge

7.0 Slab Design

7.1 Slab Structural Analysis

The reinforced concrete slab with a 5 ft tributary area is supported by two circular 2 ft diameter columns. Figure 7-1 shows the loads applied to the slab whose section properties are thickness-4 inches and a length of 12 inches. The Dead loads associated with the slab include the self weight, Parapets and guardrail at the edges of the walkway at 100 psf and 40 psf for the decking finish. Figure 7-2 shows the same slab with the presence of live load due to pedestrians.

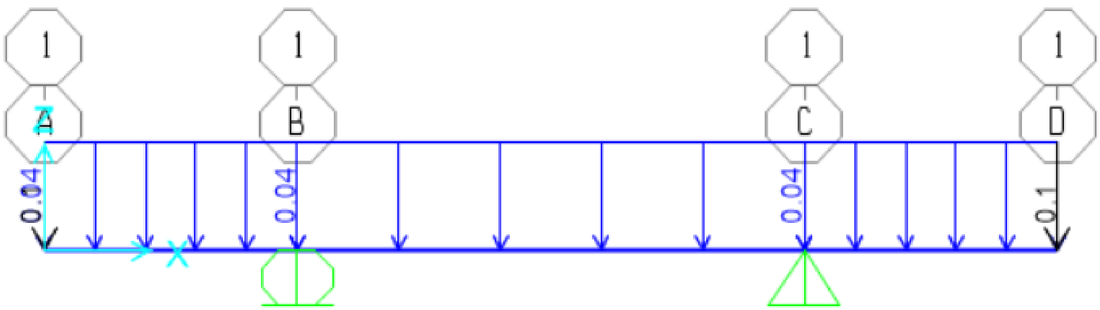


Figure 7-1 Dead Loads on Slab Using SAP.

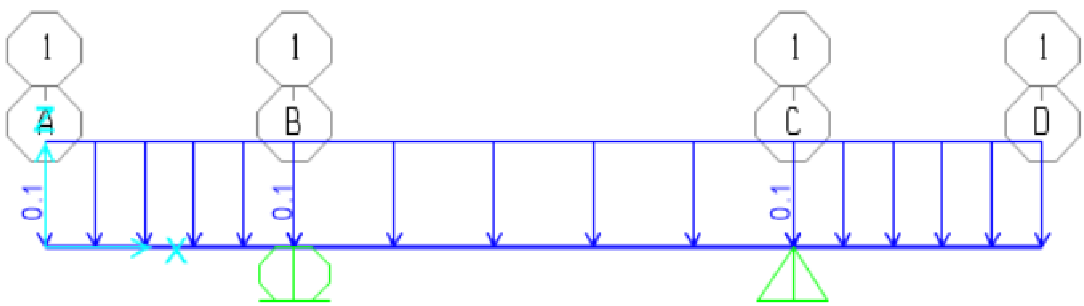


Figure 7-2. Slab Subjected to Pedestrian Live Load Using SAP.

The dead and live loads were combined through establishing the LRFD using combination 2. With the pertinent materials, data, and loads implemented. The deformation and moment diagram was retrieved (Figure 7-3). The 1.14 k-ft moment could be partly due to having a larger load value for the decking.

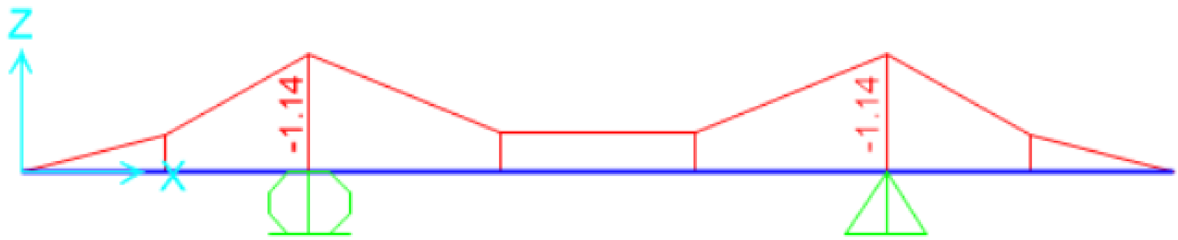


Figure 7-3. Moment Diagram for the Slab Using SAP.

7.2 Slab Design Calculations

From superimposed loads section of the report:

Dead loads consist of:

Slab Self Weight: 150 psf* (1 ft * 0.33 ft) = 75 psf
Guardrail: 50 psf
Parapet: 50 psf
Decking= 40 psf

D = 140 + beam weight

Live loads consist of :

Pedestrian Loads: 100 psf

L= 100 psf

<u>PRELIMINARY DESIGN</u>

P1. L = 10 ft = 120 inches

P2. simply supported

P3. f'c = 4000 psi
fy = 60,000 psil

P4. Based on table 4.1 in the text book
simply supported= (5*12)/20 =3"
2-end cantilever=(5*12)/26 =2.31"
cantilever= (2.5*12)/10 =3"
Hmin = 4" based on project parameters
try h = 4 in= 0.33 ft

b = 12 in = 1 ft

Try #4 rebar – D=0.5 in
d = h - ¾' - d/2 => 6in – ¾" – 0.5/2 = 3 in

P5.

W beam self-wt= 150 pcf * b * h = 150 pcf * 1ft * 0.5ft = 75 lb/ft
W dead = 140 lb/ft
W live = (100 psf * 1ft) = 100 lb/ft
load combination carried out on SAP

STRUCTURAL DESIGN

S1. Calculated max moment from SAP analysis

∴Mu (-) = 1.14 k-ft

ELEMENT DESIGN

D1.1 For negative moment, assume Φ = 0.90

D1.2 Rn = Mn/(b*d^2) = (Mu/Φ)/(b*d^2) =
((1.14 kft/0.9)(*1000*12in))/(12in * 3in ^2) = . 141 ksi = 141 psi

D1.3 PERCENT STEEL
=Using table A.13 in TB
=.0024

D1.4 As = pbd = 0.0024 * 12" * 3" = 0.0864 in
Ab = #4 = 0.20 in^2

S = 12"(Ab/As) = 12" * (0.2/.0864)) = 27.78 in
Round down => try s =26 in.

CHECKS AND DRAWINGS

C1. MIN PRIMARY REINFORCEMENT AND MIN SPACING
p = 0.0024 < pmin = 0.00333
therefore, P=Pmin=0.0033 ∴OKAY

using new p, find As
As = pbd = 0.0033 * 12" * 3" = 0.1188 in =0.12in
S = 12"(Ab/As) = 12" * (0.2/.1188)) = 20.20 in
Round down => try s =18 in.
S < Smax
S_{max} = min[3 x 6in, 18in] = 18in

S = 3" < Smax = 18" ∴S is 18"

C2. DUCTILITY
a =(Asfy)/(0.85f'c*b) = (0.12in2 x 60ksi)/(0.85 x 4ksi x 12in) = 0.177 in
β_1 = 0.85 for 4,000psi
c = a/β_1 = 0.177in/0.85= 0.208 in

ε_s = 0.003 (3in - 0.208 in)/0.208 in = 0.0403 > 0.005

∴Use Φ = 0.90

C3. DCR < 1.0

ΦMn = Φ * As * fy * (d – a/2) = 0.9 * 60ksi * (3 in – .177 in /2) (1 ft/12 in)= 1.57 K-ft

1.14/ 1.57 = 0.73 <1

C4. SECONDARY REINFORCEMENT

Selected #4 like the primary reinforcement

A_{smin} = 0.002 x 12in x 4in = 0.096in^2

From Table A.6 S = 18 in As = 0.13 in^2

S_{max} = min(5 x 4 in, 18in) = (20in, 18in)

∴S is 18 in.

C5. DRAWING OF SLAB

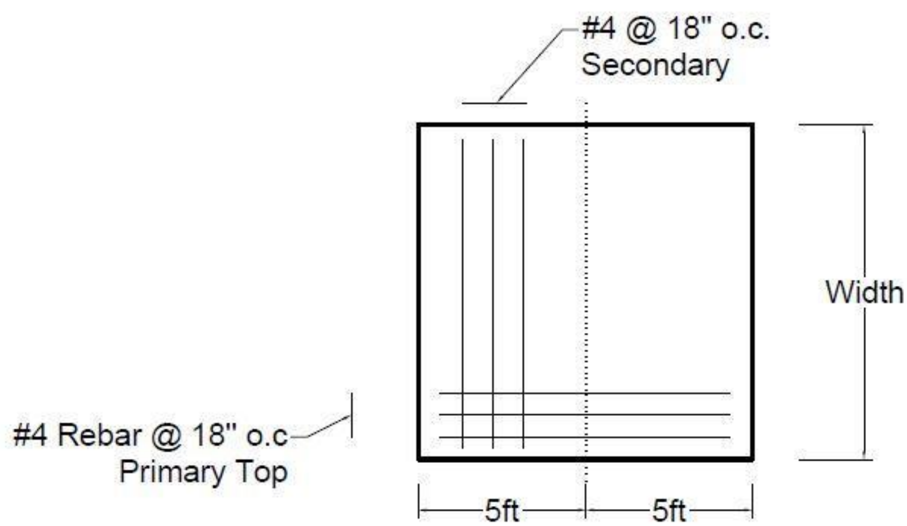


Figure 7-4. Slab with Primary and Secondary Reinforcement.

7.3 Slab Shear Design

<u>PRELIMINARY DESIGN</u>

Same parameters as the slab design portion

<u>STRUCTURAL DESIGN</u>

Based on the SAP analysis of the Slab

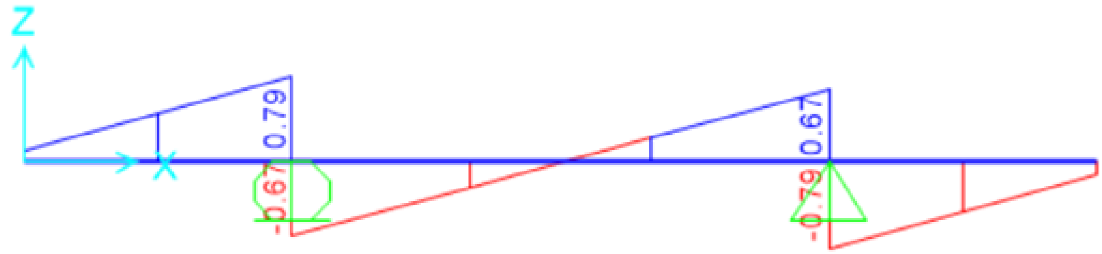


Figure 7-5. Slab Cross-Section Displaying Maximum Shear of the Slab.

Vu= 0.79 k

<u>ELEMENT DESIGN</u>

D1 Vc=2fc'bd= (2)(1)4000(12")(5")= 7.59 k

D2 Vs max=8fc'bd= (8)(1)4000(12")(5")= 30.36 k

D3 level of shear

Vc2=(.75*7.59)/2 =2.85 k > Vu =0.

Therefore, low shear. No transverse Reinforcement is needed.

8.0 T-Beam Design

For the bridge design proposed, it was established that two T beams should connected with each column as shown below in figure 8-1. The T-Beam of the pedestrian bridge has a base width of 12 in, flange thickness of 4 in, and a tributary width for one beam is 5ft. The Dead loads associated with the slab include the self weight, parapets and guardrail at the edges of the walkway at 100 psf, and 40 psf for the decking finish.

8.1 Bridge Structural Analysis

The total bridge length is 275 ft with 6 spans and 7 pairs of columns. The individual span lengths are shown in figure 8-8.

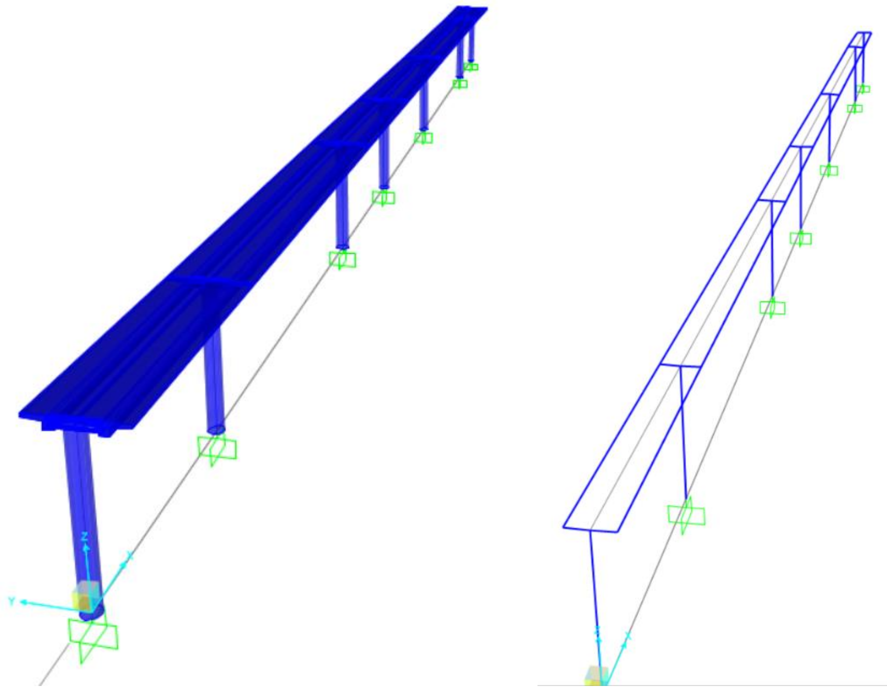


Figure 8-1. Exposed T-Beam Members. *Attached to Column: left) extruded right) distribution.*

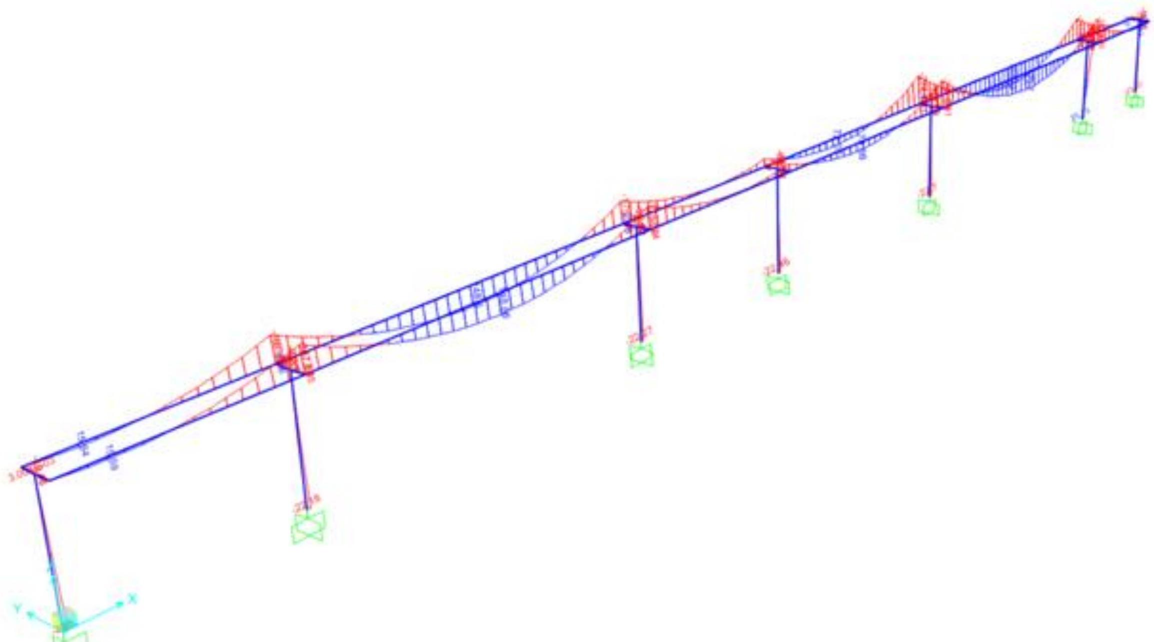


Figure 8-2. Bridge Moment Diagram At Each Span of the Bridge.

As shown in Figure 8-2, the beam is subject to both negative and positive moments. For the following calculation, the moments that will be accounted for will be M(+) = 193.12 k-ft and M(-) = 274.17 k-ft. Below is the deformed shape after placing the dead load on the members.

8.2 T beam Calculations

PRELIMINARY DESIGN

P1. L = 10 ft = 120 in

P2. Provided in SAP Figure 8-10

P3. f'c = 4000 psi NW '
fy = 60,000 psi Gr 60 Steel

P4. d = 36"
Bw = 12" = 1 ft
Hf = 4"
S = 48"

Based on table 4.1 in the text book
Hmin = simply supported= (70*12)/16 =52.5"
one-end continuous = (70*12)/18.5 =45.4"
2-end continous=(70*12)/21 =40"

Try h = 40"

P5
W beam self-wt= 150 pcf * b * h = 150 pcf * 1ft * 0.5ft = 75 lb/ft
W dead = 140 lb/ft
W live = (100 psf * 1ft) = 100 lb/ft
load combination carried out on SAP

STRUCTURAL DESIGN

S1.
Based on the SAP analysis of the bridge:
∴ M(+) = 193.12 k-ft
M(-) = 274.17 k-ft

ELEMENT DESIGN

Positive Moment M(+) = 193.12 k-ft

D1.1 Calc beff

L/4 = 70'*12"/4 = 210"
Bw + 16hf = 12" + 16 * (4") = 76"
Bw + s = 12" + 48" = 60" Use
Beff = 60"

D1.2 Rn = Mu/(0.9*beff * d^2) = (193.12 kft * 12in/ft*1000lb/k)/(0.9* 60 in * (36in)^2)

Rn =33.11 psi

D1.3 ρ= 0.85*f'cfy(1-1- 2Rn0.85*f'c) = 0.85*400060000(1-1- 2*33.110.85*4000) = .00055

ρ = 0.00055

D1.4 As = ρ * beff * d = 0.00055 * 60 in * 33 in = 1.098 in^2

Try 3 #7 As = 1.80 in^2 D = 0.75 in

a= As*fy0.85*f'c*beff = 1.80 in^2 * 600000.85* *4000* * 60 in = 0.529 in

a = 0.529 in ≤ hf = 4 in

Therefore, the stress block is within the flange

<u>CHECKS AND DRAWINGS</u>

C1. VERIFY SECTION WIDTH

b ≥ bmin b = 12” ≥ bmin = 9.0 “

C2. VERIFY SECTION HEIGHT

h ≥ hmin hmin = d + db/2 + ds + cc = 36” + 0.875”/2 + 0.375” + 1.5” = 38.31 in

h = 40 ≥ hmin = 38.31 in

C3. CHECK MINIMUM REINFORCEMENT

As = 1.80 in^2 ≥ As min Asmin = max(3* f'cfy=0.00316, 200fy=0.00333)

As = 1.80 in ^2 ≥ Asmin = 1.4 in^2 Asmin = 0.00333 * 12 in * 36 in = 1.4 in^2

C4. β1 = 0.85 a = 0.52 in d = 36”

c= aβ1 = 0.53 in^20.85=0.62 in

cd=0.62"36"=0.017

cd = 0. 017 ≤ 38=0.375 ∅=0.90

C5. ∅Mn = As * fy * (d - a2) = 0.90* 1.80 in^2 * (60 KSI)(36 in – 0.53”/2) (1’/12”)= 289.25

∅Mn = kft

DCR ≤ 1.0

Mu/∅Mn = 193.12 kft / 0.9 * 289.45 kft=0.74 ≤1.0

Negative Moment M(-) = 274.17 k-ft

D1.1 Calculating beff

L/4 = 70’*12”/4 = 210”

Bw + 16hf = 12” + 16 * (4”) = 76”
Bw + s = 12” + 48” = 60” Use
Beff = 60”

D1.2 Rn = Mu/(0.9*beff * d^2) = (274.17 kft * 12in/ft*1000lb/k)/(0.9* 60 in * (36in)^2)
Rn =47.01 psi

D1.3 ρ= 0.85*f'cfy(1-1- 2Rn0.85*f'c) = 0.85*400060000(1-1- 2*47.010.85*4000) =
ρ = 0.00079

D1.4 As = ρ * beff * d = 0.00079 * 60 in * 33 in = 1.56 in^2
Try 4 #7 As = 2.41 in^2 D = 0.875 in

a= As*fy0.85*f'c*beff = 2.41 in^2 * 600000.85* *4000* * 60 in = 0.709 in
a = 0.709 in ≤ hf = 4 in
Therefore, the stress block is within the flange

CHECKS AND DRAWINGS

C1. VERIFY SECTION WIDTH
b ≥ bmin
b = 12” ≥ bmin = 10.9 “

C2. VERIFY SECTION HEIGHT
h ≥ hmin
hmin = d + db/2 + ds + cc = 36” + 0.875”/2 + 0.375” + 1.5” = 38.31 in
h = 40 ≥ hmin = 38.31 in

C3. CHECK MINIMUM REINFORCEMENT
As = 2.41 in^2 ≥ As min
Asmin = max(3* f'cfy=0.00316, 200fy=0.00333)
As = 2.41 in ^2 ≥ Asmin = 1.4 in^2 Asmin = 0.00333 * 12 in * 36 in = 1.4 in^2

C4. DUCTILITY
β1 = 0.85 a = 0.709 in d = 36”
c= aβ1 = 0.709 in^20.85=0.83 in
cd=0.83"36"=0.023
cd = 0. 023≤ 38=0.375 ∅=0.90

C5. DCR
∅Mn = As * fy * (d - a2) = 0.90* 2.41 in^2 * (60 KSI)(36 in – 0.709”/2) (1’/12”)=
∅Mn = 386.57k-ft

MuØMn = 274.17 kft0.9 * 386.92 kft=0.79 ≤1.0 DCR ≤ 1.0

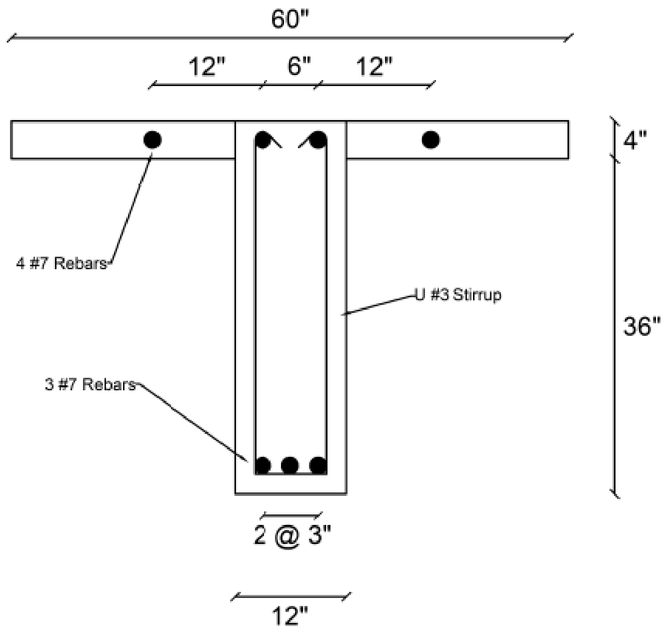


Figure 8-3. Design of T-Beam.

8.3 T-Beam Shear Analysis

PRELIMINARY DESIGN

h = 40in b_w= 12in d = 36in #3 U Stirrup

A_v = 2(0.11in^2) = A_v = 0.22in^2

STRUCTURAL DESIGN

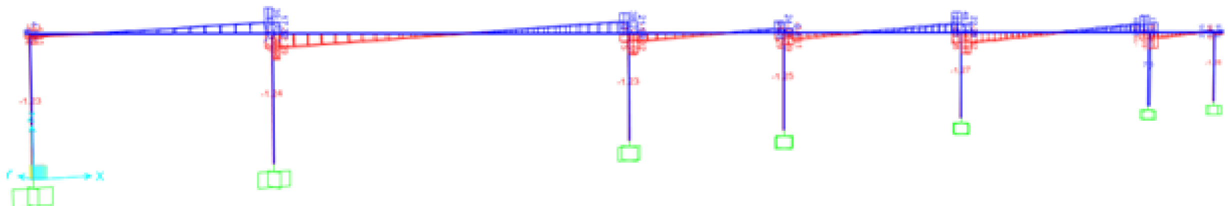


Figure 8-4. Shear Diagram of the Pedestrian Bridge. *Max shear is 26.13 k at d = 36" or 3'.*

ELEMENT DESIGN

D1.1 Vc = 2λf'cbw*d= 2 x 1.0 x4000psi x 12in x 36in /(1000lb)= 54.64 k

D1.2 Vsmax = 2λf'cbw*d=8 x 4000psi x 12in x 36in /(1000lb) = 218.57 k

Level of shear ϕ = 0.75

ϕVc/2=(0.75 x 54.64 k)/2 = 20.49 k
ϕ(Vc + Vsmax) = 0.75 x (54.64k + 218.57k) = 204.91k

20.29<26.32<204.91
Therefore: Medium - Very High Shear

ϕVc = 0.75(54.64k) = 40.98 k
Case 2: Vc/2 < Vn ≤ Vc + Vsmax
20.29<26.32<40.98
Therefore: Medium Shear

CHECKS AND DRAWINGS
SmaxA = min(60,000psi(0.22in2)/(0.75*4000psi(12in)), (60,000psi*0.22in2)/(50*12in)= min(23.19in, 22in) = 22 in
therefore s=20 in

DCR= 26.13/(.75*54.64+ 3620*.22*60= .54< 1
Drawings
Provide Stirrups 2" from the support
stirrup spacing is at 20" until ϕVc/2 is reached.

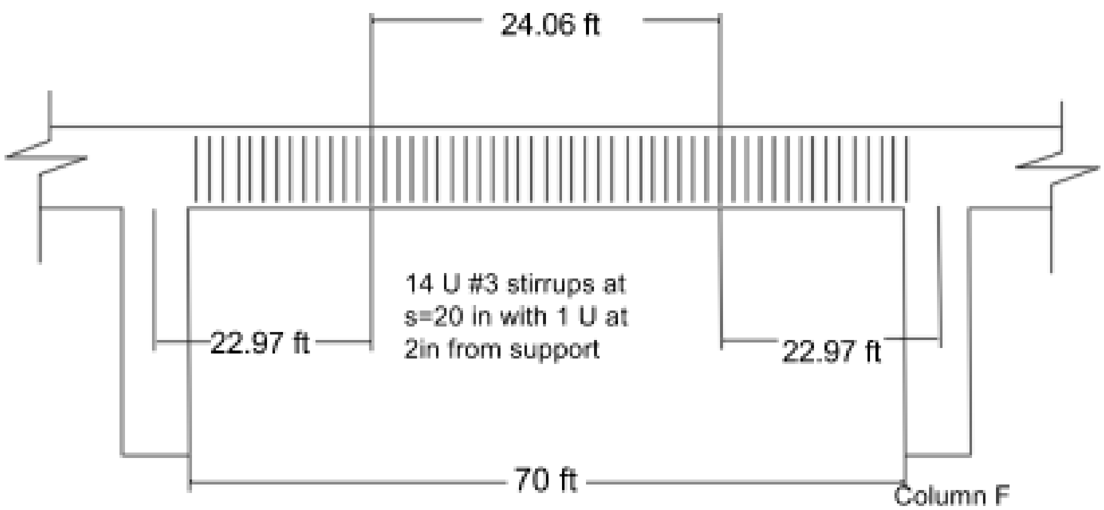


Figure 8-5. Shear Reinforcement for T Beam Between Column E and F. *Note: figure not to scale.*

9.0 Column Design

Column F was used for the calculation since it had the largest span to support and had the largest axial force.

PRELIMINARY DESIGN
F'c = 4000 psi

Fy = 60,000 psi

Dead Loads
Deck: Finish: Treated Douglas Fir: 33 lb/ft we will use 40 lb/ft
Parapet + Rail: 100 lb/ft
Slab Self Weight: 75 lb/ft
T – Beam Self Weight: 274.5 lb/ft (one beam) – We are using two
549 lb/ft (two beams)

Total D: 797 lb/ft * 1ft = 764 lb
Total L: 150 lb/ft * 1ft = 150 lb

Vertical Loads only – no moment – e=0

STRUCTURAL

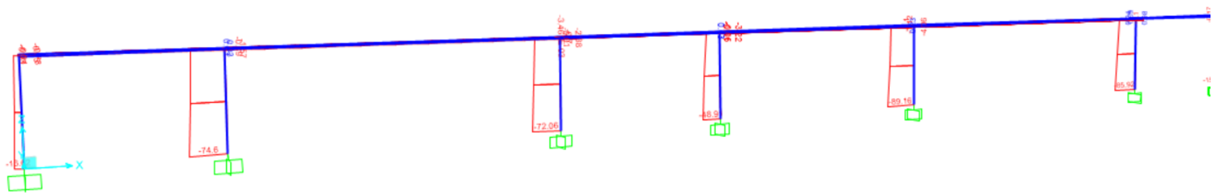


Figure 9-1. Axial Forces on Column.

Upon doing a comparative analysis from the values extruded from SAP, the maximum axial force is 89.16 k as is depicted in Figure 9-1.

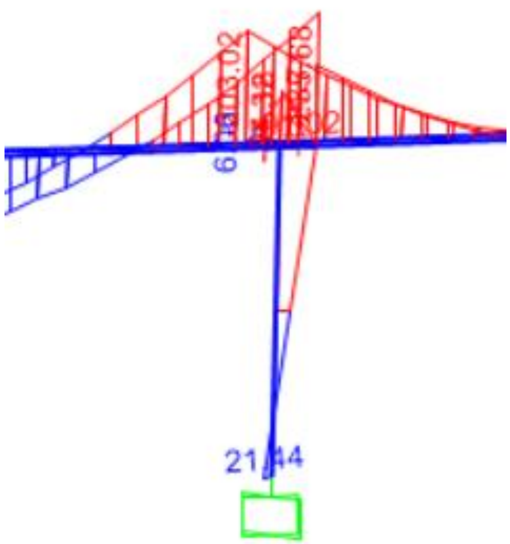


Figure 9-2. Moment at Column F. *Moment at F is a small portion of the entire bridge.*

Therefore, utilizing the axial load and moment experienced by column F. The eccentricity calculated was 0.334 ft. When compared to 0.05, H it was found that the column had small eccentricity.

e = MU/PU =29.84 kft/ 89.16 k= 0.334 ft

For spiral columns   0.05h = 0.05(18ft) = 0.9ft

e<.05h= .334<.9
Small Eccentricity

ELEMENT DESIGN

D1.

Use column diameter = 2 ft = 24 in
Ag = π*24^24 = 452.39 in^2

Pu = ∅*0.85 * [0.85*f'c(Ag – Ast) + fy*Ast] =
1076.8 = 0.75 * 0.85 *[0.85*4ksi (452.39 – Ast) + 60ksi * Ast
Ast = 24.68 in^2

Try 16 #11 Ast = 25 in^2

CHECKS AND DRAWINGS

C1.

16 bars > 6 bar minimum

C2.

0.01Ag = 4.53 < Ast = 25.67 < 0.08Ag = 36.2 OK

C3.

Use #3 bar for spiral.

C4.

ρsmin=0.45*(AgAc-1)* f'cfy= 0.45*(452.39346.4-1)* 400060000

psmin = 0.00923

Ac = π*21^24=346.4 in^2

C5.

p = 4*as*(Dc-db)s*Dc^2 => 0.00923 = 4*0.11*(21-0.375s*21^2

s = 2.17 in

therefore use s= 2in

C6. DCR check

89.16 k/ [0.75 * 0.85 *[0.85*4ksi (452.39 – 25) + 60ksi * 25]
= 0.60 < 1.0 OK

DRAWINGS

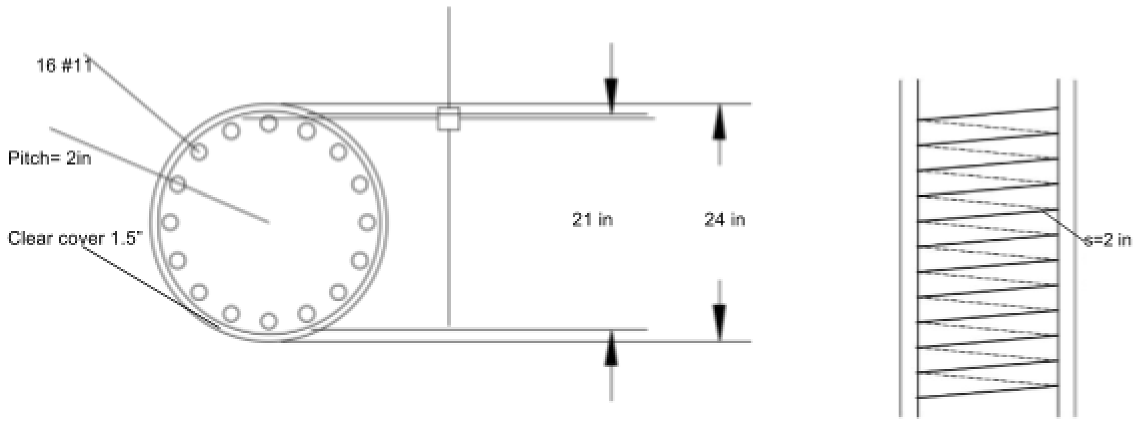


Figure 9-3. Column Dimensions*. Cross Sectional View of Column F with rebars and dimensions (left), and profile view of column F (right).*

10.0 Recommendations

The following recommendations have been made for pedestrian bridge.

10.1 Structural Recommendations

10.1.1 Deck

The total length of the bridge is 275 ft from column A to column G. (Appendix A Sheet 1 of 8). The width of the deck shall be 10 ft wide. There will be 9 ft clearance with 6" x 4" concrete guard holders. Metal fencing will be used as a parapet and will be 42" high. Slab will be 4" thick. See Appendix A Sheet 5 of 8.

10.1.2 T – Beam

The height of the beam is 40", which includes the slab thickness. Top reinforcement will use 4 #7 Gr 60 rebars and bottom reinforcement will use 3 #7 Gr 60 rebars. Stirrup will be a #3 Gr 60 rebar (Appendix A Sheet 6 of 8).

10.1.3 Cap Beam

The cap beam contains the deck of the bridge. The cap beam is 3' x 2.5' x 10' (h x w x l). A 3D visualization can be seen in Appendix A Sheet 7 of 8 and Appendix B.

10.1.4 Columns

The columns shall be 18 ft in height and 2 ft in diameter (Appendix A Sheet 8 of 8). Columns must satisfy minimum vertical clearance requirements.

10.2 Environmental Recommendations

10.2.1 Trees

There are vegetation present at the site. Trees may be a concern pertaining to the construction of the bridge. Bridge column layout will circumvent the trees as much as possible. However, an arborist may be needed to assess the situation. Removal of the trees is a last resort.

10.2.2 Utilities

Light poles and sewer pipelines are present at the site. Location of utilities will be avoided and circumvented as much as possible.

11.0 References

CPP Library Map
https://www.cpp.edu/~library/about/about-the-library/floormap-second.shtml

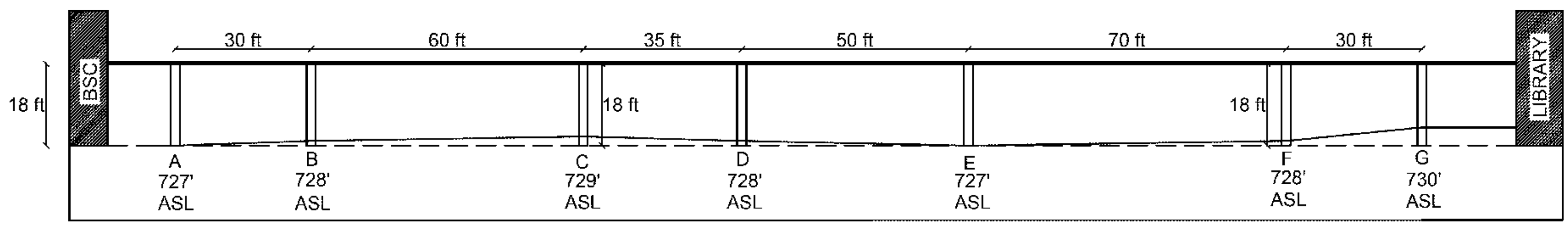
Bronco Student Center Map
http://asi.cpp.edu/services/bronco-student-center/bsc-map/

UCSC Bridge
https://admissions.ucsc.edu/campus-life/campus-photo-gallery-2014.html

Deck Finishing
http://www.excelbridge.com/for-engineers/deck-types

https://www.engineeringtoolbox.com/wood-density-d_40.html

Appendix A: Plans



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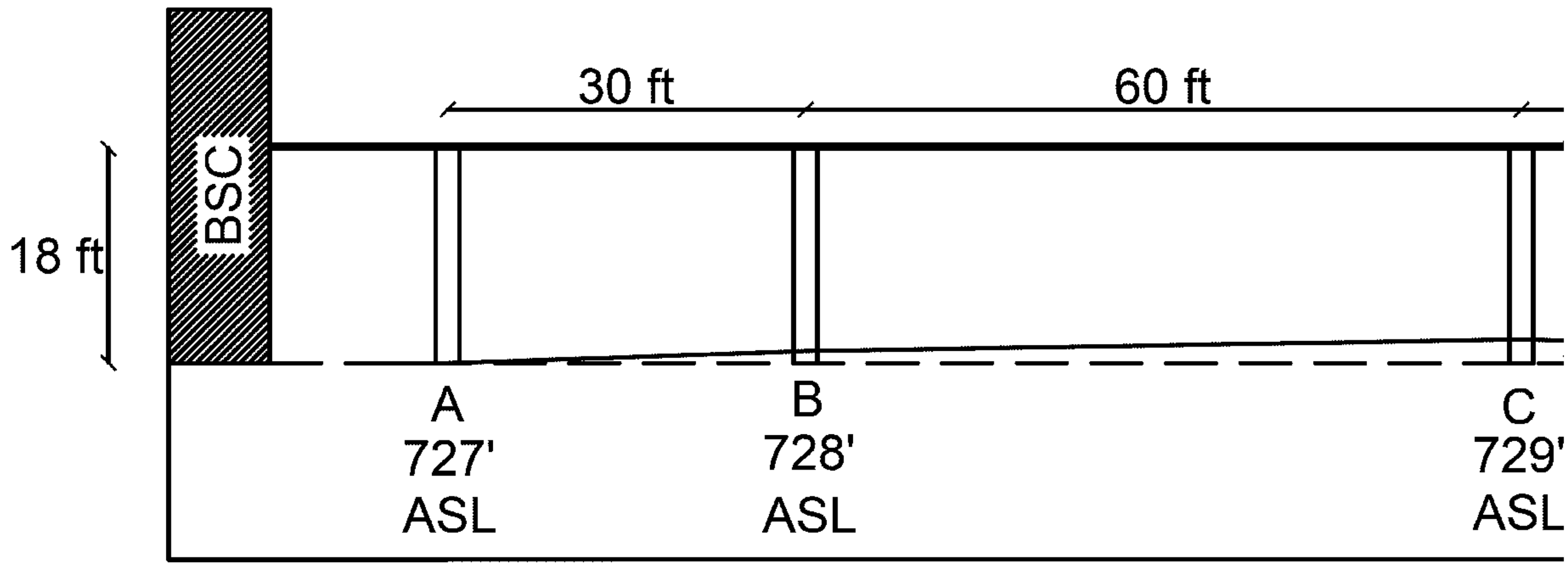
PEDESTRIAN BRIDGE PROFILE OVERVIEW

PROJECT NO. 120817

SHEET 1 OF 8



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PEDESTRIAN BRIDGE PROFILE (1/3)

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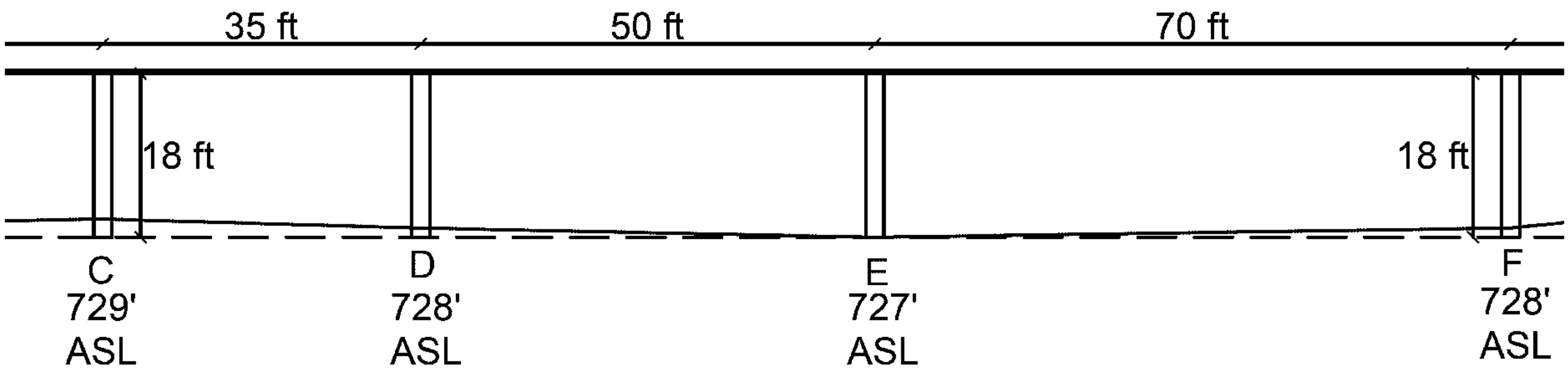

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PEDESTRIAN BRIDGE PROFILE (2/3)

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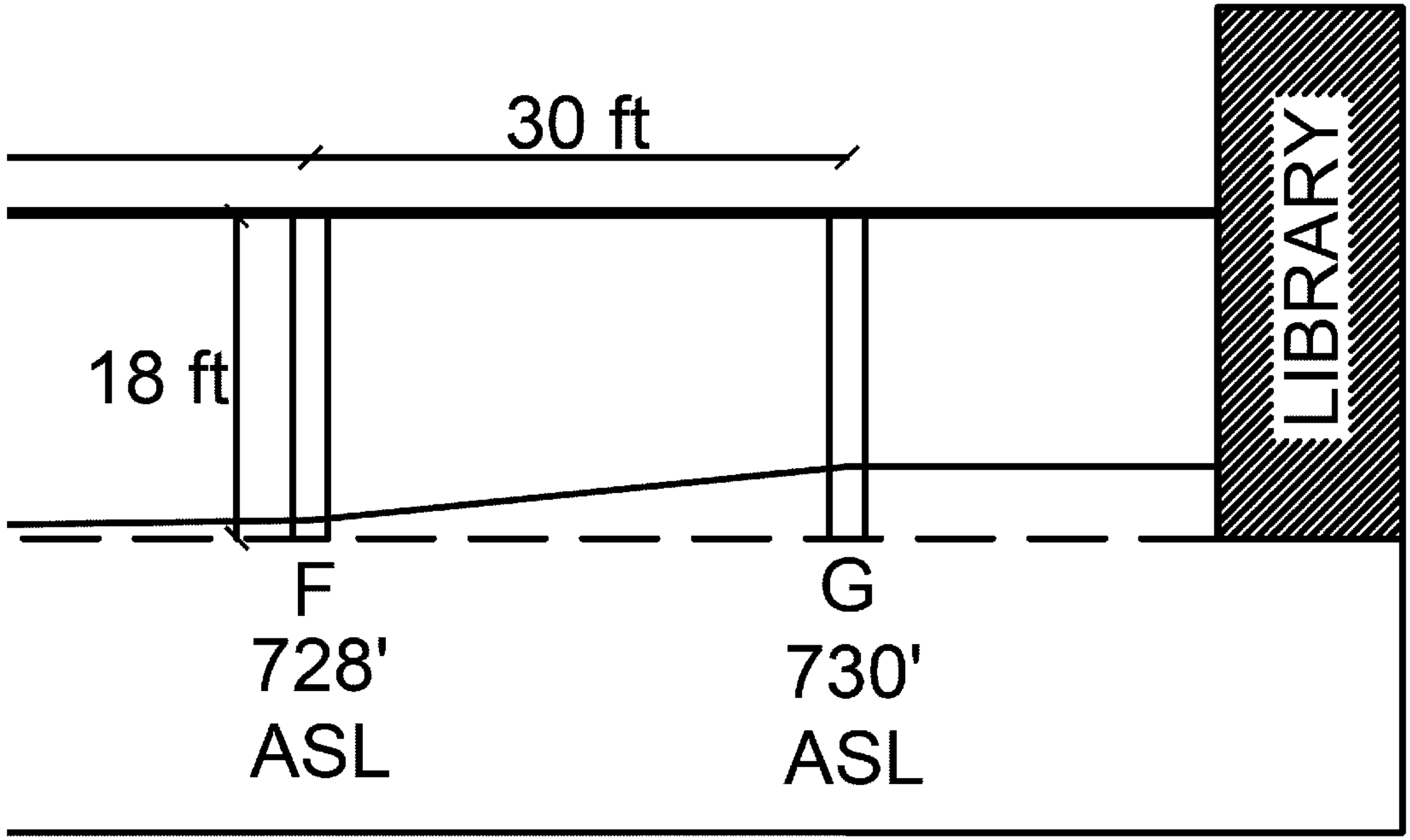

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PEDESTRIAN BRIDGE PROFILE (3/3)

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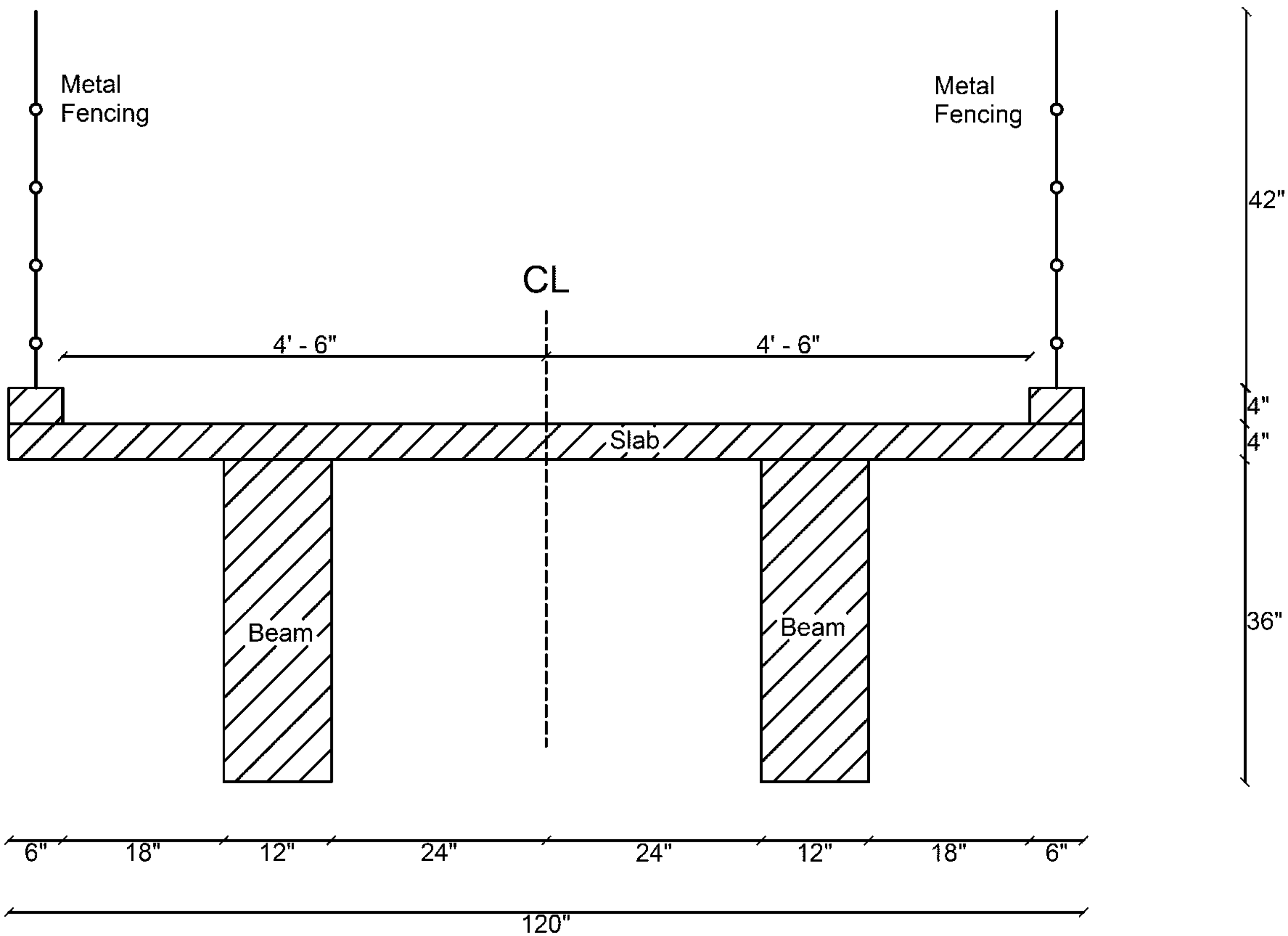

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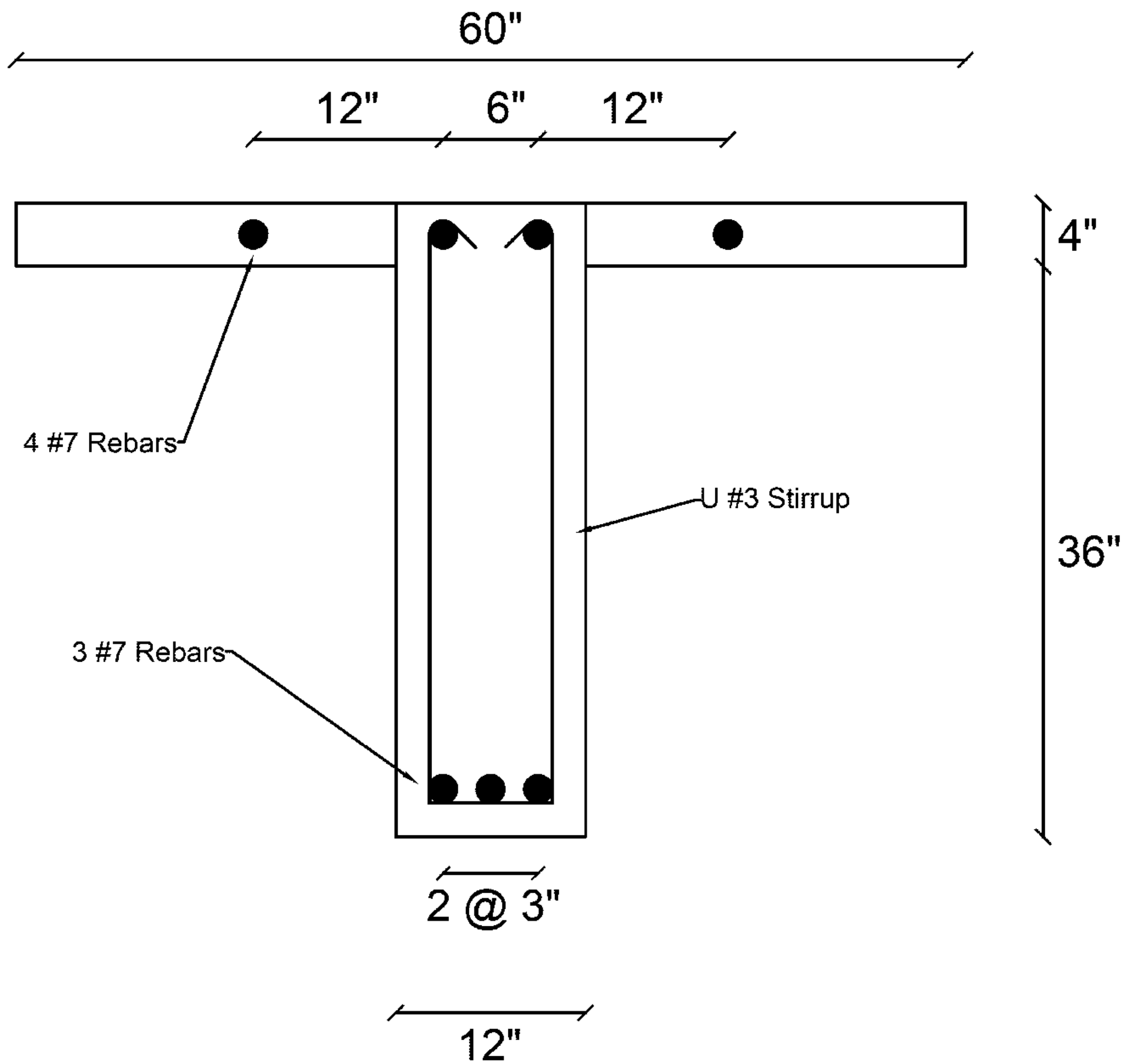
DECK CROSS SECTION

PROJECT NO. 120817

SHEET 5 OF 8



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T-BEAM DESIGN DIMENSIONS

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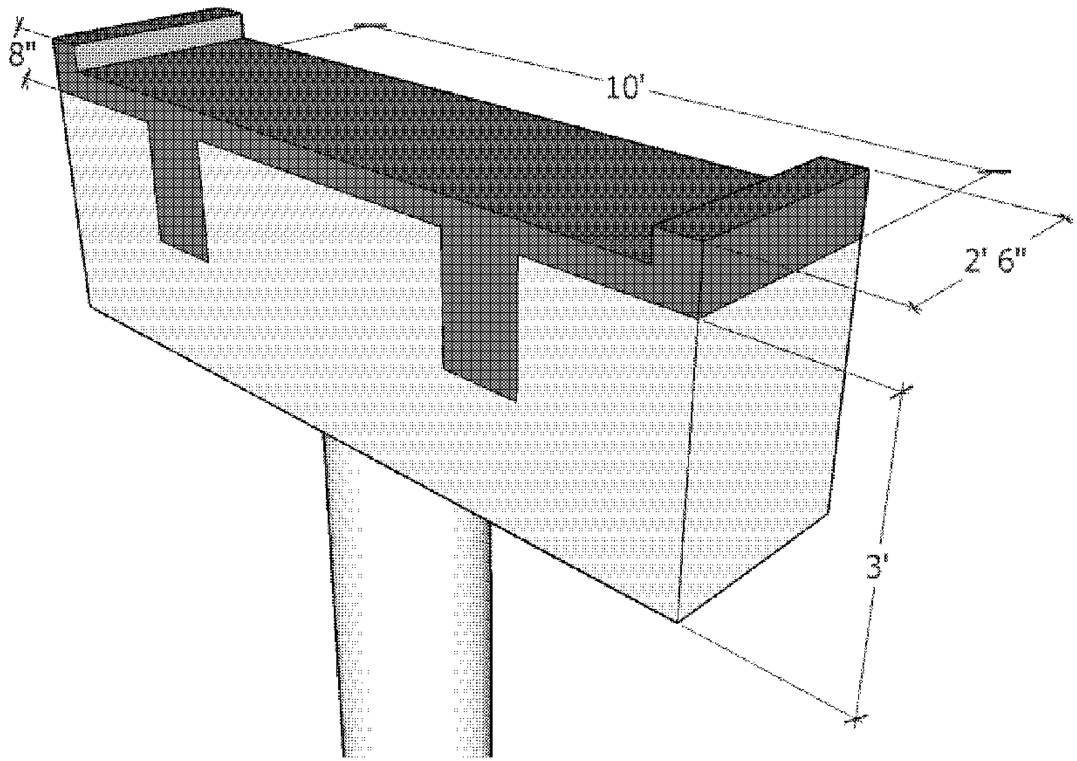

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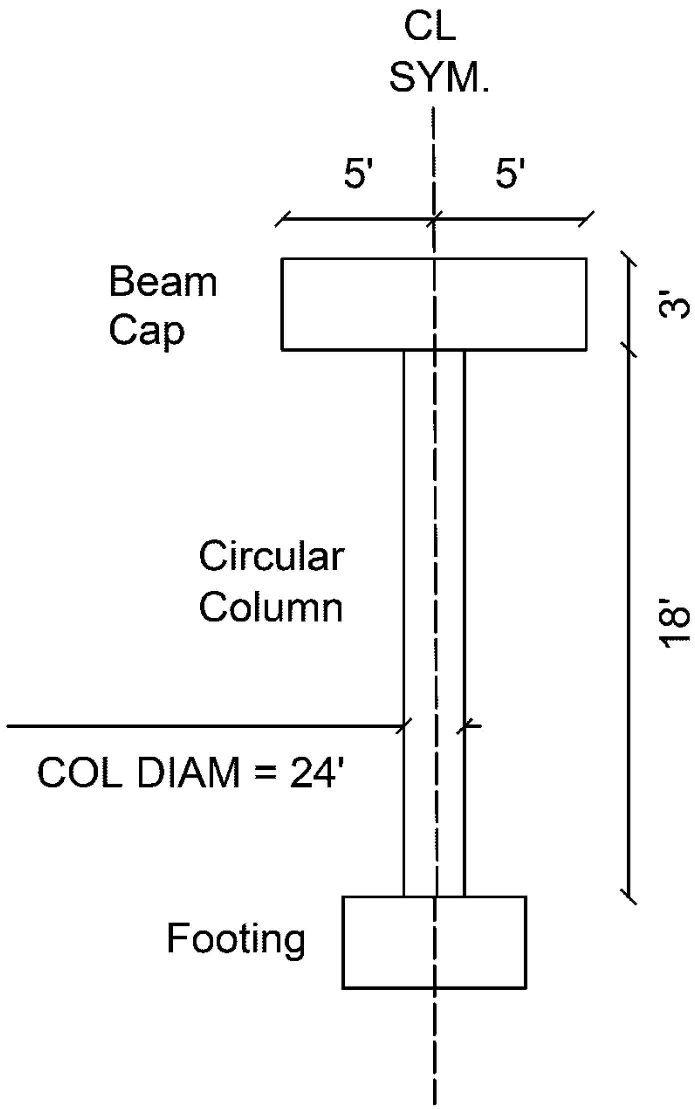
CAP BEAM ISOMETRIC VIEW

PROJECT NO. 120817

SHEET 7 OF 8



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COLUMN PROFILE OVERVIEW

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Appendix B: 3D Drawings

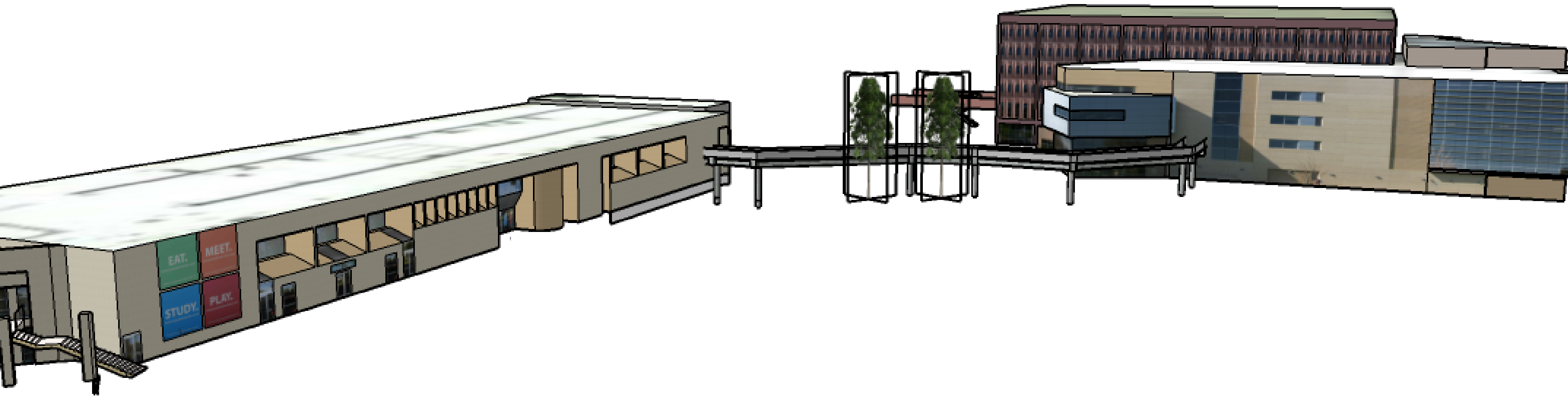

Figure B-1. Overview of the BSC, Library, and Bridge. *Bridge was drawn in SketchUp.*

Figure B-2. View of the Bridge from Library.

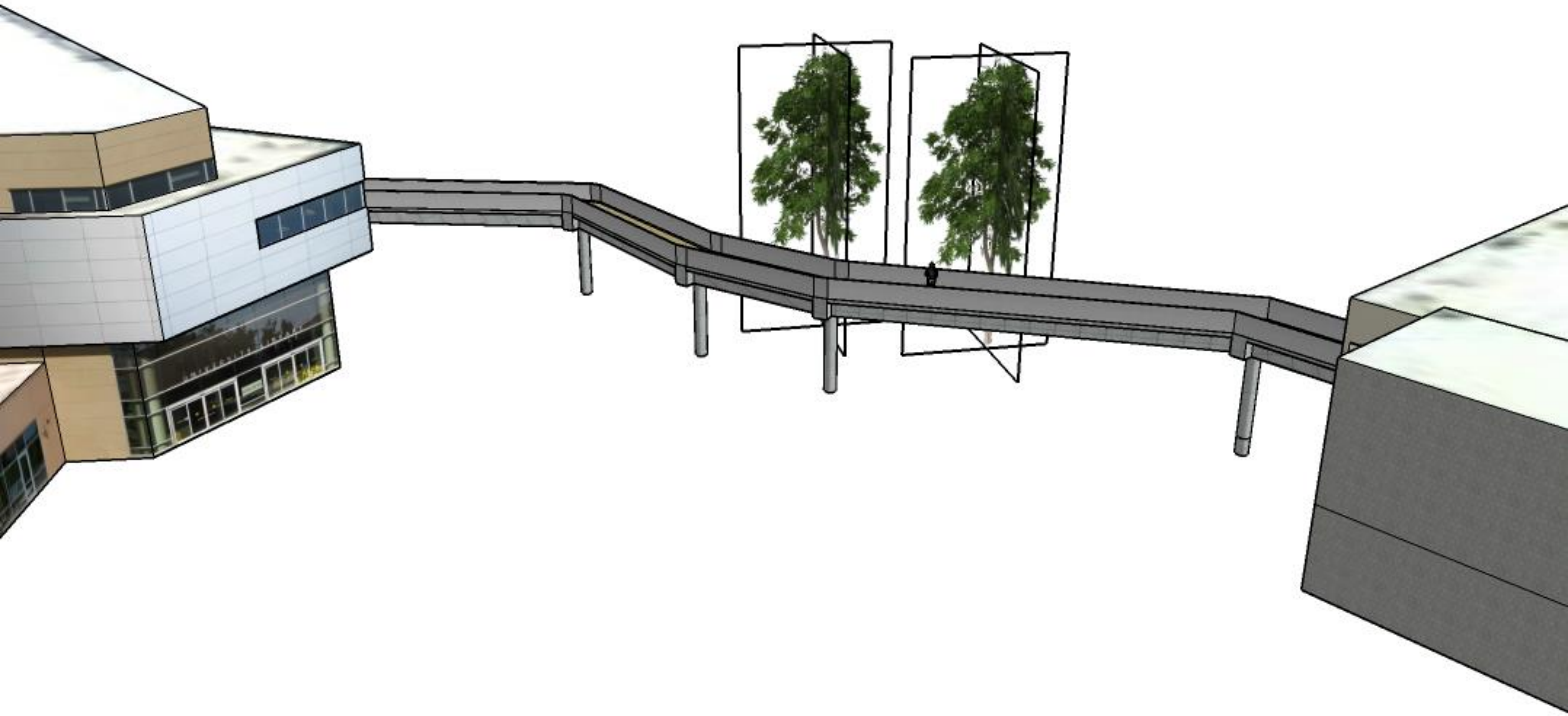

Figure B-3. View of the Bridge from North Side of BSC.

Figure B-4. View from Bridge Deck with Model to Scale.

Figure B-5. Aerial View of the Bridge in Google Earth.

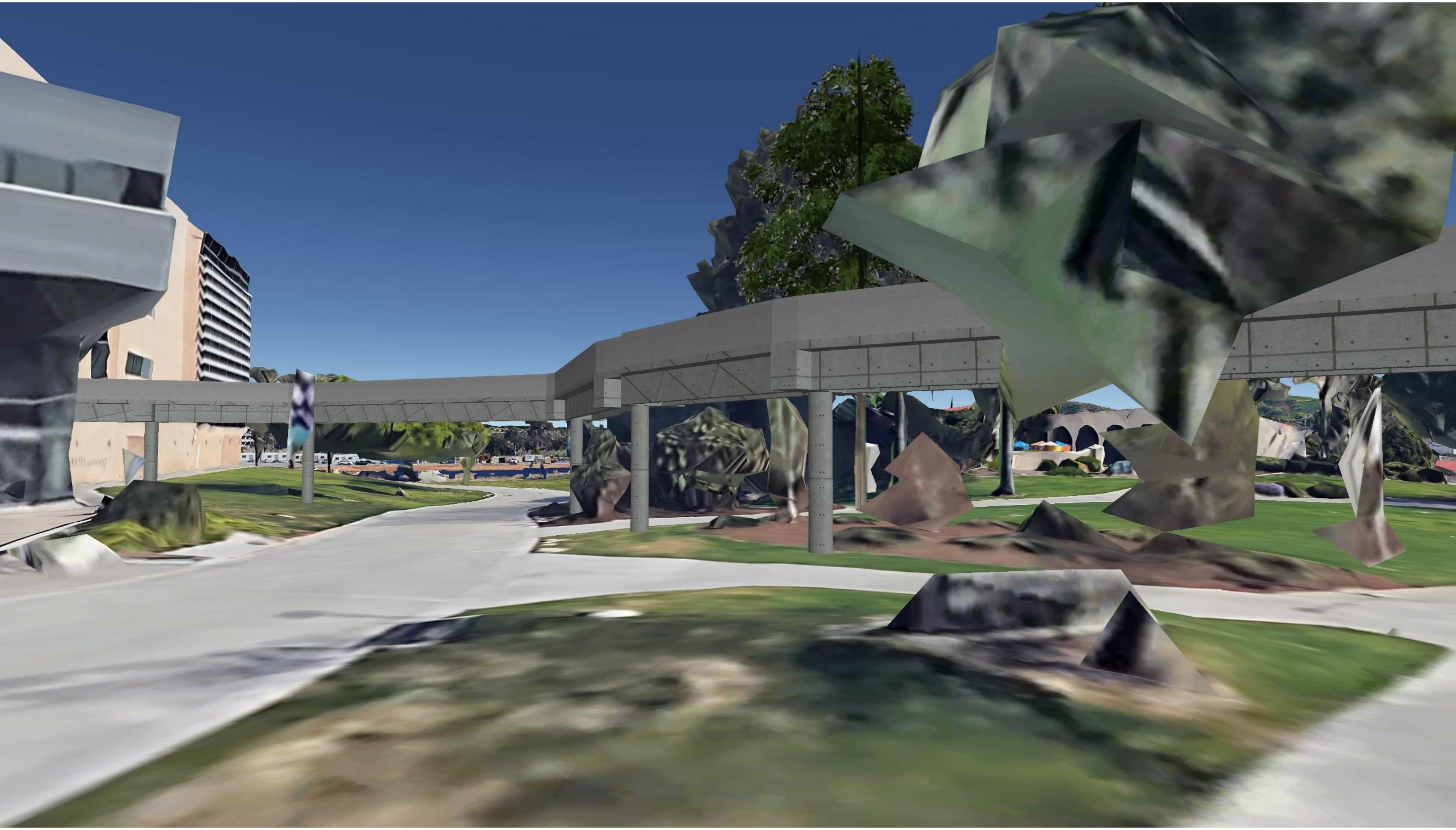

***Figure B-6. Ground View of the Bridge*.**

Figure B-7. Underside of Bridge*. Beams, beam cap, and column can be seen.*