



Buro Happold **Specialist Consulting**

Wind Engineering at Buro Happold

Dr Graham Knapp, CoSA Solutions

Buro Happold

- Multidisciplinary engineering company for complete developments, buildings and their infrastructure
- Nearly 2000 employees around the world
- Links to over 50 universities and research organisations

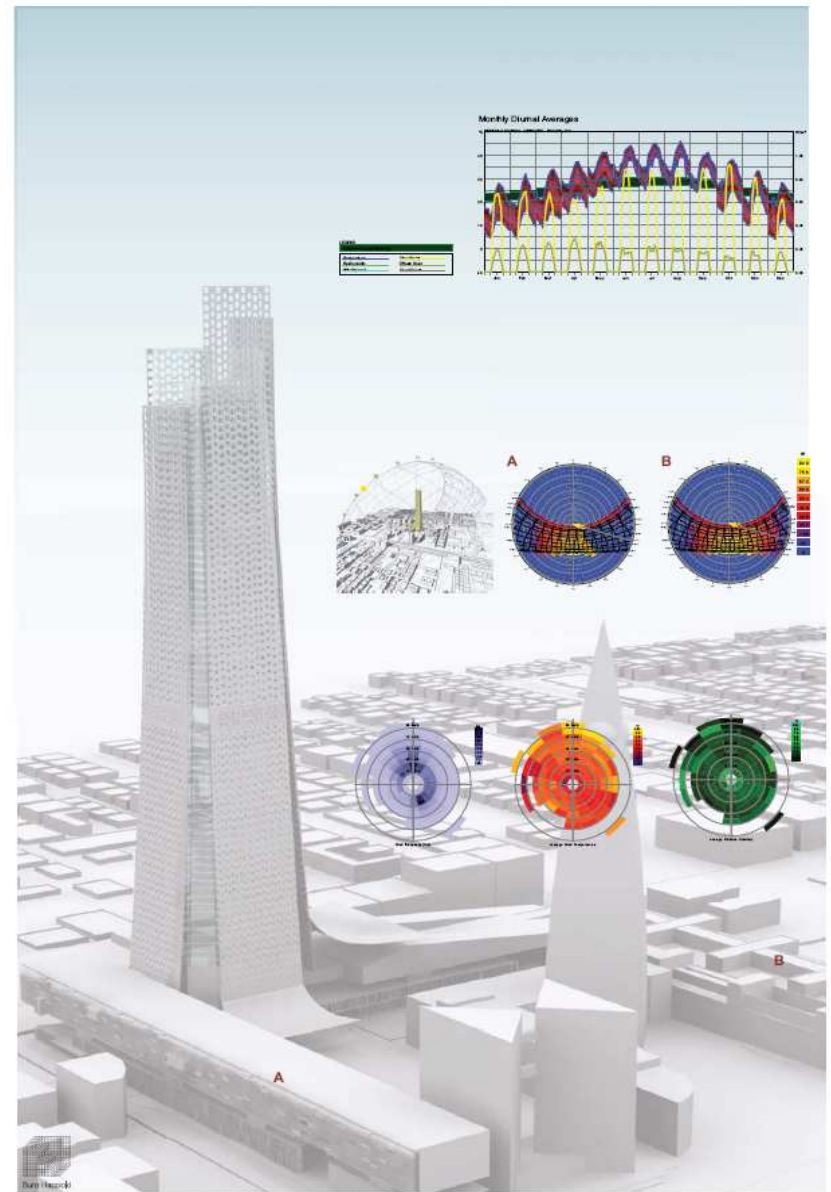


CoSA

Computational Simulation and Analysis

- Thermal performance and air movement
- Energy prediction and building regulations compliance
- Masterplanning and external comfort
- Wind engineering
- Fire and smoke modelling
- Post-occupancy evaluation
- Research and development

Approximately 30 employees around the world



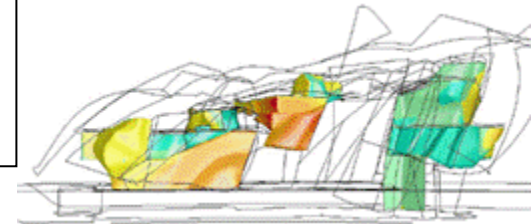
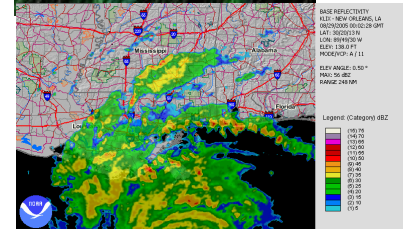
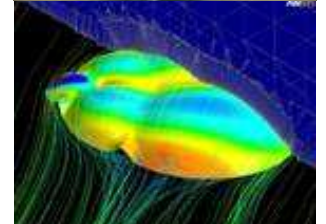
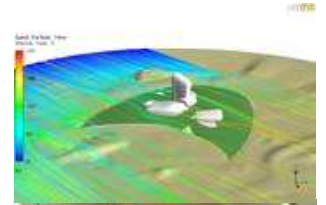
Wind Engineering

Environmental

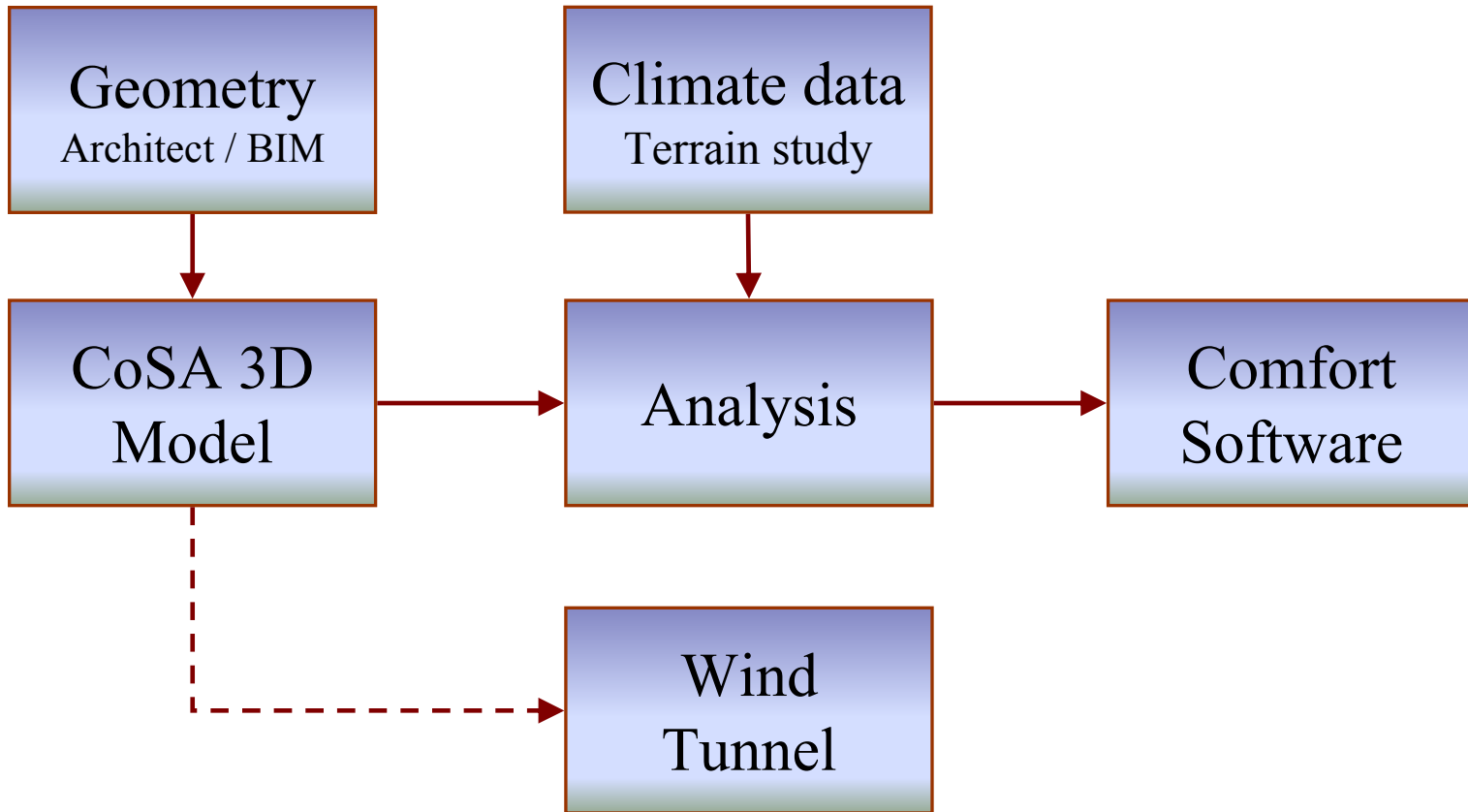
- 1) Master planning
- 2) EIA / Planning applications
- 3) Problem Solving
- 4) Support to fire and ventilation strategies
- 5) Pollution dispersion (internal & external)
- 6) Peer review, expert witness, etc

Structural / New technology

- 1) Structural wind loading
- 2) Wind tunnel
Commissioning,
Peer review
- 3) Wind Turbines:
Stand- alone
Building integrated
- 4) Rain, snow and sand drift
Modelling
- 5) Transient / gust effects of wind
(PhD)
- 6) Design for extreme events



Links to Design Team



External Comfort

- Temperature
- Radiation
- Wind
- Humidity
- Clothing
- Expectation
- Acclimatisation
- Activity
- Exposure time

Hot Climates

- Cooling breezes
- Shelter from extreme winds

Cold climates

- Protect from cold winds
- Evergreen trees

Temperate climates

- Balance cooling vs. shelter
- Shelter from strong winds
- Dependent on activity



UTCI Universal Thermal Climate Index

- European collaborative research project
- <http://www.utci.org>
- Now available
- Allows for temperature, radiative heat, humidity and wind speed
- Applicable to all climates

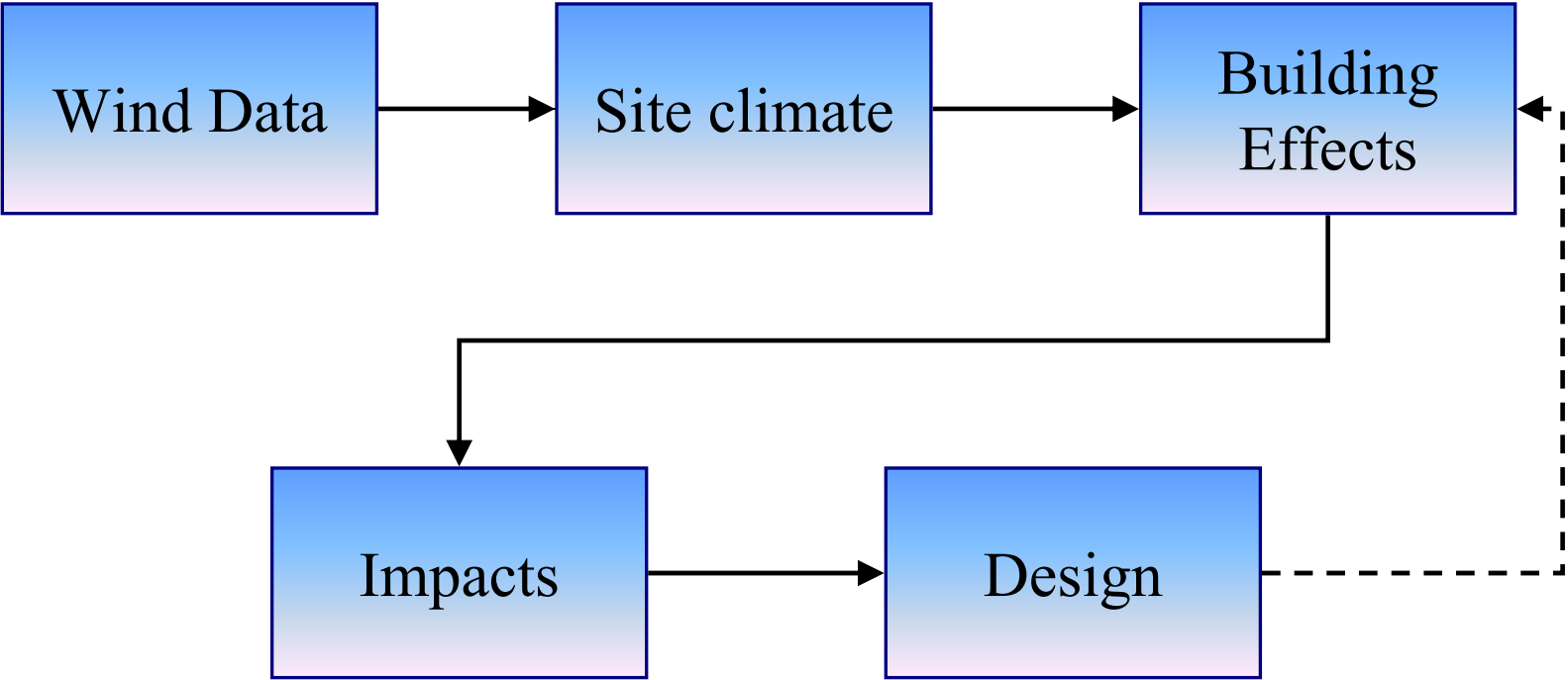


Sustainability

- Commercial viability
- Natural ventilation
- Efficient structures
- Wind power

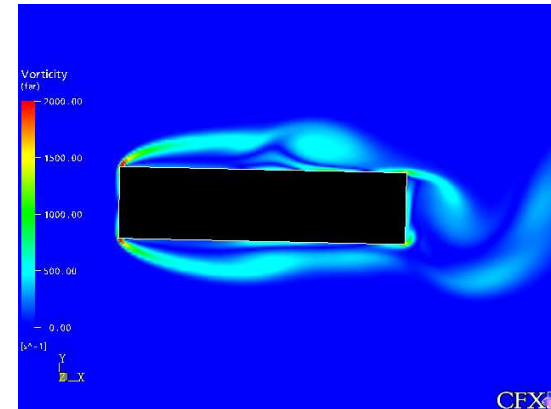
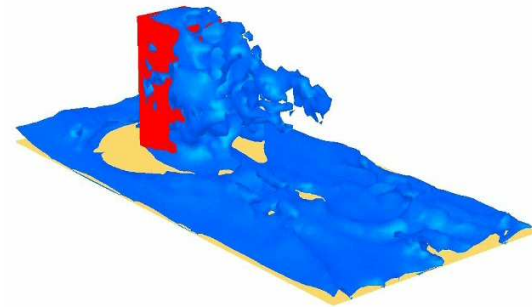


Wind Engineering Process



Computational Fluid Dynamics

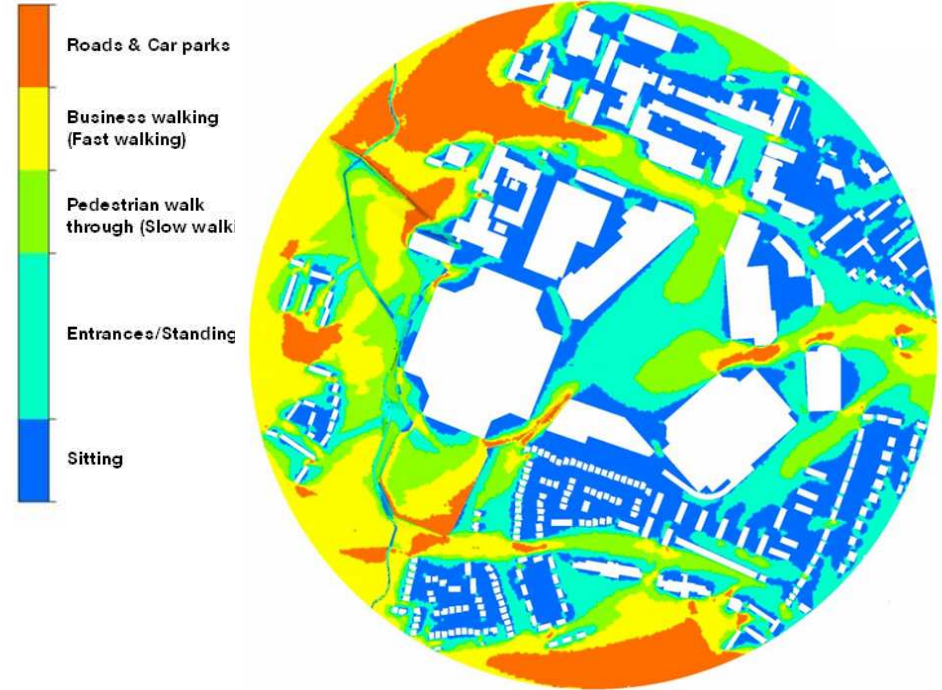
- Coupled with upstream terrain model
- RANS and LES modelling
- Custom boundary conditions – Harris and Deaves method
 - Wind speed profile
 - Turbulence kinetic energy
- QNET CFD guidelines
- Quality control through academic partners
- Typically 12 -16 wind directions
- 10M cells



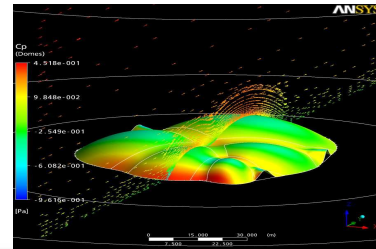
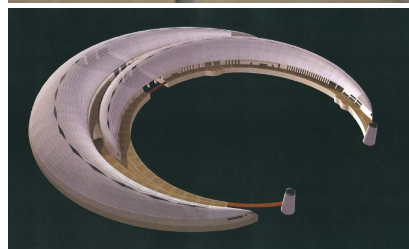
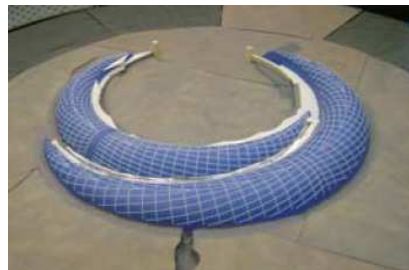
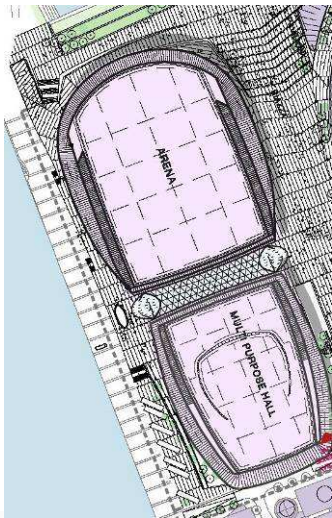
Comfort Software

- Developed by Buro Happold
- Statistical analysis of wind data
- Combines all wind directions
- Typically $10^5 - 10^6$ locations
- Produces comfort map
- For use in EIA / planning applications / design development
- Clear graphical output

$$\int_0^{360} \int v \cdot dt \cdot d\theta$$



Sectors – Sports / Stadia / Entertainment



Gelände und Gebäude

3D-Modellierung

- der benachbarten Gebäude
- der Topographie
- der Vegetation

innerhalb eines Radius von 300 m um die Tribüne. Darüber hinaus Berücksichtigung durch geeignete Randbedingungen.

Bäume/Hecken erfasst als Volumen mit 50% Porosität.

1 Tribüne

2 Bäume als Volumen mit 50% Porosität

3 Hügel auf der Südseite

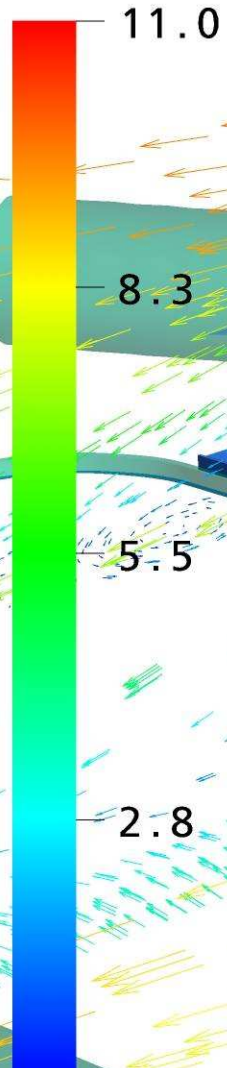
1

2

3



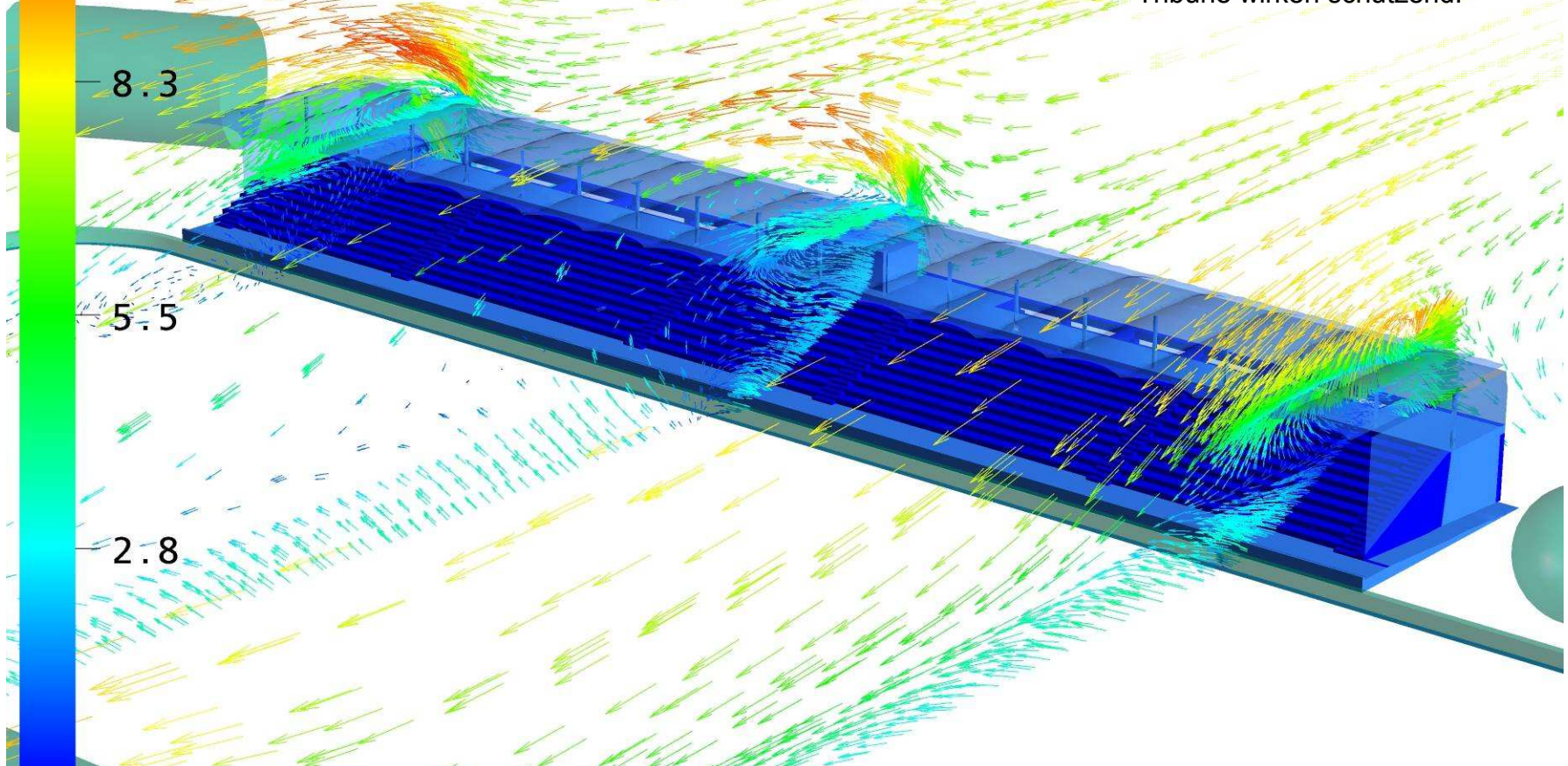
Velocity
(Vector 3)

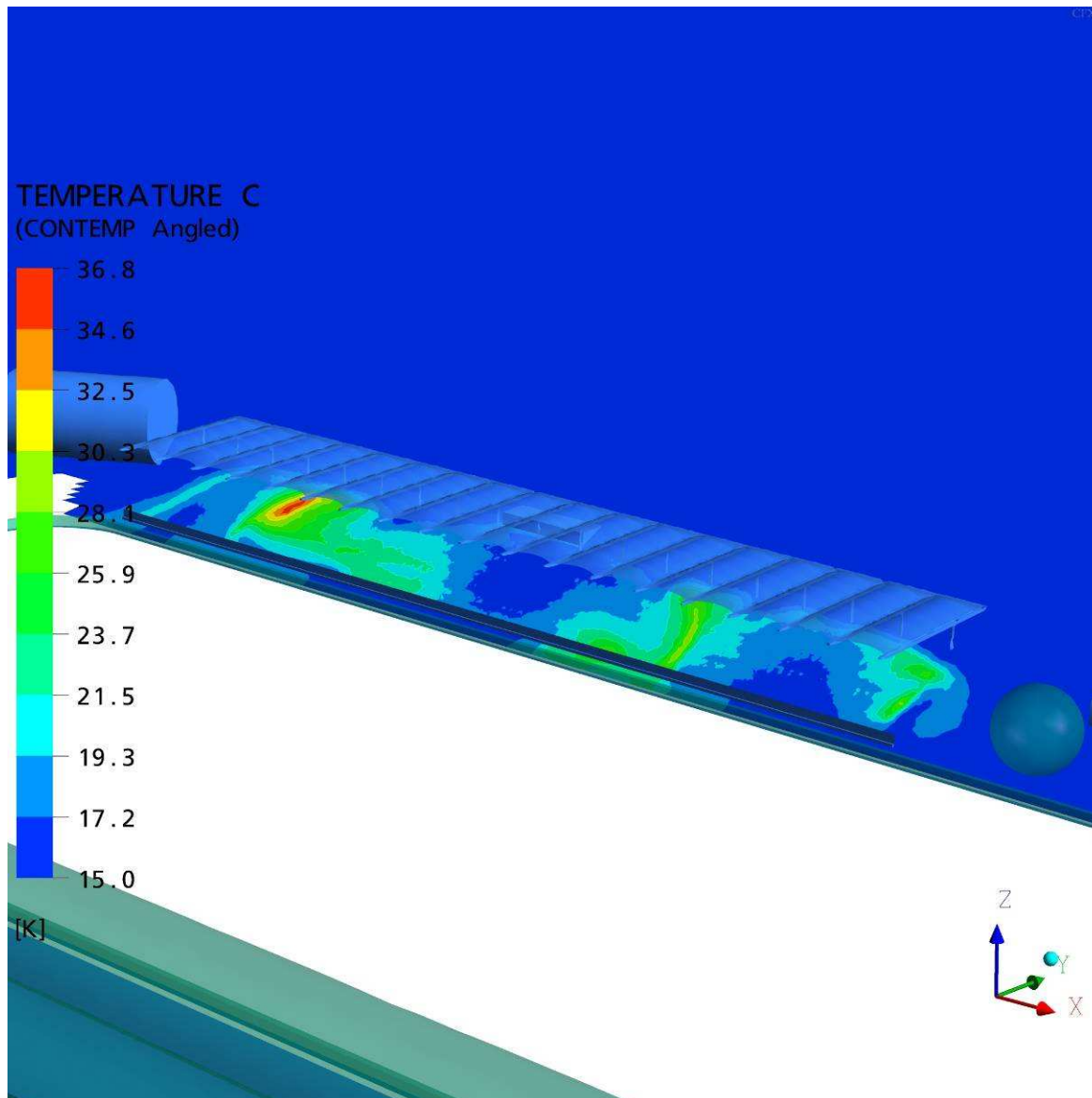


Wind (West)

Generell geringe
Windgeschwindigkeiten im
Sitzbereich (Turbulenzwalzen).

Bäume an der Nordseite der
Tribüne wirken schützend.





Temperatur

Exemplarische Berechnung an Option B.

Berechnung des Temperaturanstiegs in Sitzebene bei

- 15° Umgebungstemperatur
- Sonneneinstrahlung
- Energiedurchlässigkeit des Membrandaches von 10%
- 10 W/m² Wärmeabstrahlung aus Personen
- 0,5 m/s Wind (West)

Größere Bereiche etwa 10 K wärmer als Umgebungstemperatur.

Einzelne Peaks können ignoriert werden, da in der Realität kein stationärer Zustand vorliegt (stärkere Durchmischung der Luftmassen).

Option C+

Nutzung ohnehin anzuordnender Geländer auch als Windschutz.

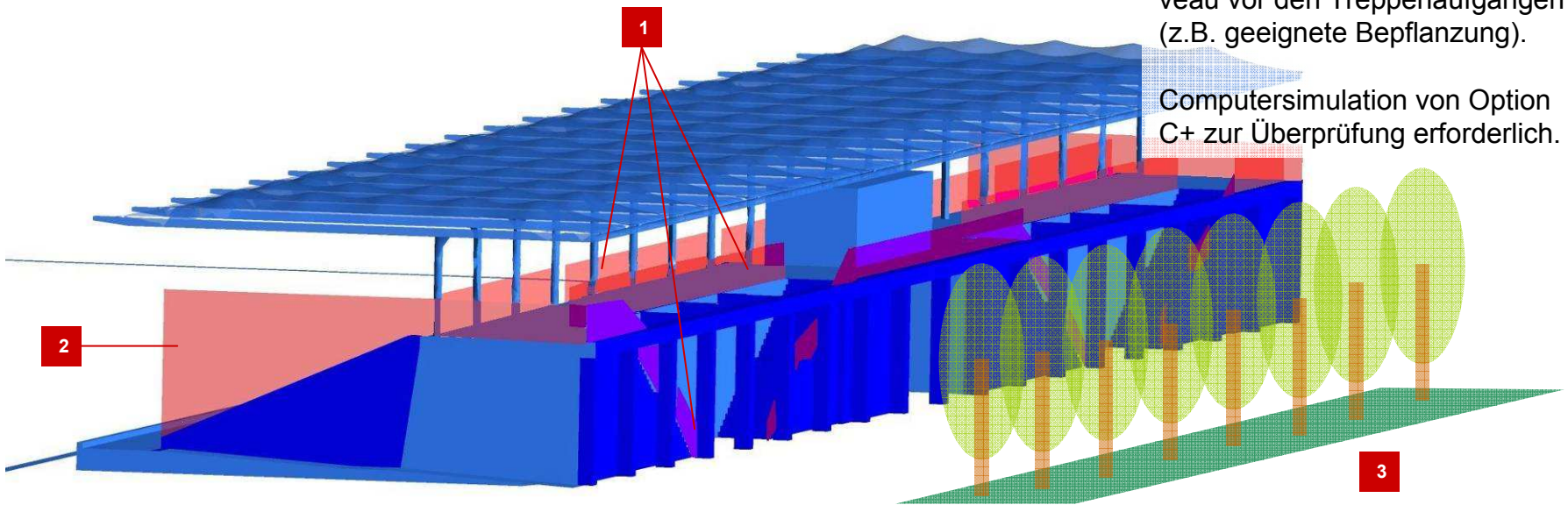
Ausbildung des Windschutzs mit 50% Durchlässigkeit (z.B. durch Metallgewebe).

An den Giebelseiten Anordnung wie bei Option C (auch in Glas möglich).

Zusätzlich Schutz auf Geländeneiveau vor den Treppenaufgängen (z.B. geeignete Bepflanzung).

Computersimulation von Option C+ zur Überprüfung erforderlich.

- 1 Geländer als Windschutz (50% Durchlässigkeit)
- 2 Giebelseiten: Anordnung wie bei Option C (ggf. In Glas)
- 3 Schutz auf Geländeneiveau durch Bepflanzung

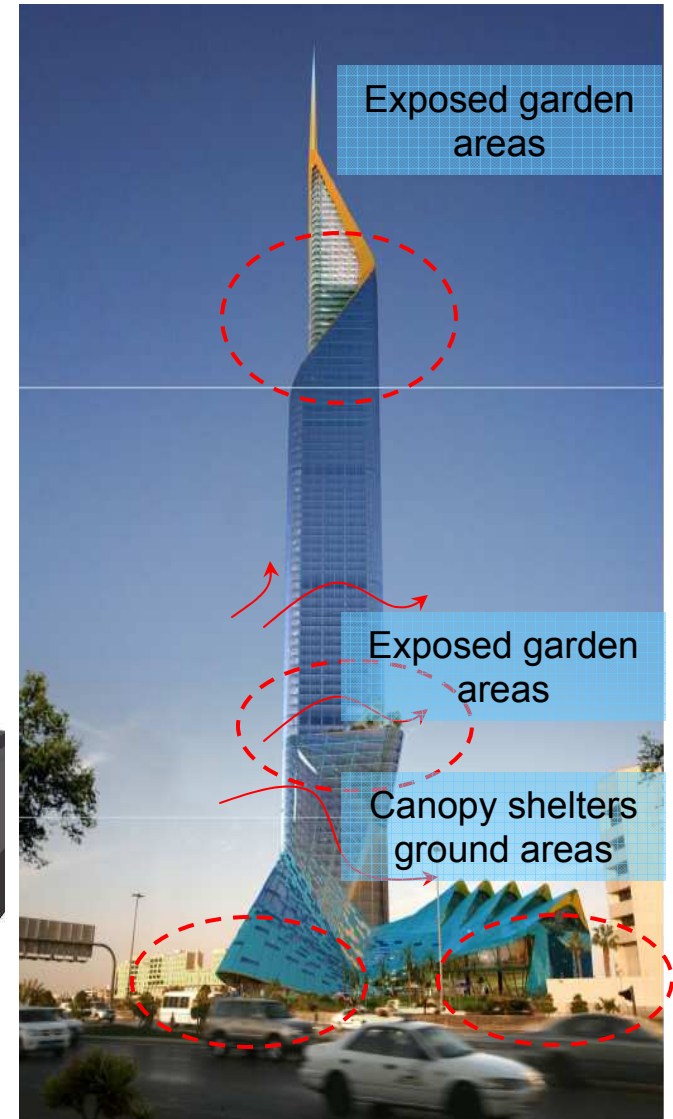




Buro Happold the engineering of excellence



Sectors – tall buildings





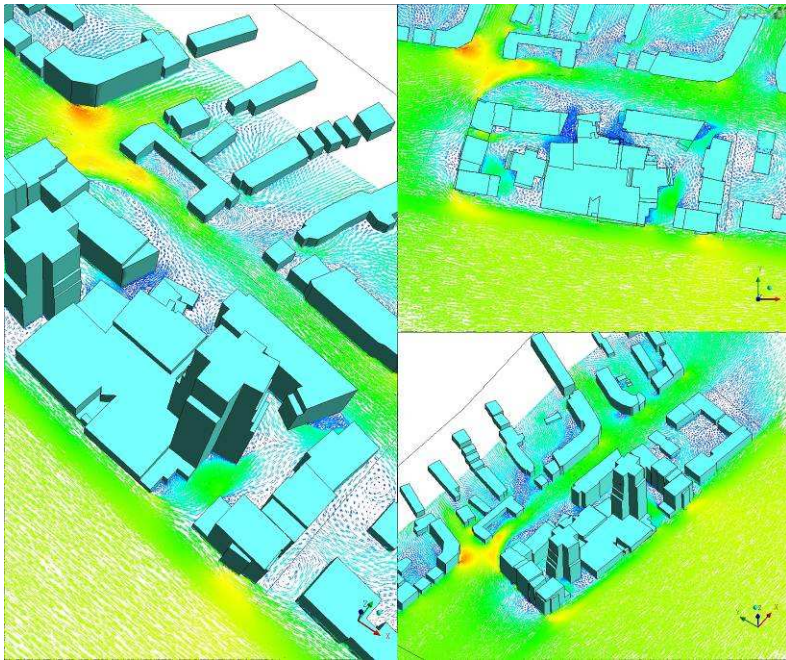
King Alfred – Hove

Frank Gehry

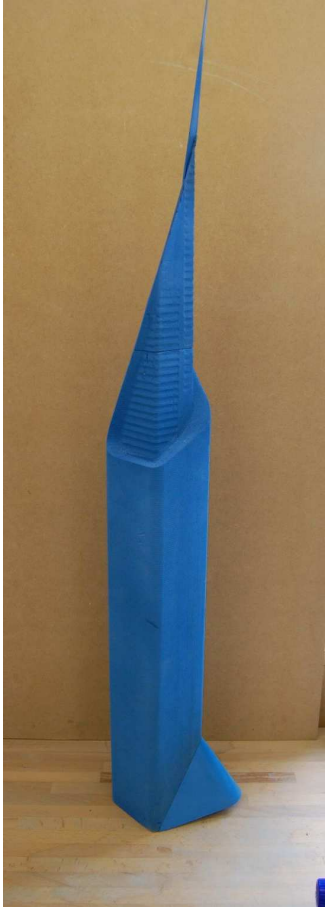
Project value – 187,000,000

Client - Karis Holdings Ltd

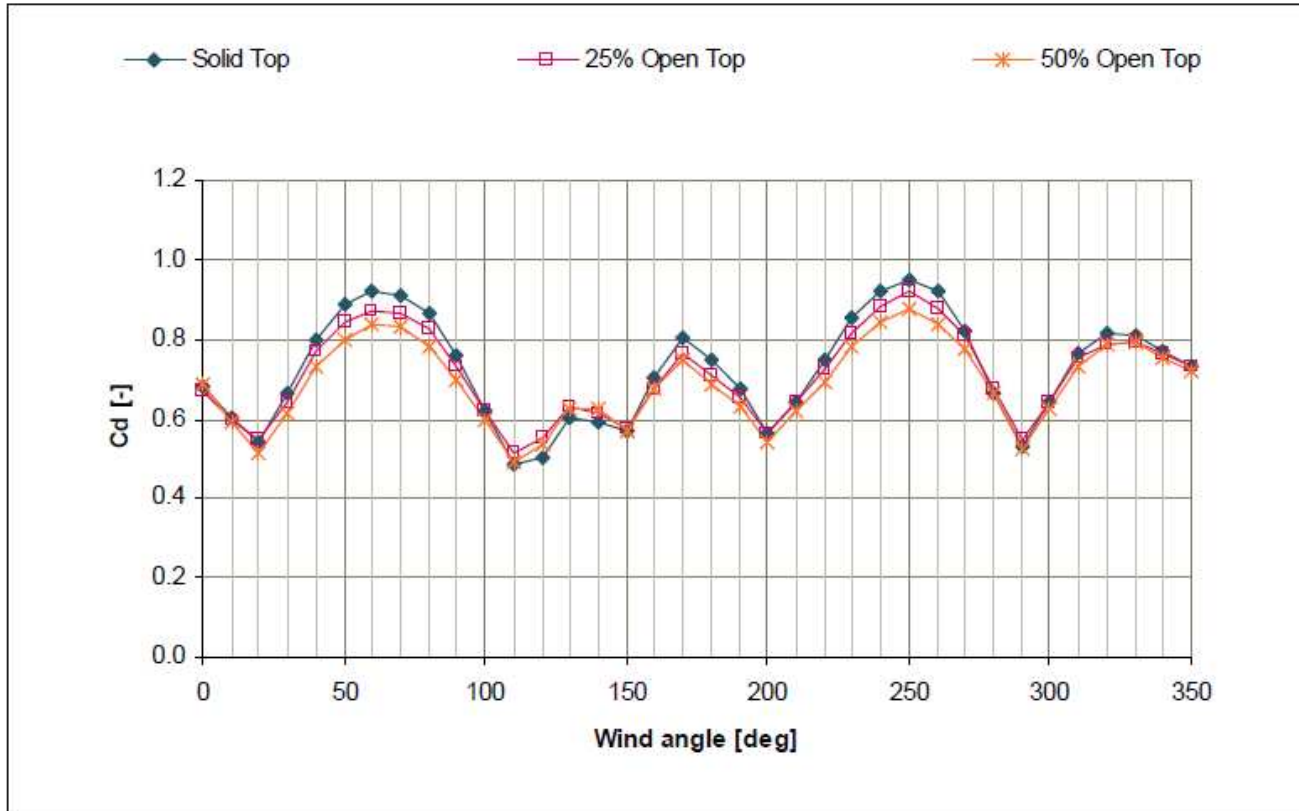
- CoSA – External appointment with Hephher Dixon Planners
- Wind assessment to support planning application
- Extensive analysis of building Towers organic shapes in close collaboration with Frank Gehry
- Peer reviewed by BRE: CFD appropriate to project stage and time scales



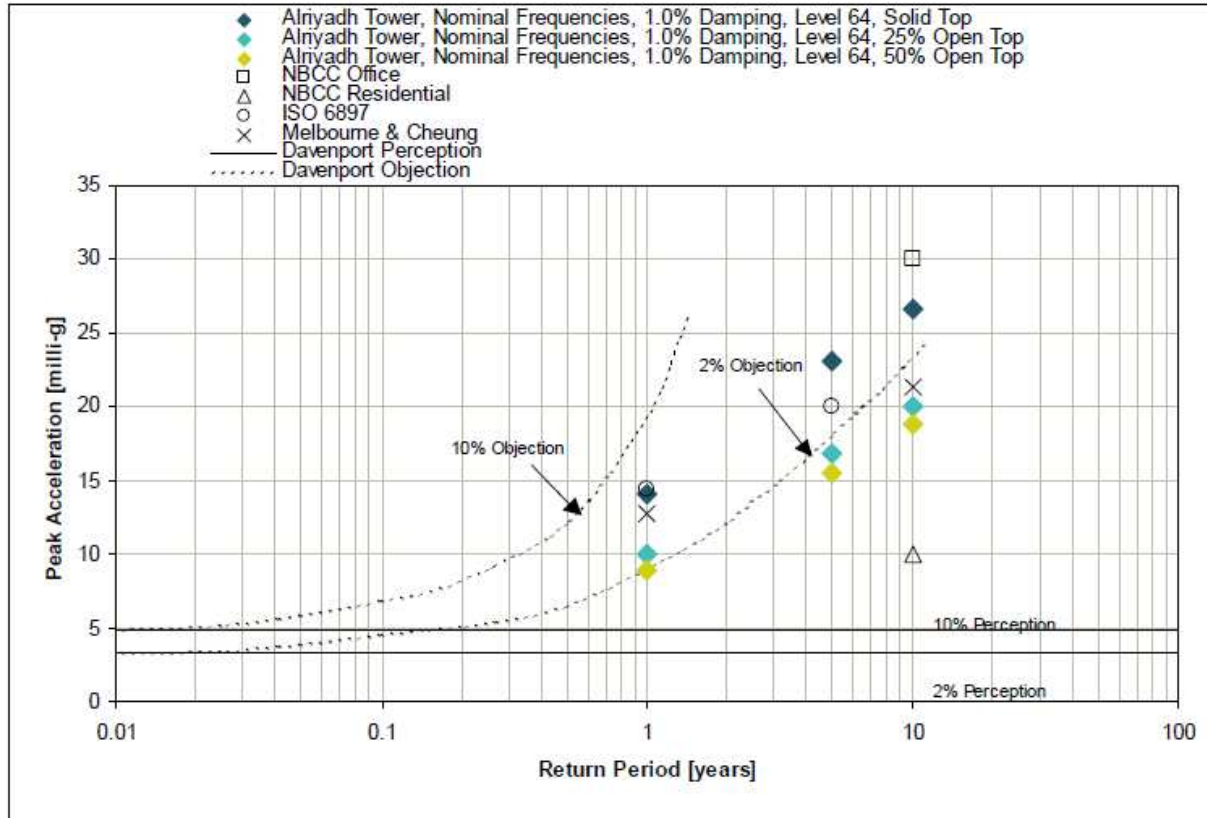
Wind tunnel testing



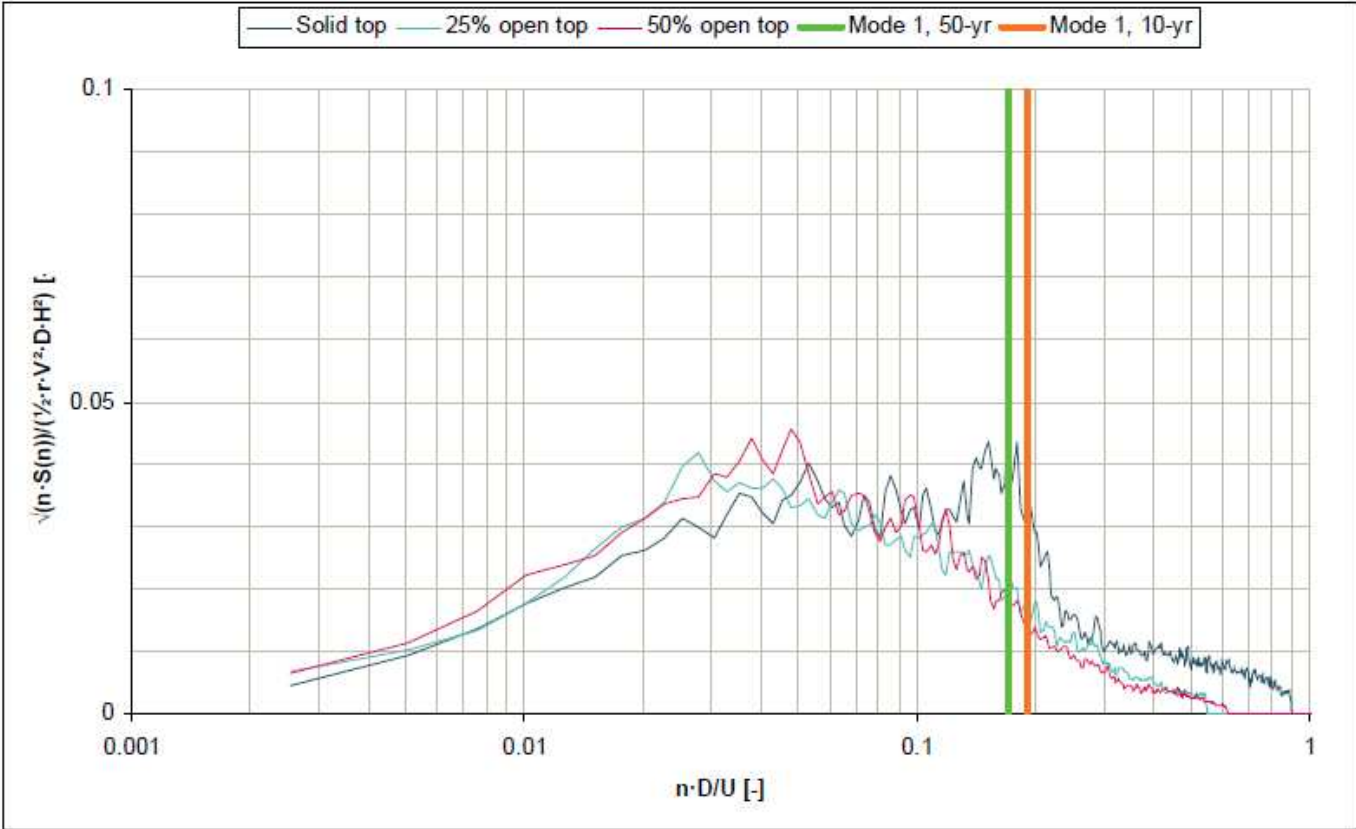
Drag on tower



Peak acceleration



Load spectrum



Sectors - Masterplanning

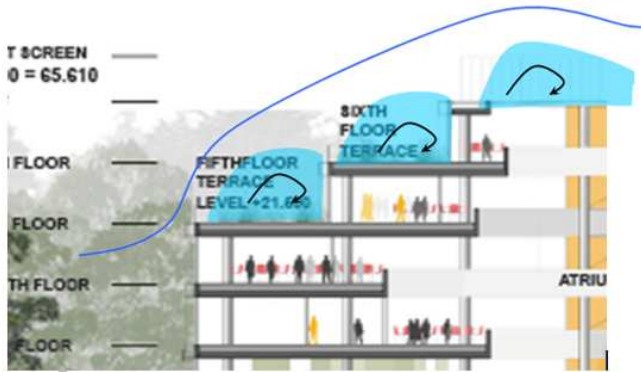
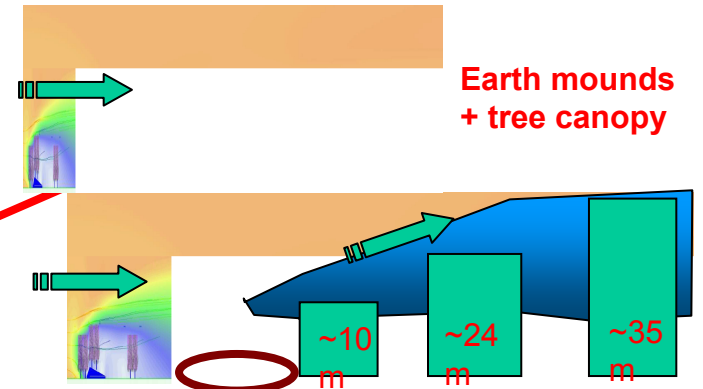
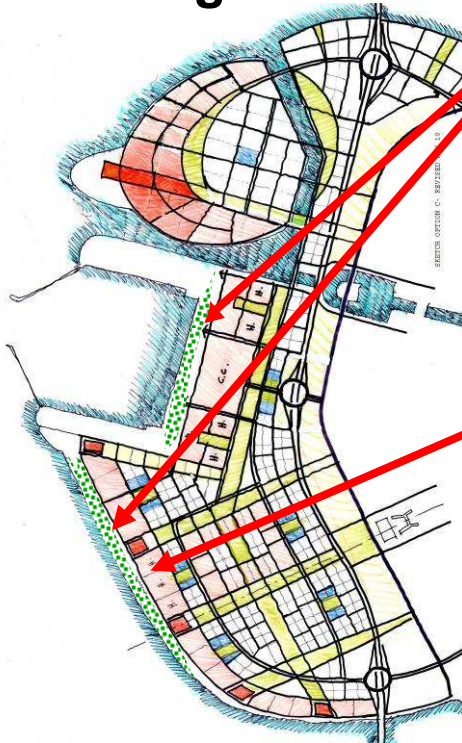


Figure 6. Areas of high local shelter and turbulence



Building Shelter



Earth mounds + tree canopy

Stepping



Earth mounds



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