Technical Report 3

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Structural Option
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LA JOLLA COMMONS
PHASE II OFFICE TOWER
La Jolla Commons, San Diego, California
• La Jolla Commons Phase II Office Tower
• Height | 198’ 8” (13 stories)
• Square Footage | 462,301 GSF
• Location | San Diego, California
  o Seismic Design Category D
• Office Building
  o Multi-tenant capabilities
  o First Class A NetZero Office Building in the USA
• Special Features
  o Underfloor Air Distribution System
  o 15 foot cantilevers at both ends
Existing Structural System

- **Mild reinforced, cast-in-place concrete structure**
- **Mat Foundation**
  - Thickness ranges from 3 ft to 6.5 ft
- **Gravity System**
  - Two-way, flat plate, reinforced concrete slab supported by a rectangular grid of concrete columns
  - Slab camber
  - Spandrel beam around slab edge
- **Lateral System**
  - Specially reinforced concrete shear walls
  - Collector beams in NS direction - levels below grade
- **Special Features**
  - 15 foot cantilevers at the North and South ends
  - Steel framed mechanical penthouse
Typical Bay and Columns
Typical Bay - Details

- 14 inch two-way slab
- 30 ft x 42 ft from centerline to centerline of columns
- 2 1/4” camber at mid-span
- 24” x 24” columns (at exterior)
- 18” spandrel beam, 4.5 feet wide
- Column strip and middle strip called out
Gravity Spot Checks: Punching Shear

- **Deflection Control:**
  - Table 9.5(c) - ACI 318-11
  - $h_{min} = 14.4'' < h_{provided} = 14''$
  - FAILED! (camber used)

- **Punching Shear – Edge Column K1**
  - Punching shear critical section through $h=18''$
  - $\Phi V_c = 358k > V_u=187k \rightarrow OK!$
  - PASSED!

- **Punching Shear – Interior Column E4**
  - Punching shear critical section through $h=14''$
  - $\Phi V_c = 481.8k > V_u=427.6k \rightarrow OK!$
  - PASSED!
Gravity Spot Checks: One-Way Shear

- **One-Way Shear - 30’ direction:**
  - Shear through $h=18”$
  - $\Phi V_c = 643k > V_u=144k \Rightarrow OK!$
  PASSED!

- **One-Way Shear – 15’ 10” direction:**
  - Shear through $h=18”$
  - $\Phi V_c = 340k > V_u=80k \Rightarrow OK!$
  PASSED!
Gravity Spot Checks: Moment Capacity

- Moment Capacity – Column Line K:
  - Checks failed when column strip and middle strip were analyzed separately
    - \( @M+ \text{ Middle Strip: } 693 \text{ ft-k} \gg \phi M_n = 573.6 \text{ ft-k} \)
  - Column strip and middle strip were combined for moment capacity checks
    - \( @ M_u+ = 1155 \text{ ft-k} < \phi M_n = 1113 \text{ ft-k} \)
    - \( @ M_u- \text{ Interior Column} = 1555 \text{ ft-k} < \phi M_n = 1630 \text{ ft-k} \)
    - \( @ M_u- \text{ Exterior Column} = 578 \text{ ft-k} < \phi M_n = 1039 \text{ ft-k} \)
      PASSED!
Gravity Spot Checks: Moment Capacity

- **Moment Capacity – Column Line 1:**

  - Check of $M_u^-$ of *Combined* C.S. and M.S.
    - $M_u^- = 512 \text{ ft-k} > \phi M_n = 426 \text{ ft-k}$
    - However, edge beam was not accounted for... most likely would pass if this was included in analysis

  - Check of $M_u^+$ of *Combined* C.S. and M.S.
    - $M_u^+ = 276 \text{ ft-k} >> \phi M_n = 715 \text{ ft-k}$
    - PASSED!
### Gravity Spot Checks: Summary

<table>
<thead>
<tr>
<th>Check</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two-Way Shear</td>
<td>Pass</td>
</tr>
<tr>
<td>One-Way Shear</td>
<td>Pass</td>
</tr>
<tr>
<td>Moment Capacity</td>
<td>Pass (if combined)</td>
</tr>
</tbody>
</table>
Alternate Floor System Designs

- Floor System Design #1: Non-Composite Steel
- Floor System Design #2: Composite Steel
- Floor System Design #3: One Way Concrete Slab
Alternate Design 1: Non-Composite Steel

D1: 2 VLI 18, 4.5 inch NW concrete topping
Alternate Design 1: Non-Composite Steel

- **Increase in overall system depth**
  - Original: 18” maximum slab thickness
  - New: 30” beam depth + 6.5” slab = **36.5”**

- **Fire Protection/Fire ratings**
  - Fireproofing required on beams & bottom of deck
  - 4.5” topping for **2 hr** fire rating

- **Cost using R.S. Means Assembly B1010**
  - 254 → **$38.19/SF**

- **System Weight** → **80.6 PSF**

- **Durability** → This assembly is used often in office spaces and can handle the normal wear and tear of this occupancy
Alternate Design 1: Non-Composite Steel

- Lateral System Options:
  (seismic detailing)
  - Reinforced Concrete Shear Walls
    - Efficient, laid out in existing system at elevator and stair core
  - Steel Moment Frame
    - Integrate around exterior in conjunction with core shear walls for additional stiffness
    - Not efficient alone
  - Steel Braced Frame
    - Braces would obstruct office space and/or facade.

- Conclusion:
  - Viable Option
  - Will integrate well with architecture
  - Options for lateral systems will work for high seismic loading
  - Lighter than existing system
Alternate Design 2: Composite Steel

**Details:**
- 2 YVL1 18, 4.5 inch NW Concrete topping
- W12 x 26 (24)
- W14 x 26 (28)
- W14 x 26 (28)
- 30'-0"
Alternate Design 2: Composite Steel

- Increase in overall system depth
  - Original: 18” maximum slab thickness
  - New: 30” beam depth + 6.5” slab = 36.5”

- Fire Protection/Fire ratings
  - Fireproofing required on beams & bottom of deck
  - 4.5” topping for 2 hr fire rating

- Cost using R.S. Means Assembly B1010
  - 256 → $25.50/SF

- System Weight → 79.3 PSF

- Durability → This assembly is used often in office spaces and can handle the normal wear and tear of this occupancy
Alternate Design 2: Composite Steel

Lateral System Options:
(seismic detailing)

- Reinforced Concrete Shear Walls
  - Efficient, laid out in existing system at elevator and stair core

- Steel Moment Frame
  - Integrate around exterior in conjunction with core shear walls for additional stiffness
  - Not efficient alone

- Steel Braced Frame
  - Braces would obstruct office space and/or facade

Conclusion:

- Viable Option
- Will integrate well with architecture
- Could possibly control depth with heavier beams
- Currently the lightest system
- Cheaper than non-composite steel
- Several lateral system options
Alternate Design 3: One-Way Slab System

Notes:
1. 4000 PSI, Normal Weight Concrete
2. Rebar $f_y = 60$ ksi and $f_{yt} = 60$ksi
Alternate Design 3: One-Way Slab System

- Increase in overall system depth
  - Original: 18” maximum slab thickness
  - New: 41” girder depth

- Fire Protection/Fire ratings
  - Fireproofing not required but minimum rebar cover must be met
  - Fire rating → Meets at least 2 hr requirement

- Cost using R.S. Means Assembly B1010 256 → $23.89/SF

- System Weight → 215.4 PSF

- Durability → This system can be very durable and has proven endurance in office spaces
Alternate Design 3: One-Way Slab System

**Lateral System Options:**
(seismic detailing required)

- Reinforced Concrete Shear Walls
  - Efficient, laid out in existing system at elevator and stair core

- Concrete Moment Frame
  - Relatively inefficient compared to shear walls
  - Potentially integrate with shear wall system

- Steel Frames – NOT ADVISED

**Conclusion:**

- **Not a Viable Option**
- High beam depths will significantly decrease floor to ceiling height
  - Beams were designed as \( b = \frac{4}{5}d \)
- Heaviest system
# Floor System Comparison

## Gravity Floor Systems

<table>
<thead>
<tr>
<th>Considerations</th>
<th>Flat-Plate Concrete Slab</th>
<th>Non-Composite Steel</th>
<th>Composite Steel</th>
<th>One-Way Concrete Slab</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maximum Depth</strong></td>
<td>18”</td>
<td>36.5”</td>
<td>36.5”</td>
<td>41”</td>
</tr>
<tr>
<td><strong>Fire Protection Required?</strong></td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td><strong>2 hr Fire Rating achieved?</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>System Statistics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cost Per Square Foot</strong></td>
<td>$21.53/SF</td>
<td>$38.19/SF</td>
<td>$25.50/SF</td>
<td>$23.89/SF</td>
</tr>
<tr>
<td><strong>System Weight</strong></td>
<td>180.4 PSF</td>
<td>80.6 PSF</td>
<td>79.8 PSF</td>
<td>215.4 PSF</td>
</tr>
<tr>
<td><strong>Durability</strong></td>
<td>Acceptable</td>
<td>Acceptable</td>
<td>Acceptable</td>
<td>Acceptable</td>
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<tr>
<td><strong>Future Design Considerations</strong></td>
<td></td>
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<tr>
<td><strong>Lateral System Options</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reinforced Concrete Shear Walls</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Steel Moment Frame</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Steel Braced Frame</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Concrete Moment Frame</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Advantages</strong></td>
<td>Maximum floor to ceiling heights, cheapest system, no fire protection required</td>
<td>Light system weight, several options for lateral system</td>
<td>Lightest system weight, several options for lateral system, system used in LJC Tower I</td>
<td>Same material as existing system, cheapest of alternative systems</td>
</tr>
<tr>
<td><strong>Disadvantages</strong></td>
<td>None</td>
<td>Most expensive system, fire protection required, large beam depth, fire protection required, Vibrations</td>
<td>Higher cost than concrete systems, large beam depth, fire protection required, vibrations</td>
<td>Heaviest system, large beam depth will significantly decrease floor to ceiling height</td>
</tr>
<tr>
<td><strong>Viable Option?</strong></td>
<td>N/A</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>
Any Questions?

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