IPRO 311 DESIGN FOR PEDESTRIAN BRIDGE OVER STATE STREET

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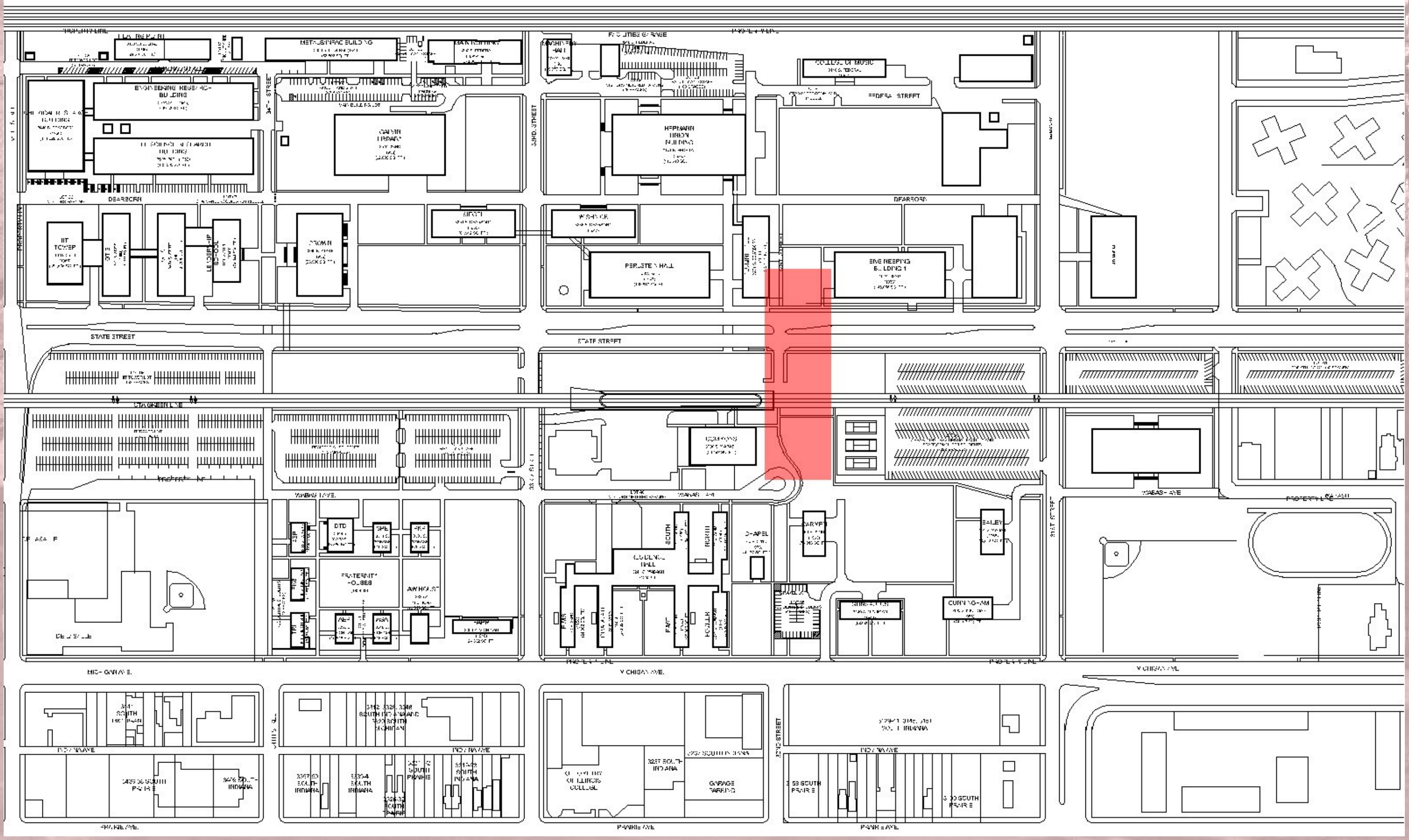
Objective

The objective of this project is to design a pedestrian bridge over an existing busy street, involving such considerations as structural design, architectural design and ease of construction.

- Easy access for students from the academic zone to the student center
- Mid-block location



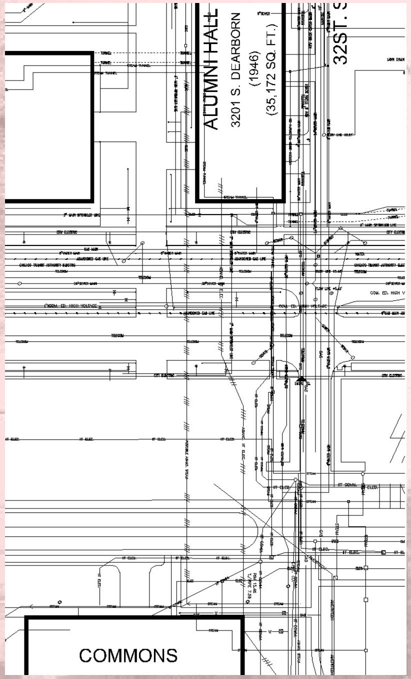
Policy on Geometric Design of Highways and Streets, AASHTO (1984)

- RAMPS
- STAIRWAYS
- HANDRAILS
- VERTICAL CLEARANCES
- WIDTH
- OBJECT DROPPING
- THE PEDESTRIAN
- BODY AREA
- WALKING RATE
- WALKWAY CAPACITIES
- HANDICAPPED PEDESTRIAN CHARACTERISTICS

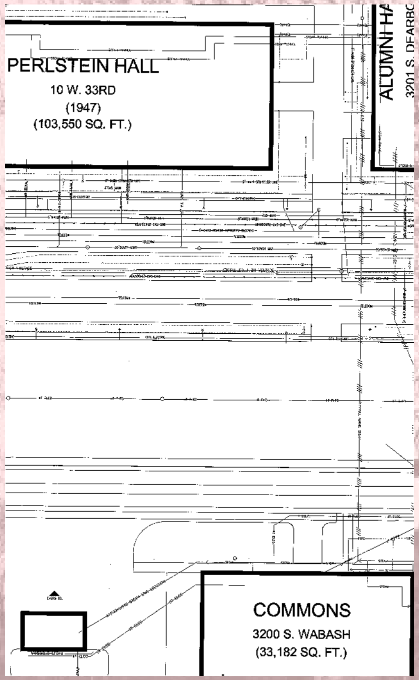
The project will involve five key elements:

1) A complete survey of the site area
2) Design of a concept for the bridge
3) Specification of structure site
4) Structural analysis of the bridge
5) Structural design of the bridge.

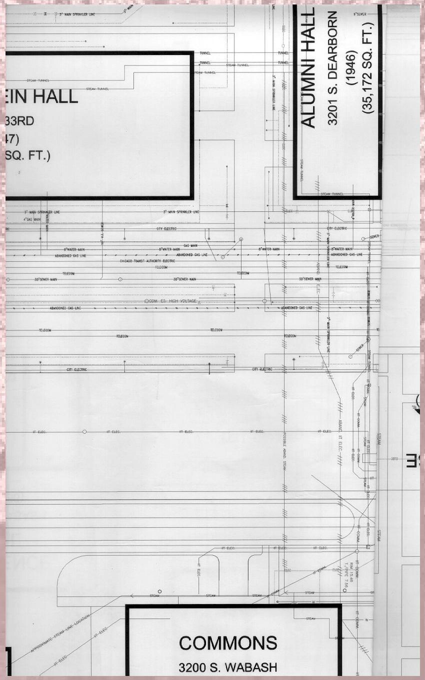
An initial survey of was required to determine the feasibility of the project in terms of accessibility and foundation design.



Utility Survey



Survey 1



Survey 2

Design Philosophy

- Provide simple and safe pedestrian travel across State St.
- Provide Handicap Accessibility
- Respect scale of campus
- Create gateway to campus
- Provide clear views to Chicago skyline

Group I

Architectural Design Details

- Minimum fence height – 8’-6”
- Stiffeners for the top arch act as the upper part of the fence.
- Acrylic plastic (Plexi-glass) acts as fencing device with holes through 20% of surface area.
- Handrail is used for safety concern.
- Light fixture is located inside handrail at 14’-0” o.c.
- Gutter at both sides of the bridge for rainwater and snow drainage.
- Curved metal plate connects from the edge of the gutter to cover the bottom structure below.

Clearances

- Minimum Traffic Clearance 16’ 6”
- Minimum Clearance Width 8’
- Minimum Fencing Height (w/partial) 8’ 6”
- Maximum Fence Opening Size 2”
- Handrail Height for Stairs (Grade > 5%) 34-38”

AASHTO Codes

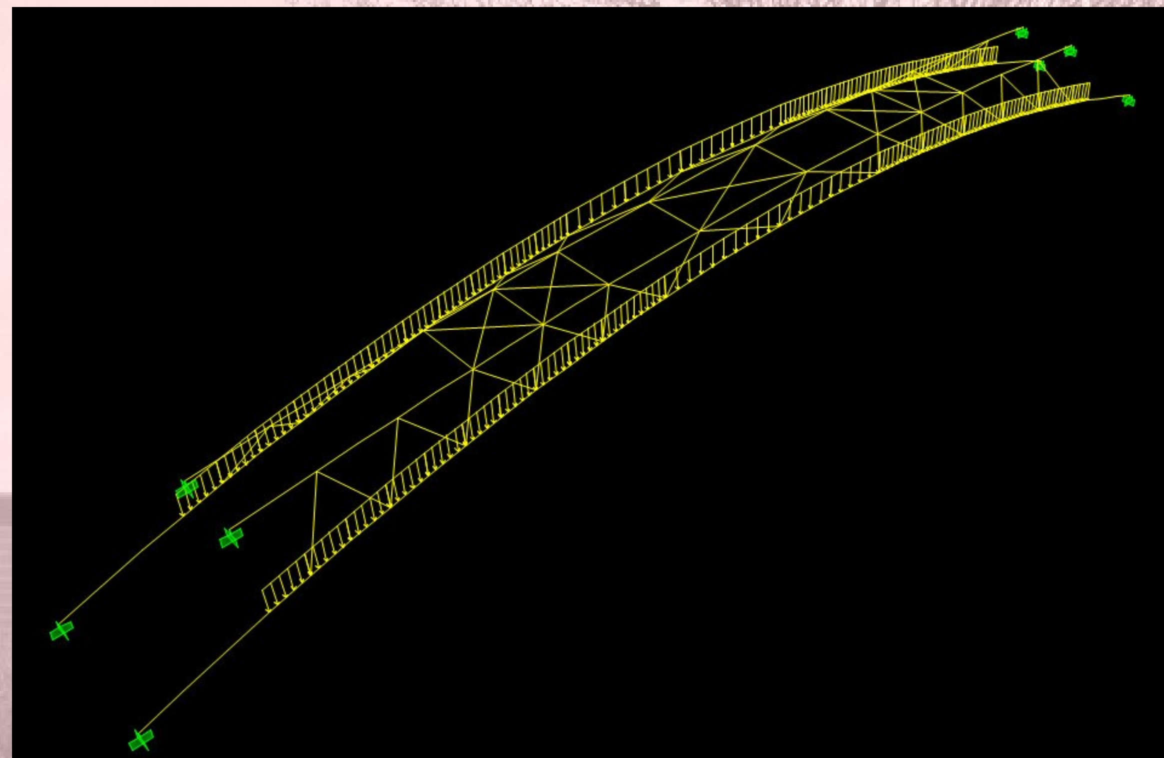
- Live Load = $85[.25 + (15/\sqrt{A_1})]$

  *Cannot be < 65 psf

- Vehicle Load = 0 (Pedestrians Only)
- Wind Load = 35 psf * Area (under curve of bridge)
- Deflection due to LL <= 1/500 of length of span
- Vibrations – Min. supported Structure Weight > 180 e^(-0.35f)
- Min. Thickness of tubular section = ¼”

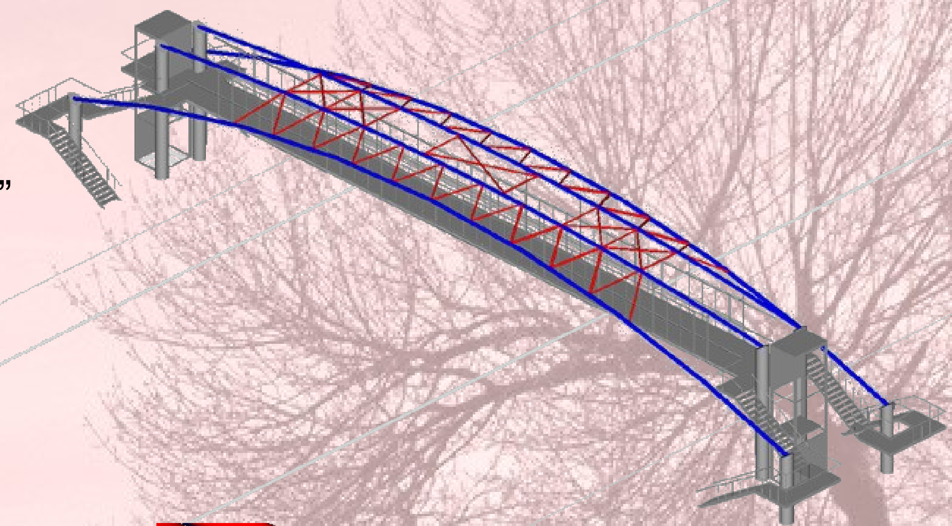
Bracing Design

- Total Dead Load = 166.67 plf
- Total Live Load = 260 plf
  - 1.7LL + 1.7WL) = 640.38 plf
- Total Wind Load = 105 plf
- Combinations
  - 1.4DL = 233.34 plf
  - 1.4DL + 1.7LL = 275.34 plf
  - 0.9DL + 1.3LL = 286.50 plf
  - 0.75 (1.4DL +



Group I

Arch/ Bracing/ Cable Design



Top and Bottom Arch:

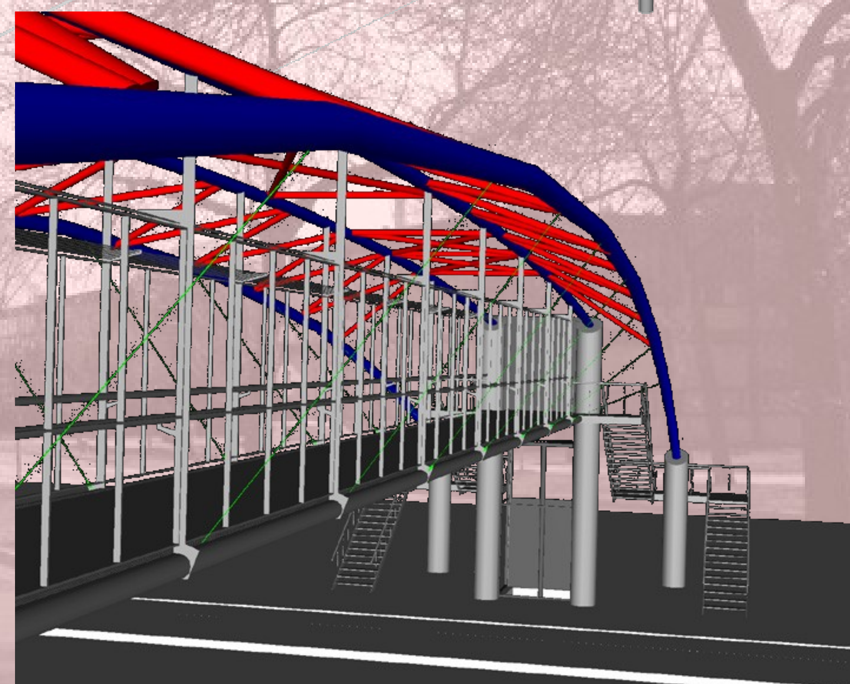
Outside Diameter = 10.5”
Thickness = 0.75”

Bracing:

Outside Diameter = 4”
Thickness = 0.5”
Distance = 10-20’

Cable:

Diameter = 5/8”
Area = 0.3068 in^2
Spacing = 14’-0” o.c.



Load combinations:

Upper Columns

Shear Force: x- direction = -29.01 kips
y- direction = -2.55 kips

Axial Force: z- direction = 9.08 kips

Axial Moment: x- direction = 50.09 kip-in
y- direction = 459.16 kip-in

Torque: z- direction = 248.60 kip-in

From Analysis:

Diameter = 29”
Height = 29’

Spiral reinforcement

4 #7 bars
(Diam = 0.875”, A = 0.60 sq.in.)
Spacing = 3”

Load combinations:

Lower Columns

Shear Force: x- direction = -196.66 kips
y- direction = -0.65 kips

Axial Force: z- direction = 83.7 kips
(includes stairs)

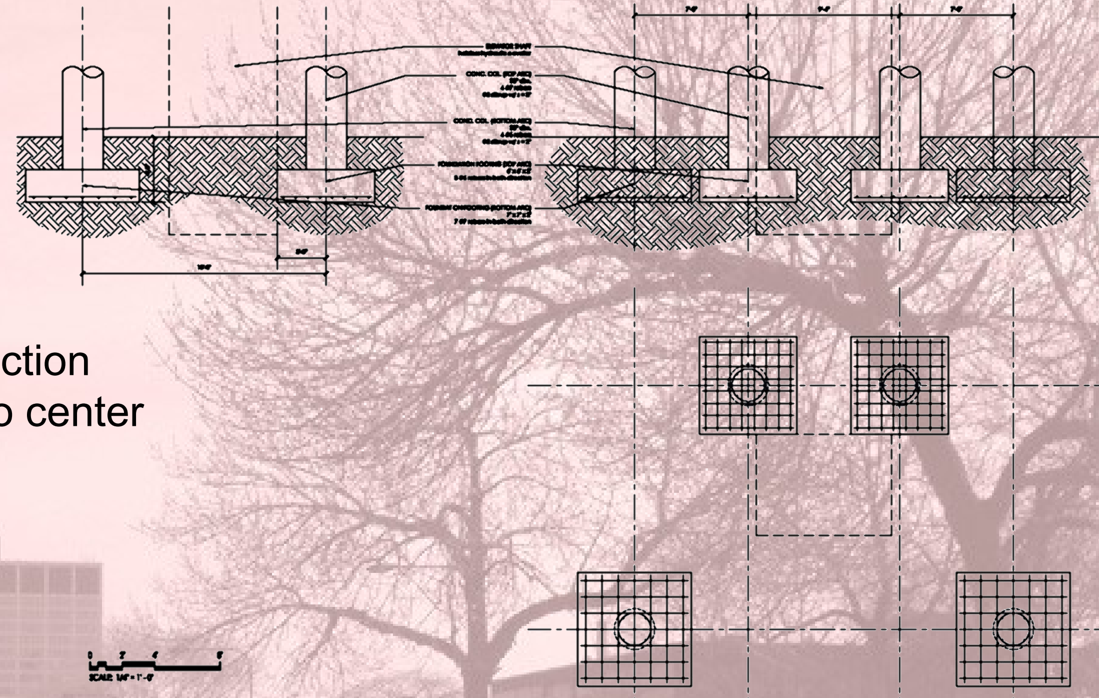
Axial Moment: x- direction = 50.24 kip-in
y- direction = -381.02 kip-in

Torque: z- direction = 75.464 kip-in

From Analysis:
Diameter = 28”
Height = 10’

Spiral reinforcement
4 #5 bars
(Diam = 0.625”, A = 0.31 sq.in.)
Spacing = 3”

Group I



Top Column:

Dimensions

Width = 6’-0”
Length = 6’-0”
Thickness = 2’-0”

Reinforcement

(8) #6 bars each direction
Spacing = 9” center to center

Bottom Column:

Dimensions

Width = 7’-0”
Length = 7’-0”
Thickness = 2’-0”

Reinforcement

(7) #7 bars each direction
Spacing = 12” center to center

Structural Perspective

Goals in the Analysis of Pedestrian Bridge

1. To provide a safe structure for the IIT community.
2. To keep the original design in tact when possible.
3. To offer a “real world” and buildable structure

Aspects of the Design

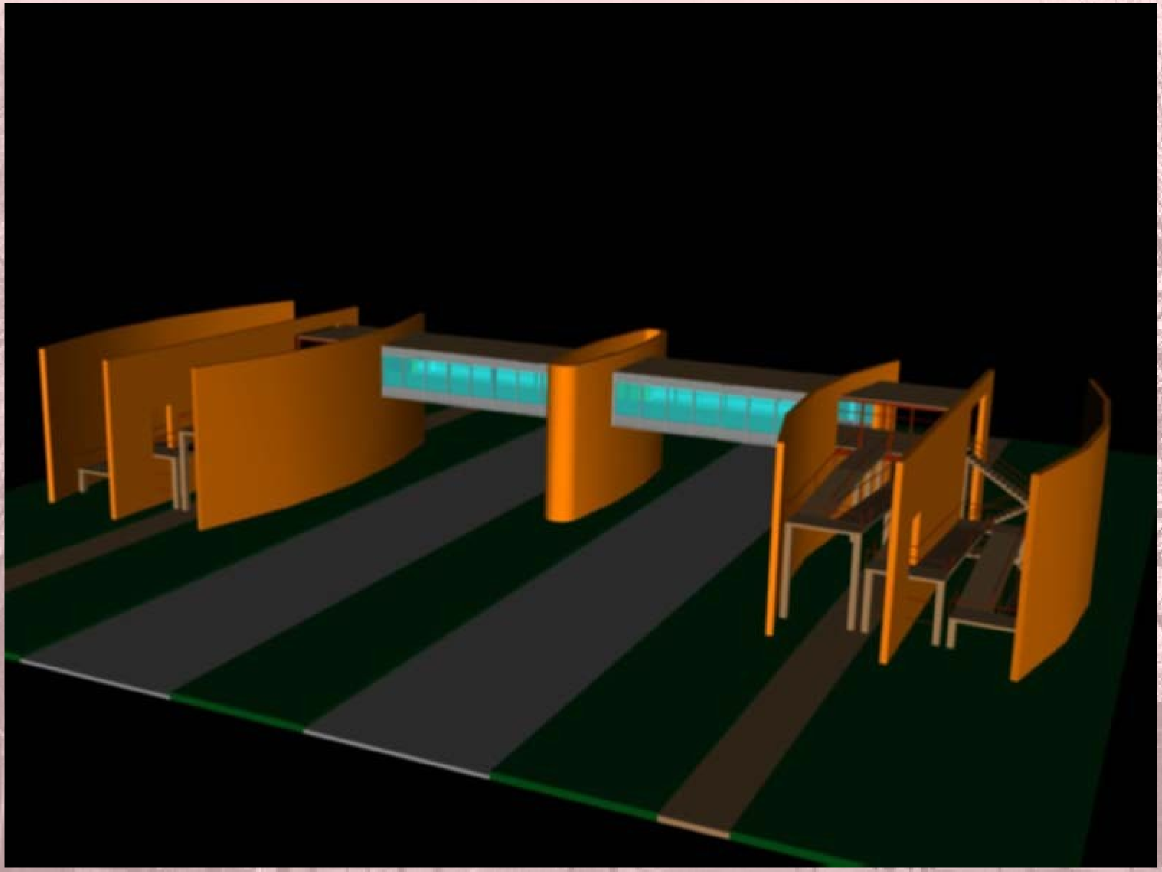


Figure 1 – Computer Generated Representation of the Design

1. Curvilinear Piers
2. Rectilinear Walkway
3. Functional

Group II

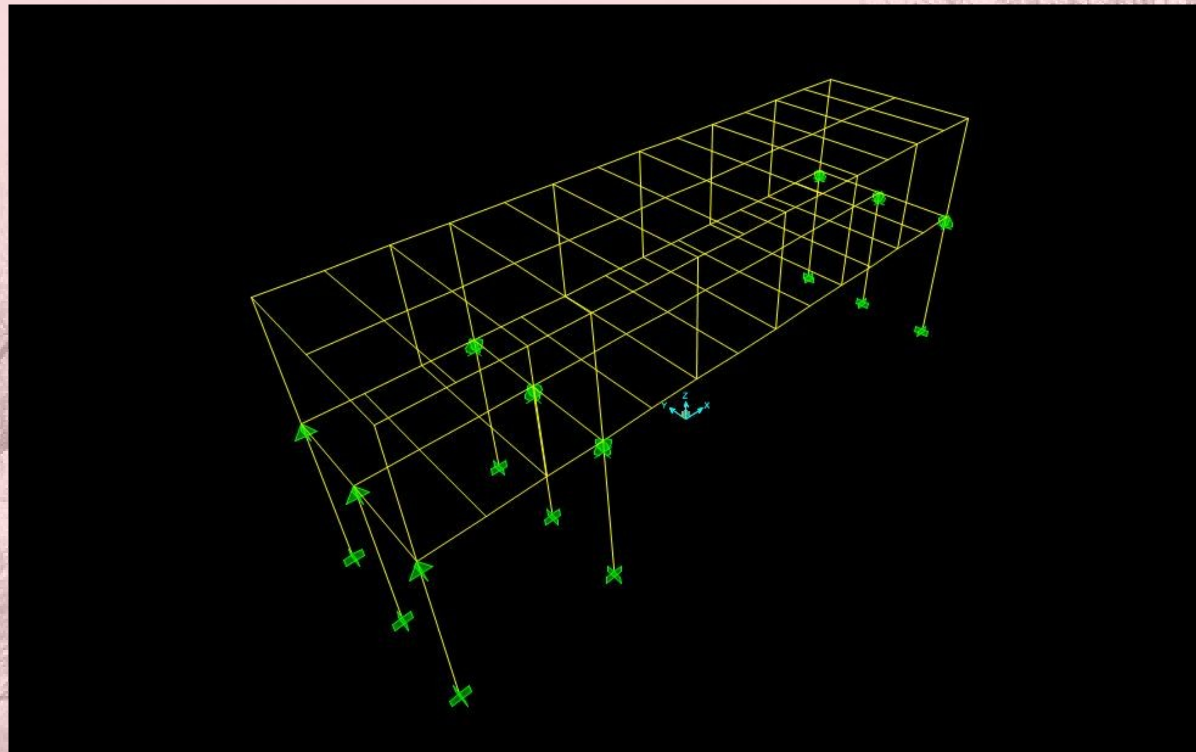


Figure 2 – Basic Structure

Technical Issues Addressed

1. Beam sizing
2. Column sizing
3. Lateral support spacing
4. Overall structural stability
5. Plexi-glass design based on calculated wind load for cladding
6. Foundation design and sizing
7. Lighting design
8. Surveying
9. Soil Mechanics

10. Composite Decking Design
11. Ramp Design

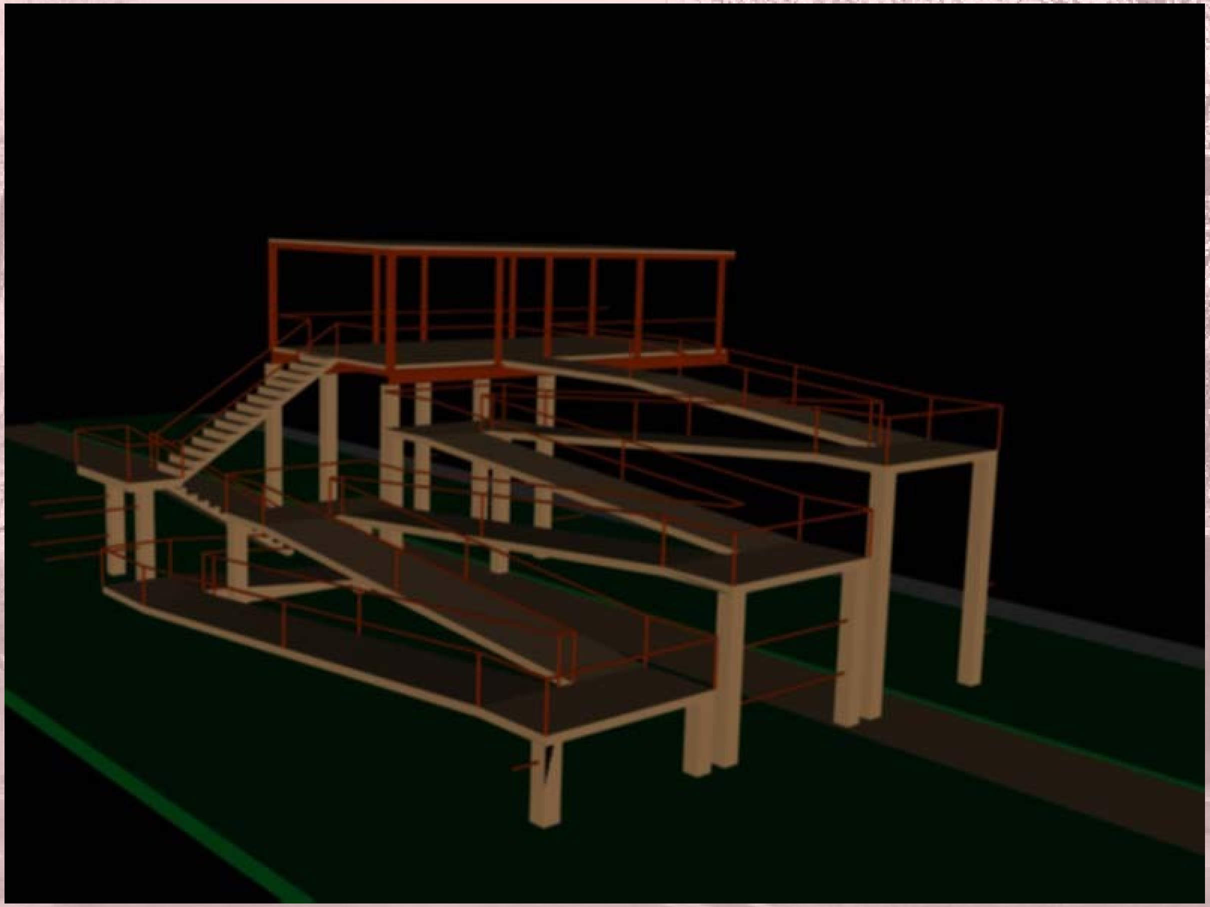


Figure 3 – Computer Generated Representation of the Ramp Design

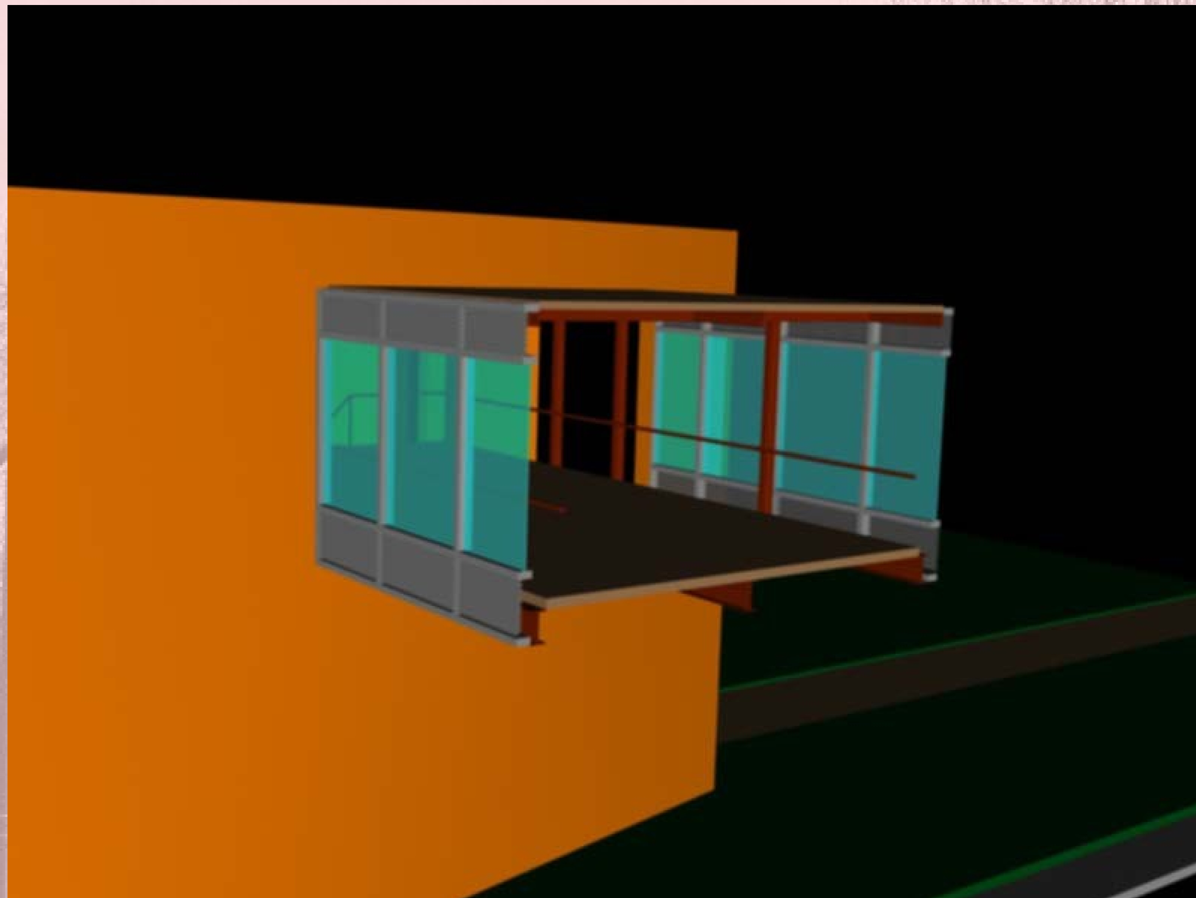


Figure 4 – Computer Generated Representation of the Deck

Procedure for Analysis

1. Surveyed location including utility survey
    a. Determined position of key points
    b. Determined changes in elevation of streets, curbs, etc.
2. Hand calculations for structural analysis
    a. Determined loads
    b. Picked preliminary beam, column, and decking sizes

3. Use of Sap 2000 for complete structural analysis
    a. Determined actual sizes of beams and columns
    b. Picked “best” types of connections
3. Research lighting design
4. Secondary wind load determination
    a. Based on 90 mph wind
    b. Based on thickness of Plexi-glass

6. Soil Mechanics
    a. Soil classification based on assumption of typical soil for location
    b. Performed the Sand Cone Test
6. Foundation design
    a. Based on column size
    b. Based on load from hand calculations
    c. Based on soil mechanics

Group II

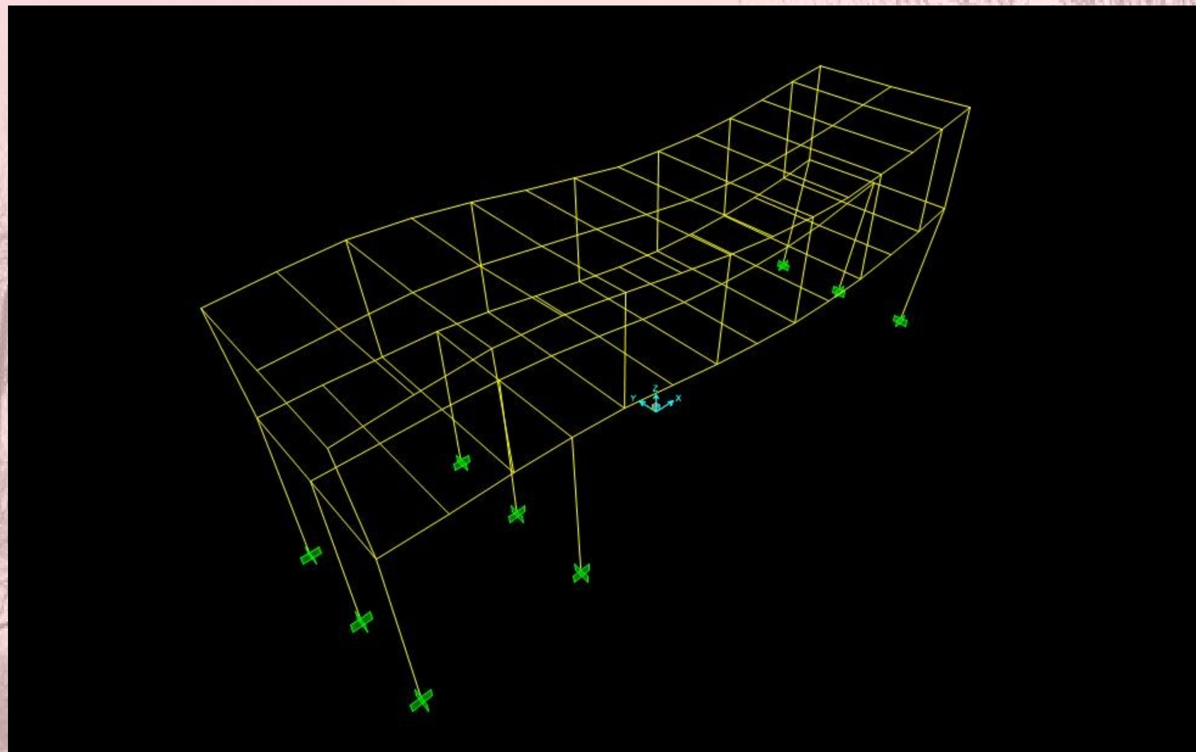


Figure 5 – Maximum Deformation

Group II

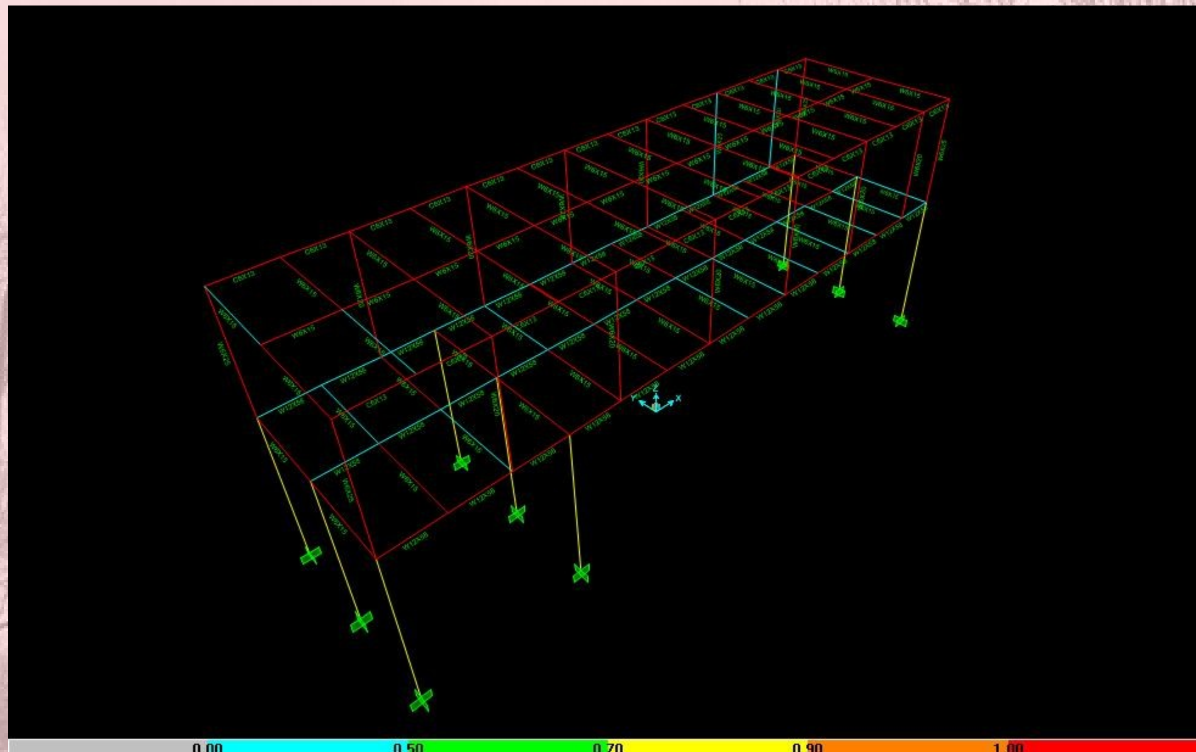


Figure 6 – Steel Frame Design