Post-Tensioned Transfer Slab in Vertically Irregular Building

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DAELIM
A. PT Transfer Slab Application
PT Transfer Slab in High-rise Building

The Cullinan, Kowloon Hong Kong (68F)

Belcher Garden, Hong Kong (63F)
Pacific Place Building (VSL Hong Kong, 1988)

1st PT Transfer Slab
(Designed by Prof. Peter Marti)

- PT Transfer Slab Thickness 4.5m
- Rebar \((480\text{kg/m}^3 \rightarrow 180\text{kg/m}^3)\)
- Better Structural Performance
- Easier Construction
- Economy

Pacific Place Building (61F)
Pacific Place Building (VSL Hong Kong, 1988)

- Installation of Side Formwork
- Installation of Anchorage
- Installation of Reinforcement & Tendon
- Installation of Reinforcement & Tendon
# Pacific Place Building (VSL Hong Kong, 1988)

<table>
<thead>
<tr>
<th>Task Name</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Transfer Plate Construction (Day count after formwork are done)</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Transfer Plate Construction</td>
</tr>
<tr>
<td>2</td>
<td>Erect side formwork</td>
</tr>
<tr>
<td>3</td>
<td>Setting out of tendon</td>
</tr>
<tr>
<td>4</td>
<td>Fix column drop rebar</td>
</tr>
<tr>
<td>5</td>
<td>Concreting of column drops</td>
</tr>
<tr>
<td>6</td>
<td>Fix bottom rebar</td>
</tr>
<tr>
<td>7</td>
<td>Fix bottom tendon</td>
</tr>
<tr>
<td>8</td>
<td>Fix middle layer rebar</td>
</tr>
<tr>
<td>9</td>
<td>Fix middle layer tendon</td>
</tr>
<tr>
<td>10</td>
<td>Fix top layer tendon</td>
</tr>
<tr>
<td>11</td>
<td>Fix top layer rebar</td>
</tr>
<tr>
<td>12</td>
<td>Fix shear links</td>
</tr>
<tr>
<td>13</td>
<td>Concreting to Bottom Layer</td>
</tr>
<tr>
<td>14</td>
<td>CJ Treatment &amp; Curing for concrete to 30MPa</td>
</tr>
<tr>
<td>15</td>
<td>Fix Tower Wall / Column Starter Bar</td>
</tr>
<tr>
<td>16</td>
<td>Stressing for Bottom Tendon</td>
</tr>
<tr>
<td>17</td>
<td>Concreting to Top Layer Concrete</td>
</tr>
<tr>
<td>18</td>
<td>Construction of Tower</td>
</tr>
<tr>
<td>19</td>
<td>Curing for concrete to 30MPa</td>
</tr>
<tr>
<td>20</td>
<td>Stressing remaining tendons</td>
</tr>
<tr>
<td>21</td>
<td>Fix Tower Wall / Column Starter</td>
</tr>
<tr>
<td>22</td>
<td>Framework for 1/F slab basement</td>
</tr>
<tr>
<td>23</td>
<td>Fix 1/F Rebar</td>
</tr>
<tr>
<td>24</td>
<td>Concreting 1/F</td>
</tr>
</tbody>
</table>
B. PT Transfer Slab Design
NEST Hotel (DAELIM, 2014)

Vertically Irregular Structure _ Design Stage
NEST Hotel (DAELIM, 2014)

Vertically Irregular Structure _ Construction Stage
Post-Tensioned Transfer Slab (Cantilevered)

Why Post-Tensioning to Transfer Slab?

Gravity Load

Lateral Load

Structural Modeling by MIDAS

NEST Hotel (DAELIM, 2014)

Post-Tensioned Transfer Slab (Cantilevered)

Reduced $V_u$ by Deviation force

Tendon

Transfer Slab

Transfer Column

Deviation force

$V_u$
NEST Hotel (DAELIM, 2014)

Post-Tensioned Transfer Slab (Cantilevered)

Structural Modeling by ADAPT
NEST Hotel (DAELIM, 2014)

8F Cantilevered Transfer Slab _ Long-term Deflection Check

Distributed Tendon Profile (10EA_15.2mm@1,200)

\[ \delta = 23.3 \text{mm} \rightarrow \delta = 14.6 \text{mm} \ (-37\%) \]
(Limit : \( L/240 = 15.6 \text{mm}, \ L = 3,750 \text{mm} \))
NEST Hotel (DAELIM, 2014)

4F Cantilevered Transfer Slab _ Long-term Deflection Check

Distributed Tendon Profile
(8EA_15.2mm@1,000)

δ=16.7mm → δ=12.6mm (-25%)  
(Limit : L/240 = 17.5mm, L=4,200mm)
NEST Hotel (DAELIM, 2014)

4F Cantilevered Transfer Slab _ Initial & SLS Check

1) Initial Stage
   ① Tensile Stress : $0.25v_f\_{ci} = 1.17\,\text{MPa}$ ($f_{ci}=22\,\text{MPa}$)
   ② Comp. Stress : $0.6v_f\_{ci} = 13.2\,\text{MPa}$ ($f_{ci}=22\,\text{MPa}$)

2) Serviceability Stage
   ① Tensile Stress : $0.5v_f\_{ck} = 2.96\,\text{MPa}$ ($f_{ck}=35\,\text{MPa}$)
   ② Comp. Stress : $0.6v_f\_{ck} = 21\,\text{MPa}$ ($f_{ck}=35\,\text{MPa}$)
**NEST Hotel (DAELIM, 2014)**

4F Cantilevered Transfer Slab _ ULS Design

**Load Combination (KBC : Korean Building Code)**

- $1.4D$
- $1.2D + 1.6L$
- $1.2D \pm W + 1.0L$
- $0.9D \pm 1.3W$
- $1.2D \pm E_m + 1.0L$
- $0.9D \pm E_m$

**Equivalent Wall Line Load Calculation**

: $P/L \pm 6M/L^2$
4F Cantilevered Transfer Slab _ ULS Design

Special Earthquake Load  (KBC : Korean Building Code)

\[ E_m = \Omega_o \cdot E \pm 0.2 \cdot S_{DS} \cdot D \]

\[ \Omega_o = 2.5 \]

<table>
<thead>
<tr>
<th>Name</th>
<th>Load</th>
<th>Axial (kN)</th>
<th>Moment (kN·m)</th>
<th>Length (m)</th>
<th>Start (kN/m)</th>
<th>End (kN/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PW1 DL</td>
<td></td>
<td>-3,139</td>
<td>-2,751</td>
<td>8.71</td>
<td>-578</td>
<td>-143</td>
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<tr>
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<td>-897</td>
<td>-641</td>
<td>8.71</td>
<td>-154</td>
<td>-52</td>
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<td>PW1 RX(ES)</td>
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<td>0</td>
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<td>8.71</td>
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<td>3</td>
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<td>PW1 RX(RS)</td>
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<td>39</td>
<td>290</td>
<td>8.71</td>
<td>27</td>
<td>-18</td>
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<td>PW1 RY(ES)</td>
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<td>875</td>
<td>8.71</td>
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<tr>
<td>PW1 RY(RS)</td>
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<td>-30</td>
<td>-343</td>
<td>8.71</td>
<td>-31</td>
<td>24</td>
</tr>
</tbody>
</table>
4F Cantilevered Transfer Slab _ ULS Design

Wood Armer Equation (Twisting Moment)

[Ref.] Manual for Design and Detailings of RC to Code of Practice for Structural Use of Concrete 2004 (HK Housing Department)

For bottom steel reinforcement provisions:

Generally \( M_X^* = M_X + |M_{XT}| \) \( ; \) \( M_Y^* = M_Y + |M_{YT}| \)

If \( M_X < 0 \), then \( M_X^* = 0 \) \( \) \( \) and \( M_Y^* = M_Y + \frac{|M_{YT}|^2}{M_Y} \)

For top steel reinforcement provisions:

Generally \( M_X^* = M_X - |M_{XT}| \) \( ; \) \( M_Y^* = M_Y - |M_{YT}| \)

If \( M_X > 0 \), then \( M_X^* = 0 \) \( \) \( \) and \( M_Y^* = M_Y - \frac{|M_{YT}|^2}{M_Y} \)

If \( M_Y > 0 \), then \( M_Y^* = 0 \) \( \) \( \) and \( M_X^* = M_X - \frac{|M_{XT}|^2}{M_X} \)

Figure D-3a – General co-existence of bending moments and twisting moment in a plate bending structure

Figure D-3b – Principal moment in a plate bending structure
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4F Cantilevered Transfer Slab _ ULS Design

Support Line 16 Moment (Y-Dir)

Support Line 16 Moment (X-Dir)

Twisting Moment Increase (Y-Dir)

Twisting Moment Increase (X-Dir)
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4F Cantilevered Transfer Slab _ ULS Design

Flexural Reinforcement without Twisting Moment

Flexural Reinforcement with Twisting Moment
C. PT Transfer Slab Construction
NEST Hotel (DAELIM, 2014)

Construction _ 01 Formwork
NEST Hotel (DAELIM, 2014)

Construction _ 02 Bottom Rebar
NEST Hotel (DAELIM, 2014)

Construction _ 03 Unbonded Tendon
NEST Hotel (DAELIM, 2014)

Construction _ 04 Distributed Tendon
NEST Hotel (DAELIM, 2014)

Construction _ 05 Concentrated Tendon
NEST Hotel (DAELIM, 2014)

*Construction _ 06 Anchorage Reinforcement*
NEST Hotel (DAELIM, 2014)

Construction _ 07 Top Rebar
NEST Hotel (DAELIM, 2014)

Construction _ 08 Punching Shear Reinforcement
NEST Hotel (DAELIM, 2014)

Construction _ 09 Tendon Stressing
NEST Hotel (DAELIM, 2014)

Precast Wall above PT Transfer Slab
NEST Hotel (DAELIM, 2014)

Vertically Irregular Building
THANK YOU