Library of Birmingham

Project Value - £193M
Client - Birmingham City Council
Architect – Mecanoo Architecten
Library of Birmingham – Building Functions
Modelling Packages

IES

FLOVENT

FloEFD™
Engineering Fluid Dynamics

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Ventilation Design Requirements

- BREEAM ‘Excellent’
- Acoustics
- Ambient Conditions

Acoustic Requirements

- East façade acoustic requirement = 35dB
- South façade acoustic requirement = 35dB
- West façade acoustic requirement = 40dB
- North façade acoustic requirement = 40dB

Site Constraints

- Noise
- Traffic
- Pollution

Annual Dry Bulb Temperature

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Ventilation Strategy

- Acoustic Louver – east/south/west
- Use of central stack for exhaust
- Maximise natural ventilation running hours
- Void Alignment
- Architectural Requirements
- Low Energy Cooling Strategy

<table>
<thead>
<tr>
<th>Stack Ventilation Principal</th>
<th>Mixed Mode Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural ventilation openings for exhaust at roof level</td>
<td>Natural Ventilation Hours Run</td>
</tr>
<tr>
<td>Natural ventilation openings on façade for fresh air inlet</td>
<td>% of occupied hrs</td>
</tr>
<tr>
<td>Internal to external temperature difference</td>
<td>Frequency of hrs</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>∆T=3</th>
<th>∆T=4</th>
<th>∆T=5</th>
</tr>
</thead>
<tbody>
<tr>
<td>30%</td>
<td>27%</td>
<td>24%</td>
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</tbody>
</table>

NCM Low Energy Cooling

<table>
<thead>
<tr>
<th>kWh/m²y</th>
<th>Auxiliary Energy kWh/m²y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant volume</td>
<td>Variable air volume</td>
</tr>
<tr>
<td>110</td>
<td>100</td>
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</tbody>
</table>

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Operation of Mixed Mode System

Heating Mode

Natural Mode

Cooling Mode

Louver Detail – Occupancy Comfort, Permeable Ceilings

Whole Building - Void Alignment
Louver Detail

- Air Supplied at Perimeter Only or Raft Ceiling
- Ambient Temperature 22°C
- Pressure Boundaries calculated from AM10

Air supplied at Perimeter

Air supplied through raft ceiling

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Louver Detail – Initial Analysis

- Cool air dumping with perimeter scenario
- High radiant temperatures with raft ceiling

Perimeter

Raft Ceiling

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Louver Detail – Design Development

• Operation in Summer and Mid Season
• Permeable Ceiling Requirements
Whole Building – Void Alignment

- Ambient Temperature of 22°C
- Louver Free Areas from AM10

**Void free area between 3rd and 4th no less than 69m² (N.B the current design at that point did not meet this)**

- Temperature within comfortable range
- Higher temperatures experienced in areas adjacent to north façade
- Area of negative pressure causing cooler air to dump
- Uncomfortable velocities on floor plate
- Areas of separation

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Whole Building – Void Alignment Design Development

- Ambient Temperature of 22°C
- Design Requirement velocities less than 0.5m/s
- Inclusion of Escalators

Increased velocity around escalator
Whole Building – Natural Ventilation During Windy Conditions

- Concerns over operation during windy conditions
- Potential reduction in energy benefit
- Potential discomfort for occupants

**August**
Joint Frequency Distribution
For Raw Data File Target site - Library of Birmingham - August

**September**
Joint Frequency Distribution
For Raw Data File Measurement site - Birmingham Coleshill - September

**October**
Joint Frequency Distribution
For Raw Data File Target site - Library of Birmingham - October

**MET Office Wind Data**

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Whole Building – Natural Ventilation During Windy Conditions

- Assessment of MET office wind data
  - maximum wind speed 10m/s
- Pressure coefficients on each façade calculated
- Highest pressure coefficients on 3rd floor

<table>
<thead>
<tr>
<th>Level</th>
<th>Façade</th>
<th>Exposure level of inlet</th>
<th>Angle of attack (°C clockwise from normal)</th>
<th>Wind pressure coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground</td>
<td>South</td>
<td>Exposed</td>
<td>22.5</td>
<td>0.25</td>
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<tr>
<td>1</td>
<td>East</td>
<td>Sheltered</td>
<td>112.5</td>
<td>-0.172</td>
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<tr>
<td></td>
<td>South</td>
<td>Exposed</td>
<td>22.5</td>
<td>0.25</td>
</tr>
<tr>
<td>2</td>
<td>East</td>
<td>Sheltered</td>
<td>112.5</td>
<td>-0.181</td>
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<tr>
<td></td>
<td>South</td>
<td>Exposed</td>
<td>22.5</td>
<td>0.313</td>
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<tr>
<td></td>
<td>West</td>
<td>Sheltered</td>
<td>292.5</td>
<td>-0.057</td>
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<tr>
<td>3</td>
<td>East</td>
<td>Semi-exposed</td>
<td>112.5</td>
<td>-0.348</td>
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<tr>
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<td>South</td>
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<td>0.313</td>
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<tr>
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<td>West</td>
<td>Semi-exposed</td>
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<td>-0.11</td>
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<tr>
<td>Roof</td>
<td>North</td>
<td>Exposed</td>
<td>202.5</td>
<td>-0.303</td>
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<tr>
<td></td>
<td>East</td>
<td>Exposed</td>
<td>112.5</td>
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<td>South</td>
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<td>22.5</td>
<td>0.106</td>
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<tr>
<td></td>
<td>West</td>
<td>Exposed</td>
<td>292.5</td>
<td>-0.213</td>
</tr>
</tbody>
</table>
Whole Building – Natural Ventilation During Windy Conditions

- Velocity contour plots at head height and working plane

Local accelerations along West façade. Do not exceed 0.4m/s

Local accelerations through openings in rotunda. Do not exceed 0.4m/s

Velocities at the majority of the working plane height maintained below 0.3m/s

Maximum air speeds occur through local accelerations along South façade. Air speeds do not exceed recommended maximum for local accelerations.

Points along South façade where velocities reach 0.4m/s

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Conclusions

• Comfortable conditions can be achieved throughout the range with permeable ceiling configuration

• High speeds restricted to voids

• High wind speeds do not cause discomfort as louvers have modulating dampers

• Control system installed is capable of understanding the external weather conditions, and on the basis of this is capable of intelligently controlling the openings on each façade and rooflight orientation proportionally and independently
Questions