`Complex Federation Moscow´

Different Room Climates under One Roof

- Project Outlines
- Climatic Concept
- Thermal Simulation
- CFD Simulation Winter
- CFD Simulation Summer
- Conclusions

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EB – Simulation Group

Shading Analysis

System Simulation

Building Simulation

Transient Moister Transport

CFD Simulation

Noise Emission Simulation

Daylight Simulation

Air Flow Simulation

Fire/Smoke Simulation

Acoustic Simulation

Lighting Simulation

Cold Bridge Simulation
Project Outline – The Team

Complex “Federation” Moscow
- Investor Mirax Group
- Architect Prof. P. Schweger & S. Tchoban
- Structural Engineering Thornton Tomasetti Group
- MEP Design Ebert-Group
- On-Site Management Turner International

Building Specifications
- Two towers, multifunctional architectural complex
- Height 448 m (93/62 floors); Spire 506 m
- Floor area 423’000 m²
- Completion 2009
The tower cap of Tower East comprises four terraced top levels (level 90 - 93) with approx. 3,000 m² / 32,300 ft², accommodating:

- hotel lobby and reception, restaurant and lounge on floors 90 and 91
- entertainment areas, such as dance club, additional lounges, as well as a VIP area on the top floors 92 and 93
Project Outline – The Challenge

- **No condensate on inner surfaces of façades**
  - surface temperature
  - relative / absolute humidity
  - outdoor air temperature
  - indoor air temperature

- **Comfortable temperatures in winter at a minimum of**
  - 21 °C in the restaurant, bar and lounge areas
  - 22 °C in the Sky Club without any cold spots

- **Comfortable temperatures in summer at a maximum of**
  - 24 °C in all areas

- **Strict limitations for technical installations**
  - limited space for technical installations
  - no visible ductwork underneath the glass dome and in the open space
Project Outline – The Objective

✔ Modeling, analysis and visualization of climatic concept is used to achieve information on heating and cooling demand and to answer following questions:

➔ Where exactly is the heating and cooling capacity needed and in what amount?

➔ Where are critical areas in terms of thermal comfort?

➔ How is the performance of the intended climatic concept and how can it be improved?
## The Climatic Concept

The diagram illustrates the climatic concept for different levels and zones within the building. The pressure zones are indicated as follows:

- **++**: High pressure
- **+/-**: Pressure balanced
- **--**: Low pressure

### Table: Supply/Exhaust Air and Air Flow Volume

<table>
<thead>
<tr>
<th>Level</th>
<th>Supply Air</th>
<th>Exhaust Air</th>
<th>Air Flow Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>91</td>
<td>Supply</td>
<td></td>
<td>14.482 m³/h</td>
</tr>
<tr>
<td></td>
<td>Exhaust</td>
<td></td>
<td>-11.668 m³/h</td>
</tr>
<tr>
<td>92</td>
<td>Supply</td>
<td></td>
<td>16.068 m³/h</td>
</tr>
<tr>
<td></td>
<td>Exhaust</td>
<td></td>
<td>-13.600 m³/h</td>
</tr>
<tr>
<td>93</td>
<td>Supply</td>
<td></td>
<td>13.451 m³/h</td>
</tr>
<tr>
<td></td>
<td>Exhaust</td>
<td></td>
<td>-12.993 m³/h</td>
</tr>
<tr>
<td>94</td>
<td>Supply</td>
<td></td>
<td>0.0 m³/h</td>
</tr>
<tr>
<td></td>
<td>Exhaust</td>
<td></td>
<td>0.0 m³/h</td>
</tr>
</tbody>
</table>

High and low pressure zones prevent air exchange between restaurant and lounge areas.

### Diagram Description

- **++**: High pressure
- **+/-**: Pressure balanced
- **--**: Low pressure

---

### Notes

- High and low pressure zones should prevent air exchange between restaurant and lounge areas.
- "The Climatic Concept" label indicates the focus on climate control within the building.
Overflow of exhaust air into Top of Tower Cap A
JET NOZZLE DIFFUSERS DISTRIBUTED ALONG CEILING EDGE

ДАЛЬНОБОЙНЫЕ РАСПЫЛИТЕЛИ ВДОЛЬ КРАЯ ПЕРЕКРЫТИЯ

SUPPLY AIR - JET NOZZLE DIFFUSER
ДАЛЬНОБОЙНЫЕ РАСПЫЛИТЕЛИ

SUPPLY AIR – SWIRL DIFFUSER
КРУГОВОЙ РАССЕИВАТЕЛЬ

EXHAUST AIR
ВЫТЯЖКА

SWIRL DIFFUSERS UNIFORMLY DISTRIBUTED ALONG CEILING
КРУГОВЫЕ РАССЕИВАТЕЛИ РАВНОМЕРНО РАЗМЕЩЕННЫЕ ВДОЛЬ ПЕРЕКРЫТИЯ

SUPPOSED AIR FLOW
ВОЗДУШНОЕ ТЕЧЕНИЕ

HEATING
ОТОПЛЕНИЕ
SWIRL DIFFUSERS UNIFORMLY DISTRIBUTED ALONG CEILING

КРУГОВЫЕ РАССЕИВАТЕЛИ РАВНОМЕРНО РАЗМЕЩЕННЫЕ ВДОЛЬ ПЕРЕКРЫТИЯ
COMPLEX FEDERATION MOSCOW
Climatic Concept Level 93– Концепт климатических условий этажа 93

FLOOR DIFFUSERS ALONG BALUSTRADE AND BAR
ВыПУСКНЫЕ ОТВЕРСТИЯ В ПОЛУ ВДОЛЬ БАРА И БАЛЮСТРАДЫ

SUPPLY AIR – FLOOR DIFFUSER
ВыПУСКНЫЕ ОТВЕРСТИЯ В ПОЛУ

SUPPLY AIR – JET NOZZLE DIFFUSER
ДАЛЬНОБОЙНЫЕ РАСПЫЛИТЕЛИ

SUPPLY AIR – SWIRL DIFFUSER
КРУГОВОЙ РАССЕИВАТЕЛЬ

EXHAUST AIR
ВыТЯЖКА

SUPPOSED AIR FLOW
ВОЗДУШНОЕ ТЕЧЕНИЕ

HEATING
ОТОПЛЕНИЕ

JET NOZZLE DIFFUSERS DISTRIBUTED ALONG INTERNAL WALL
ДАЛЬНОБОЙНЫЕ РАСПЫЛИТЕЛИ ВДОЛЬ ВНУТРЕННЕЙ СТЕНЫ
<table>
<thead>
<tr>
<th>Version</th>
<th>cover roof</th>
<th>cover facade</th>
<th>gains</th>
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<tr>
<td>V 1.0 Basic</td>
<td>0%</td>
<td>0%</td>
<td>standard</td>
</tr>
<tr>
<td>V 2.0 Roof Cover 25%</td>
<td>25%</td>
<td>0%</td>
<td>standard</td>
</tr>
<tr>
<td>V 3.0 Roof Cover 50%</td>
<td>50%</td>
<td>0%</td>
<td>standard</td>
</tr>
<tr>
<td>V 3.1 Roof Cover 50% with facade cover</td>
<td>50%</td>
<td>50%</td>
<td>standard</td>
</tr>
<tr>
<td>V 3.2 Roof Cover 50% with facade cover</td>
<td>50%</td>
<td>75%</td>
<td>standard</td>
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<tr>
<td>V 4.0 Roof Cover 75%</td>
<td>75%</td>
<td>0%</td>
<td>standard</td>
</tr>
<tr>
<td>V 4.1 Roof Cover 75% with facade cover</td>
<td>75%</td>
<td>50%</td>
<td>standard</td>
</tr>
<tr>
<td>V 4.2 Roof Cover 75% with facade cover</td>
<td>75%</td>
<td>75%</td>
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<tr>
<td>V 5.0 Heat load calculation</td>
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<td>0%</td>
<td>no gains</td>
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</table>

Facade South-West

Roof
## COMPLEX FEDERATION MOSCOW
### Thermal Simulation – Simulation Parameters

<table>
<thead>
<tr>
<th></th>
<th>Zone 1 Lounge level 91</th>
<th>Zone 2 Restaurant level 91</th>
<th>Zone 3 Restaurant level 92</th>
<th>Zone 4 Dance Club Level 93</th>
<th>Zone 5 Lounge level 93</th>
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</thead>
<tbody>
<tr>
<td><strong>Heating</strong></td>
<td>21 °C</td>
<td>21 °C</td>
<td>21 °C</td>
<td>22 °C</td>
<td>21 °C</td>
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<tr>
<td>Radiative part</td>
<td>10%</td>
<td>10%</td>
<td>10%</td>
<td>10%</td>
<td>10%</td>
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<tr>
<td><strong>Cooling</strong></td>
<td>24 °C</td>
<td>24 °C</td>
<td>24 °C</td>
<td>24 °C</td>
<td>24 °C</td>
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<tr>
<td><strong>Lighting</strong></td>
<td>10 W/m²</td>
<td>10 W/m²</td>
<td>10 W/m²</td>
<td>40 W/m²</td>
<td>10 W/m²</td>
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<tr>
<td>Light control</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
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<tr>
<td><strong>Persons</strong></td>
<td>number of persons</td>
<td>40</td>
<td>160</td>
<td>200</td>
<td>125</td>
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<tr>
<td>Gain</td>
<td>75 W/Pers.</td>
<td>75 W/Pers.</td>
<td>75 W/Pers.</td>
<td>75 W/Pers.</td>
<td>75 W/Pers.</td>
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<tr>
<td>Humidity rate</td>
<td>60 g/h/Pers.</td>
<td>60 g/h/Pers.</td>
<td>60 g/h/Pers.</td>
<td>60 g/h/Pers.</td>
<td>60 g/h/Pers.</td>
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<tr>
<td><strong>Operation schedule</strong></td>
<td>Time</td>
<td>07.00-24.00</td>
<td>07.00-24.00</td>
<td>07.00-24.00</td>
<td>20.00-02.00</td>
</tr>
</tbody>
</table>
**COMPLEX FEDERATION MOSCOW**

Thermal Simulation – Results Heating and Cooling Load

<table>
<thead>
<tr>
<th>Version</th>
<th>cover roof</th>
<th>cover facade</th>
<th>Static Cooling load [kW]</th>
<th>Static Heating load [kW]</th>
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</thead>
<tbody>
<tr>
<td>V 1.0</td>
<td>Basic</td>
<td>0%</td>
<td>0%</td>
<td>464 kW</td>
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<tr>
<td>V 2.0</td>
<td>Roof Cover 25%</td>
<td>25%</td>
<td>0%</td>
<td>412 kW</td>
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<tr>
<td>V 3.0</td>
<td>Roof Cover 50%</td>
<td>50%</td>
<td>0%</td>
<td>358 kW</td>
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<tr>
<td>V 3.1</td>
<td>Roof Cover 50% with facade cover</td>
<td>50%</td>
<td>50%</td>
<td>343 kW</td>
</tr>
<tr>
<td>V 3.2</td>
<td>Roof Cover 50% with facade cover</td>
<td>60%</td>
<td>75%</td>
<td>309 kW</td>
</tr>
<tr>
<td>V 4.0</td>
<td>Roof Cover 75%</td>
<td>75%</td>
<td>0%</td>
<td>306 kW</td>
</tr>
<tr>
<td>V 4.1</td>
<td>Roof Cover 75% with facade cover</td>
<td>75%</td>
<td>50%</td>
<td>290 kW</td>
</tr>
<tr>
<td>V 4.2</td>
<td>Roof Cover 75% with facade cover</td>
<td>75%</td>
<td>75%</td>
<td>258 kW</td>
</tr>
<tr>
<td>V 5.0</td>
<td>Heat load calculation</td>
<td>0%</td>
<td>0%</td>
<td>615 kW</td>
</tr>
</tbody>
</table>

**CFD Simulation Model**
COMPLEX FEDERATION MOSCOW
3D Model – Трёхмерная модель
COMPLEX FEDERATION MOSCOW
3D Model – Трёхмерная модель
COMPLEX FEDERATION MOSCOW

CFD Results – Wintertime – Bar level 92
COMPLEX FEDERATION MOSCOW

CFD Results – Wintertime – Bar level 92

Outside

Inside
COMPLEX FEDERATION MOSCOW

CFD Results – Wintertime – Surface temperature

Contours of inside surface temperature facade [°C]
Thermal comfort can be achieved by the proposed climatic concept with slight adjustments to improve local conditions.

The convectors along the perimeter and the balustrade are needed and have sufficient heating capacity to avoid downdraught from the façade and to ensure thermal comfort in all occupied zones.

The horizontal façade heating system in the vertical facades has not enough capacity to avoid condensate in all areas and can not guarantee sufficient thermal comfort close to the façade. Therefore, additional heating elements in the vertical frame structures were recommended.

The façade heating system of the roof (61 W/m² roof area) prevents condensate as well as discomfort due to cold surface temperatures.

Humidity control is recommended for all central AHU’s to maintain adequate supply air conditions for minimizing the risk of condensation.
Contours of static temperature [°C]
Contours of static temperature [°C]
COMPLEX FEDERATION MOSCOW
CFD Results – Summertime – Lounge level 91

Outside

Inside
COMPLEX FEDERATION MOSCOW
CFD Results – Summertime – Bar level 93

Outside

Inside
Results Summer – Conclusions

- **Thermal comfort can be achieved** in almost all areas by the proposed climatic concept. Modifications of the façade coverage as well as the climatic concept are required in order to reduce the room temperature on level 93 along terrace edge.

- A **closed restaurant area on level 92** along the terrace edge is necessary to reduce the significant influence on the comfort from the Bar on level 91.

- Room **temperatures can get higher** than previously defined – but are still acceptable.

- The **balustrades need to be closed at the floor** along the terrace edge to maintain appropriate comfort conditions on level 92 and 93.

- It is recommended to provide additional cooling capacity by **increasing the air flow rates temporarily**.
`Complex Federation Moscow´
Different Room Climates under One Roof

Thank you for your attention!

Спасибо за внимание!

Oliver Baumann
Claudius Reiser

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