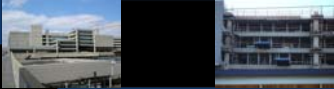



**UNION STATION EXPANSION**



WASHINGTON DC

**SIGNATURE EXPRESSION**



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S.A.E./M.A.E. CANDIDATE  
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**PRESENTATION GUIDELINE**

- EXISTING
- HISTORY
- THESES
- SIGNATURE
- ARCHITECTURE
- LIGHTING
- CONCLUSION

LOCATION



\* Located Within Block 720 Along H Street Overpass in Washington DC (1.5 Miles From Capitol Hill)

\* CM-3 Zoning Area (High Built Commercial & Manufacturing)

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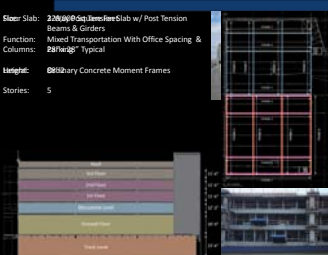
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LOCATION  
BUILDING STATISTICS

**BUILDING STATISTICS**

Slab: 230W@60x10mm-PreSlab w/ Post Tension Beams & Girders  
Function: Mixed Transportation With Office Spacing & Columns: 28'x28' Typical  
Height: 68'0" - 90'0" Concrete Moment Frames  
Stories: 5



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**HISTORY**

- Existing Portion Of Union Station Was Built In The Mid 1900's
- Glass Curtain Wall
- Designed For Travelers To View The City of Washington DC
- Office Spaces Share The View



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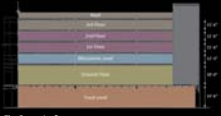
### PRESENTATION GUIDELINE

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### PROPOSAL

Design Considerations For Expansion (Design Firm)

- Long Spans Due To Track Level & Ground Floor
- Weight Of Building
- Minimum Slab Thickness
- Circulation



What About An Expression For The Expansion?

**THEIR** IS THE ONLY EXPRESSION THAT WILL MAKE THE EXPANSION STAND OUT AS A SEPARATE BUILDING

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### GOALS

1. Redesign Mezzanine through Third Floor With A New Floor System
2. Design A Transfer System Using Trusses
  - Signature Expression Of Structural Engineering & Architecture
3. Incorporate Brace Frames As Lateral System
4. Verify Support of Foundation
5. Determine Vehicular Circulation For Bus Terminal
6. Move Waiting Terminals / Ticket Reception Areas
7. Incorporate New Lighting Schemes
  - Inside
  - Waiting Terminal



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### DEPTH & BREADTHS


**PROPOSAL**

**GOALS**

**DEPTH & BREADTHS**

**Structural Depth (Structural)**

- Composite Steel Floor System
- Location Of Trusses
- Design Of Trusses (Architecture Breadth)
- Loads Within Members Of Trusses
- Preliminary Member Sizes For Trusses
- Curved Trussion Members
- Lateral Restraint System
- Steel Connections (M.A.S. Criteria)
- Final Member Sizes For Trusses


**Architectural Breadth (Architecture)**

- Wholular Circulation
- Heating Elements
- Ground Floor Plan

**Lighting Breadth (Lighting)**

- Illumination Of Trusses
- Luminaire For Working Terminal
- Luminaire Method

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### PRESENTATION GUIDELINE

- EXISTING
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### FLOOR SYSTEM

**FLOOR SYSTEM**

TRUSS LOCATION

TRUSS DESIGN

FORCES WITHIN TRUSSES

PRELIMINARY SIZES

CURVED MEMBERS

LATERAL SYSTEM

CONNECTIONS

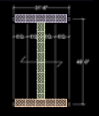
FINAL MEMBER SIZES

**Metal Deck**

- W16x17 1/2 Metal Deck Selected (Weight = 51 psf)
- Slab Thickness = 5 1/2"
- Existing Slab Thickness = 7 1/2" (Reduction of 1 1/2")

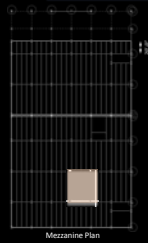
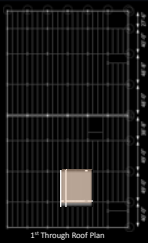
**Beams & Girders**

- Designated using LRF (1.2D + 1.6L + 0.5S)
- Partial Composite Design W/ Hand Calculations
- Full Composite Design W/ RAM



| Member [2nd] | Hand Calculations | RAM          |
|--------------|-------------------|--------------|
| Beam         | W24x55 <240>      | W18x60 <400> |
| Girder (6)   | W24x68 <42>       | W24x74 <382> |
| Girder (9)   | W24x68 <42>       | W24x74 <382> |

| Level     | Column Line K | Column Line M |
|-----------|---------------|---------------|
| 3rd       | W14x62        | W14x74        |
| 2nd       | W14x62        | W14x74        |
| 1st       | W14x62        | W14x74        |
| Mezzanine | W14x74        | W14x74        |

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- FLOOR SYSTEM
- TRUSS LOCATION
- TRUSS DESIGN
- FORCES WITHIN TRUSSES
- PRELIMINARY SIZES
- CURVED MEMBERS
- LATERAL SYSTEM
- CONNECTIONS
- FINAL MEMBER SIZES

Mezzanine Level vs. Ground Floor

|                              | Mezzanine | Ground |
|------------------------------|-----------|--------|
| Grid Attention               | Yes       | Yes    |
| Proper Location For Transfer | Yes       | Yes    |
| Enough Clearance             | No        | Yes    |
| Viewed Majority Of Day       | No        | Yes    |

Trusses Will Be Located On Ground Floor  
9 Trusses To Be Designed

### TRUSS LOCATION

MEZZANINE PLAN  
1ST THROUGH ROOF PLAN

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- TRUSS LOCATION
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- FORCES WITHIN TRUSSES
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- FINAL MEMBER SIZES

### TRUSS DESIGN

1st Iteration

- Tension Rods As Outer Bracing
- Double Angles As Inner Bracing

Design Flaws

- Buckling In Tension Rods
- Significant Deflection In Outer Segments

2nd Iteration

- Tension Rods As Outer Bracing
- Double Angles As Inner Bracing
- HSS Shapes For Columns
- Wide Flanges For Bottom Chords

Design Flaws

- Diagonal Bracing Congested
- Looks Typical

Final Iteration

- Removed Zero Force Members
- Re-Shaped As Center Bracing
- WT Shape As Top Chords

Design Flaws

- How Will Buses Travel Under?

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### PRESENTATION GUIDELINE

- EXISTING
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- ARCHITECTURE
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- CONCLUSION

Exterior Truss

Interior Truss

### TRUSS DESIGN

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### PRESENTATION GUIDELINE

- EXISTING
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- ARCHITECTURE
- LIGHTING
- CONCLUSION

| Forces in Truss & Members (kips) |               |               |                |
|----------------------------------|---------------|---------------|----------------|
| 21,443.43 [C]                    | 8,238.05 [C]  | 11,904.22 [C] | 148,655.10 [T] |
| 21,443.43 [C]                    | 7,126.09 [T]  | 12,752.34 [C] | 171,616.30 [C] |
| 3,126.08 [C]                     | 8,648.68 [T]  | 13,307.83 [C] | 148,559.25 [C] |
| 4,226.03 [C]                     | 8,992.28 [C]  | 12,206.93 [C] | 170,248.76 [T] |
| 17,332.03 [C]                    | 10,274.80 [C] | 13,538.70 [T] | 153,320.81 [T] |

### FORCES WITHIN TRUSSES

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### PRESENTATION GUIDELINE

EXISTING

HISTORY

THESIS


SIGNATURE

ARCHITECTURE

LIGHTING


CONCLUSION

- FLOOR SYSTEM
- TRUSS LOCATION
- TRUSS DESIGN
- FORCES WITHIN TRUSSES
- PRELIMINARY SIZES
- CURVED MEMBERS
- LATERAL SYSTEM
- CONNECTIONS
- FINAL MEMBER SIZES

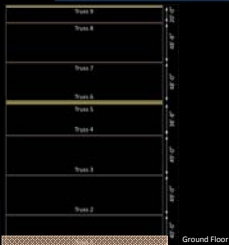


| Truss Members | 1             | 2                 | 3                 | 4              | 5              | 6                 | 7                 | 8              | 9              | 10                |
|---------------|---------------|-------------------|-------------------|----------------|----------------|-------------------|-------------------|----------------|----------------|-------------------|
| 1) WT 15x95.5 | 6) WT 15x95.5 | 11) W14x99        | 16) 10 2" x 8 Rod | 21) WT 15x95.5 | 26) WT 15x95.5 | 31) W14x99        | 36) 10 2" x 8 Rod | 41) WT 15x95.5 | 46) WT 15x95.5 | 51) W14x99        |
| 2) WT 15x95.5 | 7) W16x31     | 12) W14x99        | 17) W16x45        | 22) WT 15x95.5 | 27) W16x31     | 32) W14x99        | 37) W16x45        | 42) WT 15x95.5 | 47) W16x31     | 52) W14x99        |
| 3) WT 15x95.5 | 8) W16x31     | 13) W14x99        | 18) W16x45        | 23) WT 15x95.5 | 28) W16x31     | 33) W14x99        | 38) W16x45        | 43) WT 15x95.5 | 48) W16x31     | 53) W14x99        |
| 4) WT 15x95.5 | 9) W16x45     | 14) W14x99        | 19) 10 2" x 8 Rod | 24) WT 15x95.5 | 29) W16x45     | 34) W14x99        | 39) 10 2" x 8 Rod | 44) WT 15x95.5 | 49) W16x45     | 54) 10 2" x 8 Rod |
| 5) WT 15x95.5 | 10) W14x99    | 15) 10 2" x 8 Rod | 20) 10 2" x 8 Rod | 25) WT 15x95.5 | 30) W14x99     | 35) 10 2" x 8 Rod | 40) 10 2" x 8 Rod | 45) WT 15x95.5 | 50) W14x99     | 55) 10 2" x 8 Rod |

- AISC Steel Manual Tables Used in Determining Preliminary Sizes
  - Gaining Table 4-1
  - AISC Table 5-1
  - Top Chords Table 4-2
  - Bracing Table 5-3



### PRELIMINARY SIZES



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### PRESENTATION GUIDELINE

EXISTING

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CONCLUSION

- FLOOR SYSTEM
- TRUSS LOCATION
- TRUSS DESIGN
- FORCES WITHIN TRUSSES
- PRELIMINARY SIZES
- CURVED MEMBERS
- LATERAL SYSTEM
- CONNECTIONS
- FINAL MEMBER SIZES



- Curved Tension Members Must be Checked for Moment That Wants The Member to Go Into Compression
- Divided Members into 25 Equal Pieces Along The Radius

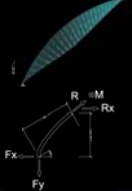
Looking At Truss 2

- Max M<sub>x</sub> = 1144.60 ft-k
- Occurs Within Section 11 of Member
- Preliminary Size is HD 10.0x6.500


Using AISC Steel Manual [Table 4-5]

- R = 13.5
- KL = 23.42
- C<sub>p</sub> = .942 R<sub>x</sub> > 8 Therefore Ok

FSS 10.0x6.500 IS Acceptable



### CURVED MEMBERS



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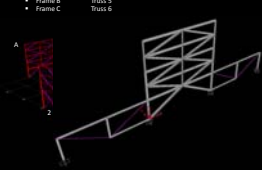
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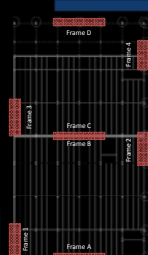
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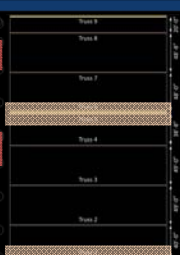
- FLOOR SYSTEM
- TRUSS LOCATION
- TRUSS DESIGN
- FORCES WITHIN TRUSSES
- PRELIMINARY SIZES
- CURVED MEMBERS
- LATERAL SYSTEM
- CONNECTIONS
- FINAL MEMBER SIZES

- Steel Brace Frames Will Act As New Lateral System
- Location Of Frames Is To Prevent Any Problems W/ Vehicular Circulation
- 3 Frames Are Part Of Trusses
  - Frame A Truss 5
  - Frame B Truss 6
  - Frame C Truss 5





### LATERAL SYSTEM



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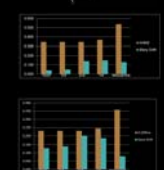
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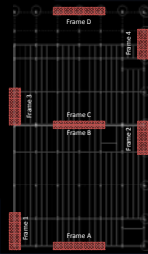
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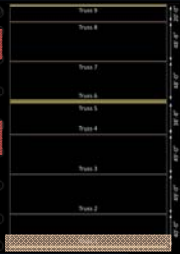
- FLOOR SYSTEM
- TRUSS LOCATION
- TRUSS DESIGN
- FORCES WITHIN TRUSSES
- PRELIMINARY SIZES
- CURVED MEMBERS
- LATERAL SYSTEM
- CONNECTIONS
- FINAL MEMBER SIZES

- ASCE 7-05 Used In Determining Wind & Seismic Criteria
- Preliminary Member Sizes Were Determined In RAM For Brace Frames
- Wide Flange Columns And Bracing That Are Part Of The Trusses Were Resized To Handle Lateral Forces
- SAP Was Used To Determine The Story Drifts



### LATERAL SYSTEM



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- CONCLUSION

**Plan Connections:**

- AISC Steel Connection Catalog
- Fabrication Manual: Angle/Boiler/Of Plate
- Table 9-5: Welded Flange-Beam Manual
- 2500K Electric Load

### CONNECTIONS

- Each Truss Consists Of 26 Connections
- Three Types Of Connections:
  - Pin
  - Heavy Brace
  - Gusset Plate
- All Connection Designs Followed AISC Criteria

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- CONCLUSION

**Heavy Brace Connection**

### CONNECTIONS

- Each Truss Consists Of 26 Connections
- Three Types Of Connections:
  - Pin
  - Heavy Brace
  - Gusset Plate
- All Connection Designs Followed AISC Criteria

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- EXISTING
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- ARCHITECTURE
- LIGHTING
- CONCLUSION

| Final 1 Members |               |                      |                      |
|-----------------|---------------|----------------------|----------------------|
| 1) WT 15x95.5   | 6) WT 15x95.5 | 11) W14x159          | 16) 10" x 2" x 8 Rod |
| 2) WT 15x95.5   | 7) W16x31     | 12) W14x159          | 17) W14x257          |
| 3) WT 20x255.5  | 8) W16x31     | 13) W14x99           | 18) W14x257          |
| 4) WT 20x255.5  | 9) W14x99     | 14) W14x99           | 19) 10" x 2" x 8 Rod |
| 5) WT 15x95.5   | 10) W14x99    | 15) 10" x 2" x 8 Rod | 20) 10" x 2" x 8 Rod |

Final Member Sizes Were the Same As The Preliminary Ones Except:

- Member 3 & 4: WT15x95.5 To WT20x255.5
- Member 15 & 20: W14x99 To W14x159
- Member 17 & 18: W14x145 To W14x257

### FINAL MEMBER SIZES

| Final 2 Members |                |                      |                      |
|-----------------|----------------|----------------------|----------------------|
| 1) WT 15x130.5  | 6) WT 15x130.5 | 11) W14x176          | 16) 10" x 2" x 8 Rod |
| 2) WT 15x130.5  | 7) W16x31      | 12) W14x176          | 17) 10" x 2" x 8 Rod |
| 3) WT 15x130.5  | 8) W16x31      | 13) W14x176          | 18) 10" x 2" x 8 Rod |
| 4) WT 15x130.5  | 9) W14x176     | 14) W14x176          | 19) 10" x 2" x 8 Rod |
| 5) WT 15x130.5  | 10) W14x176    | 15) 10" x 2" x 8 Rod | 20) 10" x 2" x 8 Rod |

All Final Member Sizes Were the Same As The Preliminary

Moment Within Tension Bracing Does Not Increase The Size of The HSS Member

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### VEHICULAR CIRCULATION

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- EXISTING
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- ARCHITECTURE**
  - VEHICULAR CIRCULATION
  - WAITING TERMINALS
- LIGHTING
- CONCLUSION

**WAITING TERMINALS**

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**PRESENTATION GUIDELINE**

- EXISTING
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- LIGHTING**
  - ILLUMINATION OF TRUSSES
  - LUMINARIES
  - LUMEN METHOD
- CONCLUSION

**ILLUMINATION OF TRUSSES**

**Truss Selection**

- Trusses Selected To Highlight The Tower's Form From 9' Stairs Up
- Select Columns With Base Plate Supports For A Height Of 18'-0"
- Rowing Used To Highlight The Marjorie's Column Base Tower Is Inside The Four Foot Stairs Will Be Placed At Each 3'-0" Segment Of The Trusses
- LEDs Are Only Intended For Illuminating The Trusses

| Height | Area | Volume |
|--------|------|--------|
| 0'     | 0    | 0      |
| 3'     | 108  | 324    |
| 6'     | 432  | 2592   |
| 9'     | 972  | 8748   |
| 12'    | 1620 | 19440  |
| 15'    | 2376 | 35625  |
| 18'    | 3240 | 58320  |

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### PRESENTATION GUIDELINE

- EXISTING
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  - ILLUMINATION OF TAUSSES
  - LUMINARIES
  - LUMEN METHOD
- CONCLUSION


### LUMINARIES

- Illuminance Categories Found In Chapter 10 IESNA Design Manual
- Ticket Counters Will Be Located In The Waiting Terminals
- Min Of 50 fc Required For Waiting Terminals

| Conditions & Required Foot Candles |                    |         |      |         |      |
|------------------------------------|--------------------|---------|------|---------|------|
| Area                               | Working Conditions | Minimum | Best | Optimum | Dark |
| Classrooms                         | 1                  | 8       | 14   | 18      | 12   |
| Small Lecture                      | 2                  | 5       | 8    | 10      | 10   |



- SELECTED THE AVANTE 2x4 DIRECT/INDIRECT LIGHTING LUMINAIRE
- 3 TB 32 WATT LAMPS WILL BE USED
- SELECTED A SYLVANIA QMC 3x32 T8 LUV I SH-DC BALLAST (FACTOR OF 1.38)



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  - ILLUMINATION OF TAUSSES
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  - LUMEN METHOD
- CONCLUSION

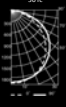
### LUMEN METHOD

Waiting Terminal One

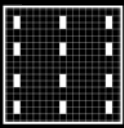
- 15' x 15' OF Ceiling
- 10' High Recessed Ceiling
- 2'x2' Ceiling Grid Used

Procedure:

- Ceiling Height: Ceiling = 0ft, Room = 6.5ft
- Floor (Work Plane) = 3.5ft
- Used REFINED ALL Ceiling Reflectance Values
- Coefficient Of Utilization = 0.67
- Light Loss Factor = 0.978
- From Calculations 12.98 Luminaires Needed for 50fc



| Coefficients of utilization |      |      |      |
|-----------------------------|------|------|------|
| Room                        | 0.5  | 0.7  | 0.9  |
| 1                           | 0.15 | 0.20 | 0.25 |
| 2                           | 0.16 | 0.21 | 0.26 |
| 3                           | 0.17 | 0.22 | 0.27 |
| 4                           | 0.18 | 0.23 | 0.28 |
| 5                           | 0.19 | 0.24 | 0.29 |
| 6                           | 0.20 | 0.25 | 0.30 |
| 7                           | 0.21 | 0.26 | 0.31 |
| 8                           | 0.22 | 0.27 | 0.32 |
| 9                           | 0.23 | 0.28 | 0.33 |
| 10                          | 0.24 | 0.29 | 0.34 |
| 11                          | 0.25 | 0.30 | 0.35 |
| 12                          | 0.26 | 0.31 | 0.36 |
| 13                          | 0.27 | 0.32 | 0.37 |
| 14                          | 0.28 | 0.33 | 0.38 |
| 15                          | 0.29 | 0.34 | 0.39 |
| 16                          | 0.30 | 0.35 | 0.40 |
| 17                          | 0.31 | 0.36 | 0.41 |
| 18                          | 0.32 | 0.37 | 0.42 |
| 19                          | 0.33 | 0.38 | 0.43 |
| 20                          | 0.34 | 0.39 | 0.44 |
| 21                          | 0.35 | 0.40 | 0.45 |
| 22                          | 0.36 | 0.41 | 0.46 |
| 23                          | 0.37 | 0.42 | 0.47 |
| 24                          | 0.38 | 0.43 | 0.48 |
| 25                          | 0.39 | 0.44 | 0.49 |
| 26                          | 0.40 | 0.45 | 0.50 |
| 27                          | 0.41 | 0.46 | 0.51 |
| 28                          | 0.42 | 0.47 | 0.52 |
| 29                          | 0.43 | 0.48 | 0.53 |
| 30                          | 0.44 | 0.49 | 0.54 |
| 31                          | 0.45 | 0.50 | 0.55 |
| 32                          | 0.46 | 0.51 | 0.56 |
| 33                          | 0.47 | 0.52 | 0.57 |
| 34                          | 0.48 | 0.53 | 0.58 |
| 35                          | 0.49 | 0.54 | 0.59 |
| 36                          | 0.50 | 0.55 | 0.60 |
| 37                          | 0.51 | 0.56 | 0.61 |
| 38                          | 0.52 | 0.57 | 0.62 |
| 39                          | 0.53 | 0.58 | 0.63 |
| 40                          | 0.54 | 0.59 | 0.64 |
| 41                          | 0.55 | 0.60 | 0.65 |
| 42                          | 0.56 | 0.61 | 0.66 |
| 43                          | 0.57 | 0.62 | 0.67 |
| 44                          | 0.58 | 0.63 | 0.68 |
| 45                          | 0.59 | 0.64 | 0.69 |
| 46                          | 0.60 | 0.65 | 0.70 |
| 47                          | 0.61 | 0.66 | 0.71 |
| 48                          | 0.62 | 0.67 | 0.72 |
| 49                          | 0.63 | 0.68 | 0.73 |
| 50                          | 0.64 | 0.69 | 0.74 |
| 51                          | 0.65 | 0.70 | 0.75 |
| 52                          | 0.66 | 0.71 | 0.76 |
| 53                          | 0.67 | 0.72 | 0.77 |
| 54                          | 0.68 | 0.73 | 0.78 |
| 55                          | 0.69 | 0.74 | 0.79 |
| 56                          | 0.70 | 0.75 | 0.80 |
| 57                          | 0.71 | 0.76 | 0.81 |
| 58                          | 0.72 | 0.77 | 0.82 |
| 59                          | 0.73 | 0.78 | 0.83 |
| 60                          | 0.74 | 0.79 | 0.84 |
| 61                          | 0.75 | 0.80 | 0.85 |
| 62                          | 0.76 | 0.81 | 0.86 |
| 63                          | 0.77 | 0.82 | 0.87 |
| 64                          | 0.78 | 0.83 | 0.88 |
| 65                          | 0.79 | 0.84 | 0.89 |
| 66                          | 0.80 | 0.85 | 0.90 |
| 67                          | 0.81 | 0.86 | 0.91 |
| 68                          | 0.82 | 0.87 | 0.92 |
| 69                          | 0.83 | 0.88 | 0.93 |
| 70                          | 0.84 | 0.89 | 0.94 |
| 71                          | 0.85 | 0.90 | 0.95 |
| 72                          | 0.86 | 0.91 | 0.96 |
| 73                          | 0.87 | 0.92 | 0.97 |
| 74                          | 0.88 | 0.93 | 0.98 |
| 75                          | 0.89 | 0.94 | 0.99 |
| 76                          | 0.90 | 0.95 | 1.00 |



12 Luminaires Will Be Used For Waiting Terminal

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- EXISTING
- HISTORY
- THESIS
- SIGNATURE
- ARCHITECTURE
- LIGHTING
- CONCLUSION**

**GOALS**  
 **ACKNOWLEDGEMENTS**

### GOALS

1. Redesign Mezzanine through Third Floor With A New Floor System ✓
2. Design A Transfer System Using Trusses ✓
  - Signature Expression Of Structural Engineering & Architecture
3. Incorporate Brace Frames As Lateral System ✓
4. Verify Support of Foundation ✓
5. Determine Vehicular Circulation For Bus Terminal ✓
6. Move Waiting Terminals / Ticket Reception Areas ✓
7. Incorporate New Lighting Schemes ✓
  - Trusses
  - Waiting Terminal

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**CRITERIA GOALS**  
 **ACKNOWLEDGEMENTS**

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- Dr. Monrad Lighting
- The Entire Ad Faculty & Staff

Family

- C. Wilcher
- J. Wilcher
- M. Wilcher
- The Rest Of My Family

Friends

- Thank You For Your Support



50' Year Architectural Engineering Class

- Thank You For All Of Your Help & Good Times

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| QUESTIONS   | COMMENTS  |
|---|---|
|  |  |