PROPOSED

LAFAYETTE COLLEGE

CEERC

Civil & Environmental Engineering Research Center
-

Report 6

Hummel Building - Structural Design Report

Site
Former Hummel Lumber Supply at 900 Bushkill Drive
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City of Easton, Northampton County, Pennsylvania
Group Name Analysis Table of Contents

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I Design Loads

I.1 Dead Loads

<table>
<thead>
<tr>
<th>Unit weight</th>
<th>12.5 psf</th>
<th>VARIED</th>
<th>VARIED</th>
<th>VARIED</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Existing Wood Deck</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Beams</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Joists</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Columns</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

I.2 Live Loads

<table>
<thead>
<tr>
<th>Uniform</th>
<th>100 psf</th>
<th>125 psf</th>
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</thead>
<tbody>
<tr>
<td>1. Variable Use Office Space*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Light Manufacturing</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*100 psf live load was chosen to conservatively estimate that any portion of the floor may be corridor.

I.3 Roof Loads

<table>
<thead>
<tr>
<th></th>
<th>Dead</th>
<th>Live</th>
<th>Snow</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Edge Column</td>
<td>66.25 k</td>
<td>32 k</td>
<td>7.36 k</td>
</tr>
<tr>
<td>2. Corner Column</td>
<td>33.12 k</td>
<td>16 k</td>
<td>3.68 k</td>
</tr>
</tbody>
</table>

II Retrofit Design

II.1 Structure Lab Beam Retrofit Design – 40 ft Span

Beam 5 – typical

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Tributary width</td>
<td>8 ft</td>
<td></td>
</tr>
<tr>
<td>$W_u$, uniform floor load</td>
<td>1.4 klf</td>
<td></td>
</tr>
<tr>
<td>$P_u$, point loads from columns above</td>
<td>19.6 kips</td>
<td></td>
</tr>
<tr>
<td>$M_u$ (excluding self weight of reinforcement)</td>
<td>515.2 kip-ft</td>
<td></td>
</tr>
<tr>
<td>$M_u/2$ (1 beam on either side of existing wood)</td>
<td>257.6 kip-ft</td>
<td></td>
</tr>
</tbody>
</table>

From Table 3-2 in AISC Manual 2013 Edition

$W_{16x40} \Phi_b M_n = 274 \text{ kip-ft}$

Check selfweight – Corrected $M_u$

$265.6 \text{ kip-ft}$

Alternative Beam Design

Use prefabricated steel joists to reduce tributary with to interior beams and columns on floors 1 and 2.
Beam:
Tributary Width 4 ft
W_u, uniform floor load 0.7 klf
P_u, point loads from columns above 9.8 kips
M_u (excluding self weight of reinforcement) 257.6 kip-ft
M_u/2 (1 beam on either side of existing wood) 128.8 kip-ft

From Table 3-2 in AISC Manual 2013 Edition
W12x26 \( \Phi_b M_n = 140 \) kip-ft

Check selfweight – Corrected M_u 133.8 kip-ft

Joist
Tributary Width 2 ft
W_u, uniform floor load 0.35 klf

From New Millennium Joist Tables
22K5 Joists at 2 ft center to center spacing

II.2 Typical 2 Bay Beam Reinforcement – 28 ft Span

Beam 5 – typical

Tributary width 8 ft
W_u, uniform floor load 1.4 klf
P_u, point loads from columns above 19.6 kips
M_u (excluding self weight of reinforcement) 271.6 kip-ft
M_u/2 (1 beam on either side of existing wood) 135.8 kip-ft

From Table 3-2 in AISC Manual 2013 Edition
W12x26 \( \Phi_b M_n = 140 \) kip-ft

Check selfweight – Corrected M_u 138.4 kip-ft

II.3 Column Reinforcement

Perimeter Columns – A2,A3,A4,A6,A5,A7,D10,D12,D13

Tributary Area 123.68 ft.\(^2\)
Floor Height 10 ft.
P_u 184.87 kips

From Euler buckling analysis
2C6 x 10.5 \( \Phi P_n = 223.15 \) kips

Perimeter Columns A8,A10,A12,D8
Tributary Area
Floor Height
$P_u$

48.8 ft.$^2$
10 ft.

From Euler buckling analysis
$2C6 \times 8.2$

$\Phi P_n = 177.47$ kips

**Perimeter Columns D4 – D7**

Tributary Area
Floor Height
$P_u$

48.8 ft.$^2$
10 ft.

From Euler buckling analysis
$2C6 \times 8.2$

$\Phi P_n = 177.47$ kips

**Perimeter Columns B1, B14, C1, C14**

Tributary Area
Floor Height
$P_u$

102 ft.$^2$
10 ft.

From Euler buckling analysis
$2C6 \times 8.2$

$\Phi P_n = 177.47$ kips

**Corner Columns A1, A14, D14**

Tributary Area
Floor Height
$P_u$

24.4 ft.$^2$
10 ft.

From Euler buckling analysis
$2C6 \times 8.2$

$\Phi P_n = 177.47$ kips

**Interior Columns – B10, B12, B13**

Tributary Area
Floor Height
$P_u$

173 ft.$^2$
10 ft.

From Euler buckling analysis
$2C6 \times 8.2$

$\Phi P_n = 177.47$ kips

**II.4 Loading Bay – New Steel Design**
Loading

Dead Load 50 psf
Live Load (Light Manufacturing) 125 psf

Typical Beam

Tributary width 8 ft
\( W_u \), uniform floor load 2.08 klf
\( M_u \) (including self weight) 204 kip-ft

From Table 3-2 in AISC Manual 2013 Edition
W12x26 \( \Phi_b M_n = 223 \) kip-ft

*Increased capacity of this beam due to composite action*

Typical Column

Controlling Tributary Area 140.82 ft.\(^2\)
Floor Height 10 ft.
\( P_u \) 36.61 kips

From Table 4-1 in AISC Manual 2013 Edition
W8x31 \( \Phi_c P_n = 317 \) kip-ft

*Bending from an asymmetric tributary area was not analyzed, due to the allowable load being 8 times the applied, this can be assumed as being adequate*

Steel Decking with Concrete Slab

Clear Span (2 bays) 7.5 ft.

From VULCRAFT manual
1.5 VLR 22 Slab thickness- 3.5 in.

Shear Studs ¾ in. studs 1ft. C-C

II.5 Foundation Recommendation

Soil conditions and existing foundations are unknown, so calculations could not been done. Due to the largely increased loads due to the green roof, more investigation of the foundation system of the building should been done to confirm that it is adequate for the loads. Recommendations for investigate are addition of concrete pilaters or intermidiate foundation system.
II.6 Existing Wood Column/Beam Analysis

Analysis of the adequacy of the existing wood column and beam structure was not completed due to lack of information on the type of wood and inexperience with wood design/analysis. Due to the increased loads on the structure, this analysis should be completed before final approval of the design. The structural plans do not include all features of the building, such as stair wells. These should be included and analyzed before final approval of the design.

II.7 Design Summary

The retrofit design included the reinforcement of beams, that instead of spanning only 12 ft. or 16 ft. were increased to 28 and 40 ft. spans. The loads used for this design were a live load of 100 psf (variable use office space) and a variable dead load. The beams spanning 28 ft. included reinforcing the existing wood beam with two I-beams (See Figure II.1). For the beams spanning 40 ft. in the structural lab, the retrofit also included reinforcing the existing wood beam with two I-beams and the addition of 22K5 joists spaced at 2 ft. center to center.

Due to the increased loads from both the green roof and increased tributary areas of the column, reinforcement was required. The loads used for this design were a live load of 100 psf (variable use office space) and a variable dead load. The design included reinforcing the existing wood columns with two steel C-Channels. The two sizes of C-Channels used were C6x8.2 and C6x10.5. See Figure II.2 for a detail of this reinforcement and Figure II.3 for detail of the connection of the reinforced beams and columns.

The design of the loading bay included the design of new steel columns and beams and steel decking with a concrete slab. See Figure II.4 for the plan view of the loading bay. The loads used for this design were a live load of 125 psf (light manufacturing) and a dead load of 50 psf. A W8x31 was found to be adequate for the columns and W12x26 was adequate for the beams. The thickness of the deck using the VULCRAFT manual was 3.5 inches and the adequate size and spacing of shear studs are ¾” studs at 1 ft. center to center spacing.
Figure II. 1: Detail of Beam Reinforcement

Figure II. 2: Detail of Column Reinforcement
Figure II. 3: Detail of Reinforced Beam to Column Connection
Figure II. 4: Plan View of Loading Bay