Marmormolen, Copenhagen: “Paving” a “Services Highway” Using Steel Beams

Riccardo Pedroni
Associate Engineer, Ramboll
MARMORMOLEN

‘PAVING’ A ‘SERVICES HIGHWAY’ USING STEEL BEAMS

RICCARDO PEDRONI
Associate Engineer
Ramboll Denmark
MARMORMOLEN
Client: AP PENSION
Architect: HENNING LARSEN ARCHITECTS
Engineer: RAMBOLL
Contractor: PIHL
Plants and soil is integrated to support biodiversity. Microorganisms, insects and birds will thrive.

Rainwater is harvested for greywater and irrigation.

By using timber as the structural material carbon is stored in the building rather than emitted.

Energy might be harvested through PV's and delivered back to the grid.

The building works as a noise barrier between a main road and a residential area.

High Performance Thermo wheels for HVAC assures less energy demand.

<41 kWh/m²/y complies with 2025 BR Energy Requirements.

A sublimely designed building adds quality to the neighborhood and the city.

Roof terrace allows users to easily enjoy fresh air and a natural environment saving space on the ground.

A compelling atrium encourages users to walk through the market hall.

A sublimely beautifully designed façade with Opaque panels provides low G&U Value allows natural daylight, low artificial lighting, low solar gain.

The ground floor will be open to the public and offer social space and services.

Energy might be harvested through PV's and delivered back to the grid.

The building is located on a brownfield site rather than on greenfield land.

Façade with Opaque panels provides low G&U Value allows natural daylight, low artificial lighting, low solar gain.

Use of renewables such as Ground Source Heat Pump for H&C makes the building standalone from the grid.

Designed for disassembly prepares the building components for reuse in the future.

Biological tank separates, recycles and avoids bio waste.

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OVERVIEW

KEY PROJECT DATA

8 LEVELS
35m HIGH

34,000 m²

4 No. STABILITY
CONCRETE CORES

8,000 m³ MET
(CLT + GLT)

3 No. BASEMENT
LEVELS
THE SERVICES HIGHWAY

MEP DISTRIBUTION
THE SERVICES HIGHWAY
STRUCTURES + MEP
THE SERVICES HIGHWAY
HOW DOES IT WORK

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THE SERVICES HIGHWAY

THE RESULT
## Challenges

### Slab Dimensioning

<table>
<thead>
<tr>
<th>RF Area</th>
<th>180mm</th>
<th>200mm</th>
<th>220mm</th>
<th>240mm</th>
<th>260mm</th>
<th>280mm</th>
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</thead>
<tbody>
<tr>
<td>&gt; RF6</td>
<td>40%</td>
<td>30%</td>
<td>22%</td>
<td>13%</td>
<td>9%</td>
<td>8.4%</td>
</tr>
<tr>
<td>&gt; RF20</td>
<td>13%</td>
<td>8%</td>
<td>5%</td>
<td>2%</td>
<td>1.8%</td>
<td>1.3%</td>
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</tbody>
</table>

### Vibration

SDL = 2.5 kpa, 2.5% Damping

### Deflection

\[
\Delta = \frac{55L^4}{384EI}\]

- Where:
  - \( L \): Span = 6.4m
  - \( E \): Modulus of Elasticity
  - \( I \): Moment of Inertia

<table>
<thead>
<tr>
<th>( \Delta )</th>
<th>180mm</th>
<th>200mm</th>
<th>220mm</th>
<th>240mm</th>
<th>260mm</th>
<th>280mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>West</td>
<td>30</td>
<td>23</td>
<td>16</td>
<td>11</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>West+Wind</td>
<td>38</td>
<td>29</td>
<td>20</td>
<td>15</td>
<td>13</td>
<td>11</td>
</tr>
<tr>
<td>Wind</td>
<td>47</td>
<td>36</td>
<td>25</td>
<td>18</td>
<td>16</td>
<td>13</td>
</tr>
</tbody>
</table>

\[ \text{Criteria} = \frac{L}{300} = 21 \]

\[ \text{Criteria} = \frac{L}{250} = 26 \]

\[ \text{Criteria} = \frac{L}{150} = 43 \]
CHALLENGES

BEAM SOLUTION

220 mm CLT

D22-300
Examine the effect of removal of an element. Is the extend of collapse acceptable based on requirements in DS/EN 1990 annex E1(7)?

Design as key element by applying $1.2\gamma_M$ (ULS+).

Is the element susceptible to identified accidental actions?

If yes, design connections to withstand element removal.

Determine Consequence Class

- CC1: Robustness not needed
- CC2: Assessment needed
- CC3: Documentation needed

Provide horizontal ties

Is the element susceptible to identified accidental actions?

If yes, ULS/AL Design

If no, ULS Design

Alternative

Is the element susceptible to identified accidental actions?

If yes, ULS+ Design

If no, ULS+/ALS Design

Documentation needed

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CHALLENGES
DIAPHRAGM ACTION – ET3 STRATEGY

13.0 kN/m

13.0 kN/m

16.5 m

27.0 m

16.5 m

V

M

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CHALLENGES
DIAPHRAGM ACTION – ET9 STRATEGY

5.8 kN/m
17.5 m
14.5 m
1280 kNm

125 kN
7 m
14 m

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CHALLENGES
CONNECTIONS